SPACE

12th National Space Symposium

PROCEEDINGS REPORT

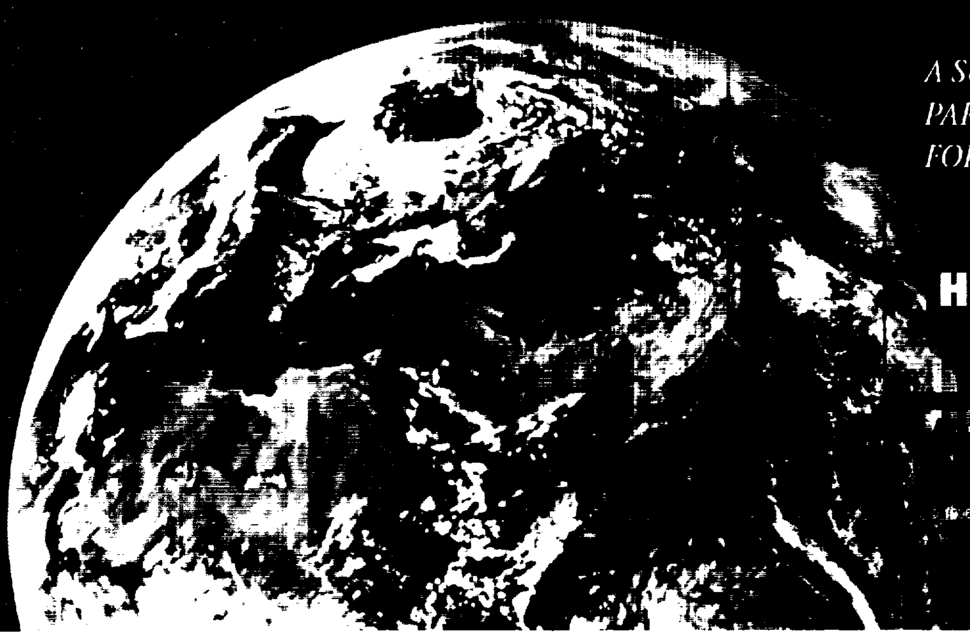
United States Space Foundation

A Symposium on
"Home" Improvement

April 9–12, 1996

Broadmoor Hotel
Colorado Springs
Colorado

SPACE NEWS



UNITED STATES SPACE FOUNDATION

THE 12TH NATIONAL SPACE SYMPOSIUM

SPACE: Enhancing Life on Earth

PROCEEDINGS REPORT

The most comprehensive compilation of civil, military, commercial, and international commentary by the key space policy decision makers.

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U.S. Space Foundation

DEDICATION

JACK SWIGERT

The United States Space Foundation is dedicated to the memory of Astronaut and Congressman Jack Swigert, who dedicated his life to the objectives and purposes for which this Foundation was exclusively created: to promote national awareness and support for America's space endeavors.

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THE WHITE HOUSE

WASHINGTON

March 14, 1996

Warm greetings to everyone gathered in Colorado Springs for the twelfth National Space Symposium, sponsored by the United States Space Foundation.

America's endeavors in space have been among humanity's greatest achievements. Space exploration has offered us new knowledge of the universe, new rewards in technology, and new opportunity to bring our world closer together by developing strong relationships and shared goals among nations. As we reach for the stars and beyond, our accomplishments in space will help us to advance peace and prosperity on Earth.

I applaud the organizers and participants of the National Space Symposium for your commitment to the future. Sharing your leadership, participation, and successes in America's space program will pave the way to new and even greater achievements. By spurring interest in space exploration in our youth — the scientists, mathematicians, engineers, and leaders of tomorrow — you are making a long-term investment in America's future and in the future of the world.

Best wishes for a most productive symposium and every continued success.

Bill Clinton

HONORARY PROCLAMATION

UNITED STATES SPACE FOUNDATION WEEK
APRIL 7–13, 1996

WHEREAS,
the United States Space Foundation is dedicated to carrying out its mission of promoting national awareness and support for America's space endeavors; and

WHEREAS,
the world's space policy decision makers will gather at the 12th National Space Symposium in Colorado Springs, April 9–12, 1996, to discuss and focus on how space enhances life on Earth; and

WHEREAS,
three innovative technologies, Fire-Resistant Aircraft Seats, Radiant Barrier and the Anti-Shock Trouser System, developed for America's space program and now widely used in the industry, the medical field and purchased by the consumer, will be inducted into the Space Technology Hall of Fame on April 11, 1996;

NOW, THEREFORE,
I, Roy Romer, Governor of Colorado, proclaim April 7–13, 1996, as

UNITED STATES SPACE FOUNDATION WEEK
in the State of Colorado.

GIVEN
under my hand and the Executive Seal of the State of Colorado, this nineteenth day of March, 1996

WELCOME

On behalf of the United States Space Foundation, welcome to the **12th National Space Symposium** and the beautiful Pikes Peak region. The week's schedule is packed with exciting topics and events that will contribute substantially to our understanding and cooperation as the world becomes more engaged in space — in all its many dimensions.

The theme for our meeting this year — *Space: Enhancing Life on Earth* — is most appropriate as we come together representing government, industry, nations and indeed, interests from around the globe to explore how space is improving our lives. Many of the world's foremost space authorities and decision makers are on hand to discuss and debate the critical issues facing our space-faring societies today.

The experts will stimulate your thinking and improve your ability to succeed by offering insights into all aspects of contemporary space issues. Each year, participation in the symposium and surrounding events becomes more international which merely reflects the nature of research and business in the world today.

In recognition of this important trend, we are hosting concurrently with the **12th National Space Symposium**, the **United Nations/United States International Conference on Spin-off Benefits of Space & Technology**. Focused on developing nations, the theme for this meeting — *Challenges and Opportunities* — complements the other sessions and activities perfectly. The Foundation is delighted and proud to be integrating this international event into our exciting schedule of activities this week.

Please take full advantage of all that is happening here at the five-star Broadmoor Hotel this week from the superb professional sessions and first rate industry exhibits to the entertaining opening ceremony and very special Space Technology Hall of Fame dinner.

Sincerely,

James E. Hill, General, USAF (Ret.)
Chairman of the Board
United States Space Foundation

United States Space Foundation
12th National Space Symposium 1996

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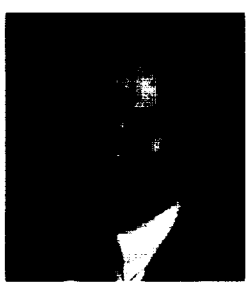
THE U.S. LAUNCH VEHICLE INDUSTRY — WILL IT SURVIVE?

CO-SPONSORED BY THE UNITED STATES SPACE FOUNDATION

MONDAY, APRIL 8, 1996

8:30 AM	Welcome and Introduction to Launchspace
8:45 AM	Introduction to Launch Vehicles and How They Function.
10:00 AM	Mass Ratio Limitations and the Difficulty in Getting to Orbit.
10:45 AM	Launch Vehicle ingredients and How They Go Together.
11:30 AM	Launch Vehicle Design Drivers.
12:00 Noon	Lunch
1:00 PM	The Connections Between the Payload and the Launch Vehicle.
1:30 PM	Worldwide Survey of Launch Vehicles and Sites.
2:30 PM	Cost Elements of Expendable and Reusable Vehicles.
3:15 PM	The Truth About America's Developing Launcher Programs.
4:00 PM	Adjourn



Instructor: Marshall H. Kaplan, Ph.D., is the chairman of Launchspace, Inc., an education services company endeavoring to offer the broadest selection of relevant, high quality, professional development and continuing education courses and seminars to the space community. Dr. Kaplan is a specialist in the development of new launch vehicles and space flight concepts and programs. He has served as the Chief Engineer on a fully reusable launcher system in its early stages of development and on the Conestoga expendable launch vehicle. Dr. Kaplan is also a co-inventor of a new mobile, small expendable launch system for military applications, and he is involved in a number of other new booster concept developments. Your instructor is a member of the National Research Council's Committee on Reusable Launch Vehicle Technology Development and Test Program, and he has over 30 years of academic and industrial experience with launch vehicles, satellites, and space technologies. He was a Professor of Aerospace Engineering at the Pennsylvania State University and the Director of the space Research Institute. Dr. Kaplan enjoys an international reputation as an expert and lecturer in aerospace vehicle design, dynamics, and control. In addition to publishing some 75 papers, reports, and articles on aerospace technologies, he is the author of several books, including the text, "Modern Spacecraft Dynamics and Control." Dr. Kaplan holds advanced degrees from MIT and Stanford University.

GPS INTERNATIONAL ASSOCIATIONSECOND ANNUAL MEETING
"GPS: AN ENABLING TECHNOLOGY"

CO-SPONSOR OF THE UNITED STATES SPACE FOUNDATION
12TH NATIONAL SPACE SYMPOSIUM

TUESDAY, APRIL 9, 1996

8:30 AM	**Opening Remarks** Dr. Francis X. Kane, GIA Founding President
9:00 AM	**"The GPS Program Status"** Col. John P. Caldwell, USAF, Deputy Assistant Program Director, NAVSTAR GPS Joint Program Office
9:45 AM	**"Geographic Information System and Mapping Management with GPS"** Jeff Allen, GPS/GIS Project Manager, GEO Research, Inc.
10:30 AM	**"GPS Vehicle Location for Personal Security and Recovery"** Steven W. Riebel, President, ATX Research, Inc.
11:15 AM	**"Japan's View of GPS"** Thomas Kato, Director, Japan Institute for Future Technology
12:00 PM	**Luncheon** Speaker: Dr. Bonnie J. Dunbar, NASA Astronaut
1:30 PM	**Keynote Address** The Honorable F. James Sensenbrenner, Jr., Chairman, Space & Aeronautics Subcommittee; Science Committee, U.S. House of Representative
2:00 PM	**Questions and Answers with Congressman Sensenbrenner**
2:15 PM	**Special Address: "The Global Positioning System: Assessing National Priorities"** Dr. Scott Pace, RAND-CTI
2:45 PM	**"New Direction in Atmospheric Remote Sensing at NOAA's Boulder Laboratories"** Dr. Russell B. Chadwick, Chief-Demonstration Division, NOAA Forcast Systems Lab
3:15 PM	**"Equipment Location Systems — Providing Intermodal Terminal Operators with Information Accuracy"** Ken Kelley, Vice President, STC Applications
3:45 PM	**Questions and Answers with Dr. Pace, Dr. Chadwick, and Mr. Kelley**
4:00 PM	**GIA Annual Meeting** Dr. Francis X. Kane, Founding President and GIA Staff
4:30 PM	**Adjourn**

Moderator: Dr. Francis X. "Duke" Kane is the president of the GPS International Association and participates in government committees concerned with civil users and GPS technology including consulting for the Office of the Secretary of Defense on development of long range strategy and policy. He has served as director of strategic systems, Advanced Systems Development, for Rockwell International; manager of requirements analysis for TRW Systems Inc., which included performing studies of national security policy and strategy and application of technologies to emerging business opportunities; deputy for development plans for Air Force Space and Missile Systems Organizations;and special assistant to the deputy chief of staff of research and development in the Office of the Secretary for the Air Force. He initiated and conducted internal analyses of the impact of SALT and SALT II on Minuteman and MX missiles and provided the data to OSD and the Air Force. He holds a BS form the U.S. Military Academy, West Point, NY; an MA and a Ph.D. from Georgetown University. He is a Fellow of the American Institute of Aeronautics and Astronautics and of the International Academy of Astronautics and its Space Safety and Rescue Committee.

United Nations/United States International Conference on Spin-Off Benefits of Space Technology: Challenges and Opportunities

Monday, April 8 - Friday, April 12, 1996

Participating Organizations:

National Aeronautics and Space Adminstration
U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of Energy
U.S. Federal Laboratory Consortium
U.S. Information Agency
U.S. Department of State
American Institute of Aeronautics and Astronautics
United States Space Foundation
United Nations Office of Outer Space Affairs

Monday, April 8

6:00-7:30 p.m.
Welcoming Ceremony & Remarks
Richard P. "Dick" MacLeod, President, U.S. Space Foundation
John G. Hazlehurst, Member, Colorado Springs City Council
Beth A. Masters, Director, International Relations, NASA Headquarters
Adigun Ade Abiodun, Expert on Space Applications, United Nations Office for Outer Space Affairs

Tuesday, April 9

9:00 a.m.
Welcome, Introductions, and Opening Remarks
Chair: Dr. Brenda Forman, Director, Federal Planning & Analysis, Lockheed Martin Corp.
Richard P. "Dick" MacLeod, President, U.S. Space Foundation
Adigun Ade Abiodun, Expert on Space Applications, United Nations Office for Outer Space Affairs

9:30 a.m.
Space Technology Applications: Evolution Status
Speaker: Dr. Robert Norwood, Director, Commercial Development & Technology Transfer Division, NASA

10:15 a.m.
Benefits of US-Federal Research and Development to Society, Role of Federal Laboratories
Keynote Speaker: Dr. Catherine Woteki, Deputy Undersecretary for Research, Education and Economics, U.S. Department of Agriculture

10:35 a.m.
Panel Discussion
Chair: Frank Peñaranda, U.S. Department of Commerce
Panelists: Dr. Catherine Woteki, Deputy Undersecretary for Research, Education and Economics, U.S. Department of Agriculture
Dr. Robert Norwood, Director, Commercial Development & Technology Transfer Division, NASA
W. David Thompson, President, Spectrum Astro, Inc.
Frank Stewart, Manager
Golden Field Office, U.S. Department of Energy
James A. M. Muncy, Legislative Assistant for Space to Congressman Dana Rohrbacher (R-CA)

12:00 p.m.
U.N./U.S. Conference and Global Positioning System International Association (GIA) Luncheon
Speaker: Dr. Bonnie Dunbar, NASA Astronaut

1:30 p.m.
U.N./U.S. and GIA Conference
Chair: Francis X. "Duke" Kane Ph.D., GIA Founding President
Introduction: Richard P. "Dick" MacLeod, President, U.S. Space Foundation
Keynote Address:
The Honorable F. James Sensenbrenner, Jr. (R-WI), Chairman, Space & Aeronautics Subcommittee of the Science Committee, U.S. House of Representatives

2:00 p.m.
Q & A

2:15 p.m.
The Global Positioning System: Assessing GPS National Priorities
Speaker: Dr. Scott Pace, Critical Technologies Institute, Rand Corporation

2:45 p.m.
New Direction in Atmospheric Remote Sensing At NOAA's Boulder Laboratories
Speaker: Dr. Russell B. Chadwick, Chief, Demonstration Division, NOAA Forcast Systems Lab,

3:10 p.m.
Equipment Location Systems-Providing Intermodal Terminal Operators with Information Accuracy
Speaker: Ken Kelley, Vice-President, STC Applications and Consultant to Amtech Systems Corp.

3:30 p.m.
Q & A
Dr. Pace, Mr. Chadwick, and Mr. Kelley

4:00 p.m.
U.N./U.S. Conference Resumes
Chair: Dr. Brenda Forman, Director, Federal Planning & Analysis, Lockheed Martin Corp.
High Resolution Imaging and Data Applications
Speakers: Jim Frelk, Vice President, Government Operations, EarthWatch, Inc.
John Neer, President, Space Imaging Co.
Ted G. Nanz, President, SPOT Image Corp.
M.G. Hammann, Head, Asesores en Biologia Pesquera S.A. de C.V., Mexico

5:00 p.m.
Q & A

7:00 p.m.
12th National Space Symposium Opening Ceremony (See Symposium Program)

Wednesday, April 10

8:30 a.m.
Using Space to Enhance Life on Earth Keynote Address:
Dr. Krishnaswamy Kasturirangan, Chairman, Government of India, Departmentof Space, Indian Space Research Organization

9:10 a.m.
Space Applications and Cooperation (See Symposium Program)

1:30 p.m.
OPTION I - Tours to aerospace technology firms in Colorado Springs
OPTION II - Earth Sensing, Communication, and Navigation Applications (See Symposium Program)

3:45 p.m.
Faster, Better, Cheaper (See Symposium Program)

Thursday, April 11

8:30 a.m.
U.S. Commercial Use of Space: Industry vs. Government Roles
Chair: Frank Peñaranda, U.S. Department of Commerce, U.S. Commercial Space Policy
Speaker: Keith Calhoun-Senghor, Director, Office of Air & Space Commercialization, Department of Commerce

8:50 a.m.

U.S. Commercial Ventures and Trends

Speakers: Dr. George May, Director, ITD, Space Remote Sensing Center, Center for the Commercial Development of Space, NASA, Stennis Space Center

Mr. Herb Satterlee, President, Resource 21

9:30 a.m.

Q & A

Mr. Calhoun-Senghor, Dr. May and Dr. Satterlee

9:50 a.m.

International Trends

Speaker: Ms. Anne-Marie Hieronimus-Leuba, Head, Office of Space Commercialization, European Space Agency, France

10:10 a.m.

Roles/Opportunities for Developing Nations in the Utilization of Space Derived Products

Speaker: Dr. K.V.C. Rao, Managing Director, ABR Organics Ltd., India

10:30 a.m.

Q & A

Ms. Hieronimus-Leuba and Dr. Rao

10:50 a.m.

Successful Mechanisms for Establishing Commercial Partnerships & for Transferring Technology within a Country

Speakers: Brenda Karasik, Far West Regional Coordinator, Federal Laboratory Consortium, Naval Command, Control Ocean Surveillance Center, San Diego, CA

Gary Sera, Director, Mid-Continent Region, Regional Technology Transfer Center

11:20 a.m.

Licensing Domestic and International Intellectual Property

Speaker: John Paul, Finnegan, Henderson, Farabow, Garrett and Dunner, LLP

11:40 a.m.

Q & A

Ms. Karasik, Mr. Sera, and Mr. Paul

12:00 p.m.

Symposium/Conference Luncheon

Speaker: The Honorable Daniel S. Goldin, NASA Administrator

1:30 p.m.

Space Technology Spin-off Sectors of Potential Benefit to Developing Nations

Chair: John J. Egan, President, Egan International

1:50 p.m.

Heathcare Telecommunications

Speakers: Dr. W. Ferguson, MD, Director, Aerospace Medicine & Occupational Health, Division, Office of Life and Microgravity Sciences & Application, NASA

Dr. A.M. House, MD, Chairman, Telemedicine Program, Memorial University of Newfoundland, Canada

Alok Garg, Director, OPTOMECH Engineers PVT. Ltd., India

2:30 p.m.

Q & A

Dr. Ferguson, Dr. House, and Mr. Garg

2:45 p.m.

Global Monitoring and Human Health

Speaker: Dr. Arnauld Nicogossian, M.D., Deputy Associate Administrator, Office of Life & Microgravity Sciences & Applications, NASA Headquarter

3:05 p.m.

Monitoring Crop Conditions and Assessment of Yields Using Satellite and Ground-Based Observations

Speaker: Dr. Paul C. Doraiswamy, U.S. Department of Agriculture, Agricultural Research Service, Natural Resources Institute

3:25 p.m.

Telecom Africa: An Indigenous Initiative

Speaker: Dr. Joseph Okpaku, Sr., President, Okpaku Communications Company, Nigeria

3:40 p.m.

The SALSA (Semi-Arid Land-Surface-Atmosphere) Program: A Multi-national, Multi-disciplinary Program Utilizing Remote Sensing and In-situ Observations with Models

Speaker: Dr. David C. Goodrich, Research Hydraulic Engineer, U.S. Department of Agriculture

3:55 p.m.

Q & A

Dr. Nicogossian, Dr. Opaku, Dr. Doraiswamy, and Dr. Goodrich

5:15 p.m.

Space Technology Hall of Fame Reception

6:30 p.m.

Space Technology Hall of Fame Dinner

Speaker: Joseph T. Gorman, Chairman & CEO, TRW Inc.

Friday, April 12

9:00 a.m.

PLENARY SESSION

Developing Country's Involvement and Benefits from Space, Applications and Commercialization

Chair: Dr. Mazlan Othman, Director General, Space Sciences Study Division, National Planetarium, Malaysia

Spin-off Benefits of Space Technology: Specific Industry Experience

Speakers: Joseph Elbling, President/CEO, Digicon S.A., Brazil

Professor Janusz Bronislaw Zielinski, CEO, Polspace Ltd., Poland

Morteza Hosseini Abkenari, Managing and Technical Director, Solar Power, KGALAGADI Resources Development Co., Botswana

10:30 a.m.

Human Resources Development

Speaker: Adigun Ade Abiodun, Expert on Space Applications, United Nations Office for Outer Space Affairs

Dr. Jerry Brown, Director of Education, United States Space Foundation

11:15 a.m.

Featured Address:

The Honorable Daniel S. Goldin, NASA Administrator

12:00 p.m.

Conference Luncheon

1:15 p.m.

Breakout Sessions on Space Technology and Spin-Off Opportunities

Concurrent Sessions:

1. "Space Technology in Health, Biomedicine and Education Applications and Human Resource Development"

Breakout Chair: John J. Egan, President, Egan International

Vice-Chair: Professor Boris I. Bonev, President, Bulgarian Aerospace Agency, Bulgaria

2. "Communications for Development: Development of Communications Infrastructure with Emphasis on Applications Opportunities in Agriculture, Natural Resources and Global Information Systems"

Breakout Chair: W. David Thompson, President, Spectrum Astro, Inc.

Vice-Chair: Engr. Gilbert O. Uzodike, Chairman, ADSWITCH PLC, Nigeria

3:30 p.m.

Plenary - Summary and Recommendations for Sessions 1 and 2

Chairs: John J. Egan, President, Egan International

M.G. Hammann, Head, Aseores en Biologia Pesquera S.A. de C.V., Mexico

4:15 p.m.

Plenary - Summary and Recommendations for Session 3

Chair: Dr. Mazlan Othman, Director General, Space Science Studies, National Planetarium, Malaysia

5:00 p.m.

Closing Remarks

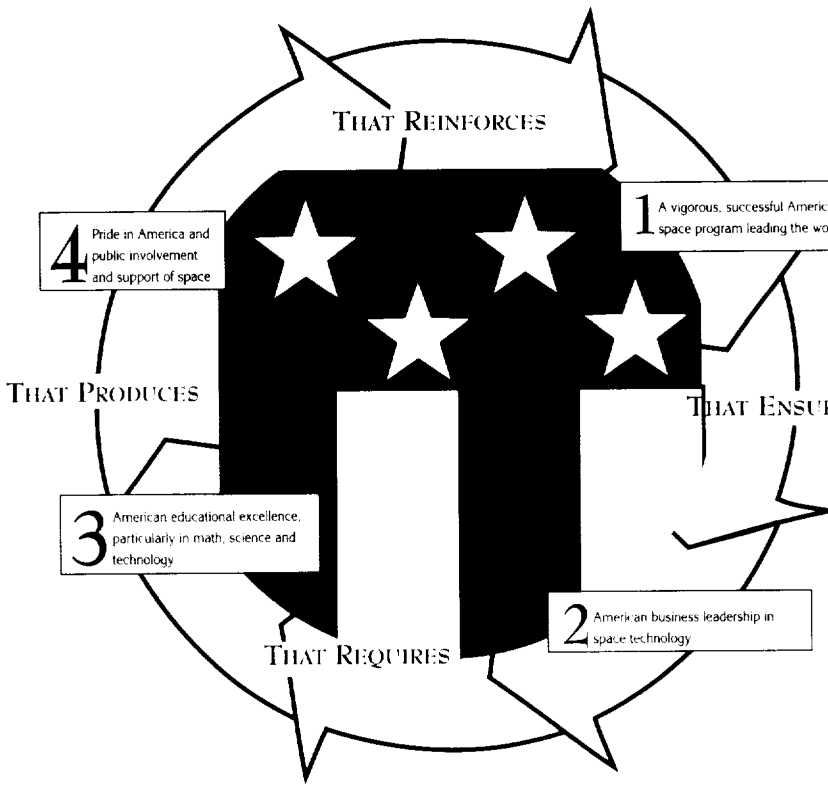
United Nations-Speaker: Adigun Ade Abiodun, Expert on Space Applications, United Nations Office for Outer Space Affairs

United States of America-Speaker: Beth A. Masters, Director of International Relations, NASA Headquarters

THE UNITED STATES SPACE FOUNDATION

OUR VISION

A vigorous, successful American Space Program leading the world; that ensures American business leadership in space technology; that requires American educational excellence, particularly in math, science, and technology; that produces pride in America, and public involvement and support of space.



OUR MISSION

To promote national awareness and support for America's space endeavors

OUR GOALS

Promote the romance and relevance of space to the public with information, entertainment, and products.

Prepare K - 12 educators in using space science and technology in the classroom to inspire students and enhance learning.

Provide access to information on space policy, programs, and current issues for space and business professionals.

Develop and operate a Space Discovery Center theme attraction in Colorado Springs to support, distribute, and deliver the Foundation's programs, products, and services.

BOARD OF DIRECTORS

EXECUTIVE COMMITTEE

GENERAL JAMES E. HILL, USAF (Ret.), Chairman

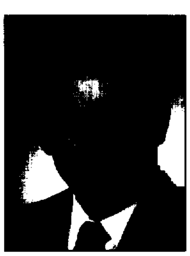
General James Hill served as President of the Colorado Springs-based Olive Company from 1986 to 1993, and President of the Colorado Springs Chamber of Commerce for several years after his retirement from the U.S. Air Force. He is a graduate of the University of Maryland and the Royal Air Force Flying School in England. Former Commander-In-Chief of the North American Air Defense Command, General Hill was a Air Force combat fighter ace in WWII and the Korean Conflict.

WILLIAM B. TUTT, Vice Chairman

William Tutt is principal of Tutco and Chairman Emeritus of the Colorado Springs Sports Corporation. He served as Vice President of the U.S. Olympic Committee and President of the Broadmoor Management Co. Mr. Tutt is now the the Chairman of the U.S. Olympic Festival Committee and Co-Chairman of the Colorado Thirty Group. Mr. Tutt serves on the Board of Directors for the Air Force Academy Foundation (Vice President), Norwest Banks of Colorado, Colorado Interstate Gas Company and previously served on the Board of Directors for U.S. West Communications Colorado.

W. BRUCE KOPPER, ESQUIRE, Secretary-Treasurer

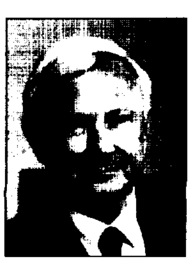
Bruce Kopper is President of the investment counseling firm, Kopper Investment Management, Inc., in Colorado Springs. Mr. Kopper is a graduate of Washington University in St. Louis, Missouri, with degrees in economics (A.B. 1958) and law (J.D. 1959), and is licensed to practice law in Missouri and Colorado. He practiced law for 28 years before entering the investment management business in 1987. He is a member of the Denver Society of Security Analysts and the Association for Investment Management & Research.



WILLIAM H. HUDSON, Director

Executive Committee Member-at-Large William Hudson's entire professional career of 31 years was with Corning Glass Works, now Corning Incorporated. When he retired in 1985, he was President of the Glass and Ceramics Group and a member of the Board of Directors, the Executive Committee and the Management Committee. Prior to the Group Presidency he was Senior Vice-President and General Manager of the Technical Products Division. Mr. Hudson lived in Paris, France for more than six years where he was Chairman and CEO of Corning's largest overseas subsidiary. He is now a Director of Analytical Surveys Inc., Colorado Springs, CO, and investor/advisor in several start-up companies. Mr. Hudson has a degree in Physics from Carnegie Institute of Technology and attended the Harvard Business School Advanced Management Program.

DIRECTORS

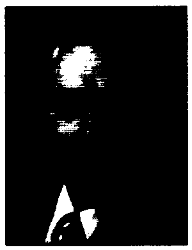


EDWARD C. "PETE" ALDRIDGE, JR., Director

Edward C. Aldridge, Jr. is President and Chief Executive Officer of The Aerospace Corporation, a nonprofit organization dedicated to the objective application of science and technology toward the solution of critical national problems. Previously, Aldridge served as president of McDonnell Douglas Electronic Systems Company. He also served in many government positions, including Secretary of the Air Force. Aldridge received his undergraduate degree from Texas A&M University and earned his graduate degree from the Georgia Institute of Technology.

ROBERT ANDERSON, Director

Robert Anderson is Chairman Emeritus of Rockwell International and past CEO. He earned a Bachelor's degree in Mechanical Engineering from Colorado State University, a Master's degree in Automotive Engineering from the Chrysler Institute of Engineering and spent 22 years with the Chrysler Corporation, rising to Vice President of Corporate Automotive Manufacturing. Under his direction, Rockwell shared the 1982 Collier Trophy for the company's work on the Space Shuttle Orbiter, awarded by the National Aeronautic Association for "the greatest achievement in aeronautics or astronautics in America with respect to improving the performance, efficiency or safety of air or space vehicles". He has served as Chairman of the Business Higher Education Forum and the Board of Aerospace Industries Association of America (AIAA).

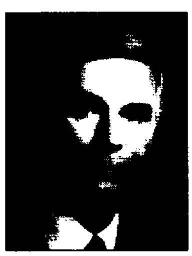


JAMES M. BEGGS, Director

James Beggs is the former Chairman of the Board, SPACEHAB, Inc., and is a principal in Beggs International. As Administrator for NASA (1981-1985) he was responsible for initiating and obtaining President Reagan's support for the Space Station program. He was Administrator during 22 successful shuttle flights and was responsible as the President's representative for obtaining cooperation in the Space Station Program of the European Space Agency, Japan and Canada. Mr. Beggs graduated from the U.S. Naval Academy and Harvard Graduate School of Business. He holds six honorary degrees and was awarded the Robert H. Goddard Trophy by the National Space Club in 1988

COLONEL FRANK BORMAN, USAF (Ret.), Director

Colonel Frank Borman, USAF (Ret.) is the Chairman, CEO and President of Patlex Corporation. He was the commander of the 1968 Apollo 8 Mission and led the first team of American astronauts to circle the moon. After his retirement from the Air Force, he joined Eastern Airlines and became Chairman of the Board before he retired from Eastern. He is currently a member of the Boards of Directors of The Home Depot, AutoFinance Group, Thermo Instrument Systems and American Superconductor. He earned a B.S. from the U.S. Military Academy, West Point and an M.S. in aeronautical engineering from the California Institute of Technology. He has received the Congressional Space Medal of Honor and the National Geographic Society's Hubbard Medal. He was inducted into the International Aerospace Hall of Fame in 1990, and the U.S. Astronaut Hall of Fame in 1993.



CAPTAIN EUGENE A. CERNAN, USN (Ret.), Director

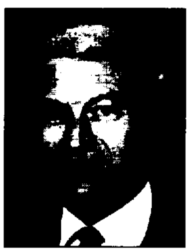
Captain Eugene A. Cernan is President and CEO of The Cernan Corporation and The Cernan Group, Inc. In a recent acquisition, Captain Cernan became Chairman of the Board of Johnson Engineering Corp. Captain Cernan was an Executive Consultant for Aerospace and Government for Digital Equipment Corporation from 1986-1992. From 1976 to 1981, he was International Executive Vice President, for Coral Petroleum, Inc. Prior to 1976, he was a naval aviator and NASA astronaut. He flew three separate space missions, Gemini IX, Apollo X, and holds the distinction of being the last man to leave his footprints on the surface of the moon as commander of Apollo XVII. Captain Cernan received a Bachelor of Science in Electrical Engineering from Purdue University and a Master of Science in Aeronautical Engineering from the U.S. Naval Post Graduate School, honorary doctorates of engineering from Purdue, Drexel and Gonzaga Universities and an honorary doctorate from Western State College of Law.

THE HONORABLE E. J. "JAKE" GARN, Director

E.J. "Jake" Garn was named Vice Chairman of Huntsman Chemical Corporation in Salt Lake City, Utah, in 1993 after he retired from the U.S. Senate where he served three terms. During his 18 years in the Senate he served as Chairman of the Senate Committee on Banking, Housing and Urban Affairs, VA, HUD and the Independent Agencies Subcommittee. He received a B.S. in Banking and Finance from the University of Utah. He served in the U.S. Navy as a pilot and is a retired Brigadier General in the Utah Air National Guard with more than 10,000 hours of flight experience. He was invited by NASA to fly as a payload specialist on the space shuttle Discovery, flight 51-D, in 1984. During his 109 orbits of the earth he conducted various medical tests. In 1992, he was honored with the Wright Brothers Memorial Trophy. He serves on several boards including Dean Witter Funds of New York City, The Aerospace Corporation and the Salt Lake City Airport Authority.

JAMES B. HAYES, Director

James B. Hayes is president and CEO of Junior Achievement Inc., a nationwide non-profit organization which provides economic education to over 2 million students in the U.S. and an additional 600,000 young people in more than 85 countries around the world. Hayes has been a board member of that organization since 1987. In 1994, following a 35-year career at Time Inc., Mr. Hayes founded The New American Revolution, a not-for-profit organization. The mission of The New American Revolution is to rally the efforts of the U.S. business community to address the social, economic, and educational needs of children. An advocate for improvement of the U.S. public education system, Mr. Hayes established the *Fortune* Education Summit. Held annually in Washington, D.C. from 1988-1993, the Summit brought together government, business and academic leaders to discuss the role of the business community in education reform. In September of 1990, Mr. Hayes was one of 15 U.S. executives selected to join a presidential mission to the Soviet Union to discuss new business development and economic cooperation. Mr. Hayes is a former chairman of the board of Morehouse School of Medicine. He continues to serve on the board as well as the board of trustees of the New York Hall of Science. Mr. Hayes received his education at the Canterbury School and Georgetown University.

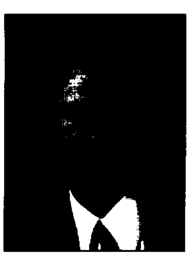


SAM F. IACOBELLIS, Director

Sam F. Iacobellis is former Deputy Chairman and former Executive Vice Chairman for major programs for Rockwell International. He worked with key customers and Rockwell businesses on large government programs including the Space Station, Space Shuttle, B-1B, National Aero-Space Plane, Ground Based Interceptor, Brilliant Eyes and Joint Primary Aircraft Training Systems programs. He joined Rockwell's predecessor company, North American Aviation, in 1952, as an aircraft design engineer. He also has served Rockwell as President of Aerospace Operations. He received a Bachelor of Science degree in Engineering at the University of California at Los Angeles. He is a Fellow of the International Academy of Astronautics and a Fellow of the American Institute of Aeronautics and Astronautics.

DR. JOHN L. McLUCAS, Director

Dr. John McLucas is an Aerospace Consultant, Chairman of the Board of External Tanks Corp., and on the Board of Directors of Orbital Sciences Corp. Dr. McLucas was Secretary of the Air Force from 1973 to 1975. He has served as Chairman of the International Space University, as NATO's Assistant Secretary for Science, President and CEO of MITRE Corporation, Under Secretary of the Air Force, FAA Administrator, Executive Vice President of COMSAT, President of COMSAT World Systems Division and President of COMSAT General. A space authority, Dr. McLucas is the former U.S. Chairman of the International Space Year Association and Chairman of NASA's Advisory Board. He is the author of the book, **Space Commerce**, published in April, 1991, by Harvard University Press. He earned his bachelor's degree from Davidson College, his master's degree from Tulane University and his Ph.D. from Penn State University, all in Physics.

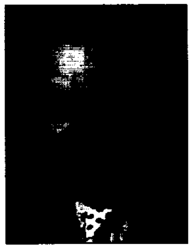


THE HONORABLE BILL NELSON, Director

Bill Nelson was recently elected Treasurer and Insurance Commissioner of the State of Florida. He has been a practicing attorney since 1970, graduating from the University of Virginia Law School, J.D. in 1968, and until his election was an attorney with Maguire, Voorhis & Wells, P.A. in Melbourne, Florida. He served in the U.S. Army as a Captain from 1968-1970. Nelson trained and flew with the crew of STS-61 C, Columbia, the 24th flight of the Space Shuttle in 1986. Among his publications is his book, MISSION: *An American Congressman's Voyage to Space.* Nelson served with the U.S. House of Representatives from 1979 to 1991, representing the 11th Congressional District in Florida and the Florida House of Representatives from 1972 to1978.

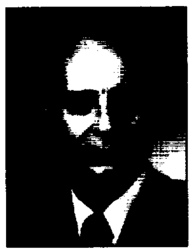
THE HONORABLE JAIME OAXACA, Director

Jaime Oaxaca is vice chairman of Coronado Communications Corporation, Los Angeles, Calif., in charge of public relations, marketing, and research. He has 37 years of experience in the fields of engineering, engineering management, and program management. He held various administrative positions including director of international and domestic marketing and long range planning; Vice president of missile programs and vice president and assistant general manager of the Northrop Corporation, Electromechanical Division; and president of Northrop-Wilcox Electric, Inc. He holds a B.S. in electrical engineering from the University of Texas, El Paso, and is a graduate of the School of Business at Stanford University. He is a Distinguished Fellow of the Institute for the Advancement of Engineering. He was the first recipient of the "Jaime Oaxaca" award for excellence in engineering and dedication to the community from the Society of Hispanic Professional Engineers, the Business and Industry Award from the Mexican-American Opportunities Foundation, and the Outstanding Engineer Merit Award from the Institute for the Advancement of Engineering.



RICHARD D. O'CONNOR, Director

Richard D. O'Connor is Chairman and Chief Executive Officer of Lintas:Campbell-Ewald Company and aBoard member of Lintas Worldwide, an international advertising agency. Mr. O'Connor joined Campbell-Ewald in 1956, as a trainee on the Chevrolet account and held various positions with the company. Mr. O'Connor is Chairman of the American Advertising Federation, and is a member of the Menninger Foundation Board of Trustees. He is a graduate of the University of Michigan.



GENERAL JOHN L. "PETE" PIOTROWSKI, USAF (Ret.), Director

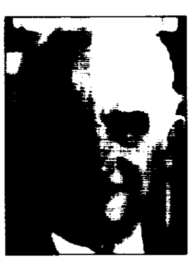
General Pete Piotrowski retired from the U.S. Air Force as Commander in Chief of the North American Aerospace Defense Command and the United States Space Command. The General has logged more than 5,000 flying hours, including 100 combat missions and 210 combat flying hours. He has received numerous awards, to include the Defense Distinguished Service Medal, Distinguished Service Medal, Legion of Merit and the Eugene M. Zuckert Management Award for 1979. He graduated from the University of Nebraska at Omaha in 1965, with a Bachelor of Science degree. He completed postgraduate work at the University of California and Auburn (Ala.) University and attended the program for management development at Harvard University.

DR. WESLEY W. POSVAR, Director

Dr. Wesley W. Posvar is Professor of International Politics and President Emeritus of the University of Pittsburgh. He is a founding member and former Chairman of the Business-Higher Education Forum, an organization composed of the chief executives of about 30 of the nation's most powerful corporations and a like group of presidents of leading universities. In this capacity he leads efforts to improve national awareness and action in such areas as capital formation, international competitiveness, science and technology, research and regulatory reform. He was founding chairman of the Federal Emergency Management Advisory Board and of the National Advisory Council on Environmental Policy and Technology. He is presently Trustee Chairman of the Czech Management Center in Prague. He is a graduate of the U.S. Military Academy where he graduated first in his class. He was a professor at West Point and the founding chairman of the Political Science Department of the U.S. Air Force Academy. Dr. Posvar is a command pilot. He flew as a test pilot at the Air Proving Ground in the Berlin Airlift and in combat in Southeast Asia. He was a Rhodes Scholar at Oxford, a Littauer Fellow at Harvard and Research Fellow at the MIT Center for International Studies.

THE HONORABLE KENNETH B. KRAMER, Director Emeritus

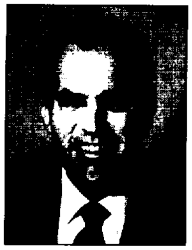
A former four-term United States Representative, Ken Kramer is an Associate Judge for the U.S. Court of Veterans Appeals. He is a graduate of the University of Illinois and the Harvard School of Law. Judge Kramer was a founding member of the United States Space Foundation. He served as a Colorado State Representative from 1973 to 1978. Mr. Kramer is a former Assistant Secretary of the Army for Financial Management. He also served on the U.S. Air Force Academy Board of Visitors.



DR. SIMON RAMO, Director Emeritus

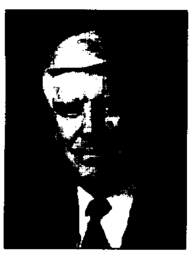
Dr. Simon Ramo, recipient of the Presidential Medal of Freedom and the National Medal of Science, is co-founder of TRW Inc. He has been Chairman of the President's Committee on Science and Technology and Chief Scientist in the development of the U.S. Intercontinental Ballistic Missile. He has been a member of the Advisory Council to the Secretary of State on Science and Foreign Affairs, the White House Council on Energy Research and Development, the Advisory Council to the Secretary of Commerce and the National Science Board. A visiting Professor at Caltech, he has been a Fellow of the Faculty of the Kennedy School of Government at Harvard University and Chairman of UCLA School of Medicine Planning Committee. He is the author of tests widely used in the world's universities.

FOUNDATION EXECUTIVES



RICHARD P. MacLEOD, President

Dick MacLeod was named president of the United States Space Foundation in 1988 after serving as Executive Director since 1985. Under his leadership the National Space Symposium has become a premier event that provides broad pro and con space policy dialogue, the Foundation established, with NASA, the *Space Technology Hall of Fame*, and launched Getting Comfortable Teaching with Space, the cornerstone of the Foundation's educational programs. MacLeod is well known to many space organizations as a cooperative innovator and has served on the Space Policy Advisory Board for the Vice President. While a senior research fellow at the National Defense University, he co-authored *Space — A National Security Dilemma.* He concluded his 24-year Air Force career as chief of staff, NORAD and the first chief of staff, Air Force Space Command. He received a bachelor of arts in government from the University of Massachusetts and a master of arts in international relations from the University of Southern California. He is also a graduate of the Armed Forces Staff College, the National War College, the State Department Interdepartmental Seminar on Foreign Policy and is a distinguished graduate of the Industrial College of the Armed Forces.



JACK FLANNERY, Executive Director

Jack Flannery joined the U.S. Space Foundation as executive director in January 1991. Responsible for the day-to-day operations of the Foundation he has brought new focus and efficiency to the organization through strategic and operational planning. Under his leadership, the Foundation's education programs have expanded dramatically and new and innovative public outreach and education programs have been developed. Previously vice president of Flight Safety Services Corporation, he was responsible for the company's Space Training Systems and Instructional Systems Divisions providing state-of-the-art training solutions for government and industry clients. Mr. Flannery, completed a 27-year U.S. Air Force career as Air Force Space Command's Director of Training, Standardization and Evaluation where he introduced a completely redesigned architecture for space operations missions training systems. He holds a Master of Business Administration from Auburn University and a bachelor of science in electrical engineering from the Air Force Institute of Technology.

1996 United States Space Foundation Awards

DOUGLAS S. MORROW PUBLIC OUTREACH AWARD

President Ronald Reagan congratulating Doug Morrow on his successful efforts to promote America's space programs.

Douglas S. Morrow, born in 1913, was best known for his work in the entertainment industry. Among the numerous awards bestowed upon him, Morrow received the Academy Award for Best Screen Play in 1949 for writing "The Stratton Story," staring Jimmy Stewart and June Allison. Morrow also received the Golden Dove Award and NAACP Image Award as producer of the year and motion picture of the year for "Maurie" in 1973. Additionally, Morrow produced over 200 television programs.

In 1984, at age 71, Morrow climbed Mount Everest to an altitude of 21,000 feet. Interested in Morrow's physical abilities for a man his age, NASA approached Doug to study the physiological factors involved in such a feat. Morrow entered Astronaut training and a year later was NASA certified for space flight. Morrow went on to serve on NASA's Advisory Council and as Co-Chairman of its Subcommittee on Communications. For this work, Morrow was honored by both NASA and the United States Congress.

In 1991, the American Institute of Aeronautics and Astronautics awarded Morrow its Public Service Award for his outstanding efforts in supporting the national space program.

Doug Morrow created and produced the United States Space Foundation public service television and radio campaign, Space Technology - This is What's In It For You. This series of public service announcements promoted the Earthly benefits of the American space program.

The Douglas S. Morrow Public Outreach Award is presented in memory of the late Douglas S. Morrow; renown writer, film producer, space advocate and former U. S. Space Foundation Director; to an individual or organization for outstanding achievement in the promotion of America's space endeavors.

1996 DOUGLAS S. MORROW PUBLIC OUTREACH WINNER
THE APOLLO 13 MOVIE TEAM

The 1996 Douglas S. Morrow Public Outreach Award is presented to the Apollo 13 movie team — Imagine Entertainment, MCA Universal Studios, the National Aeronautics and Space Administration, Astronaut Jim Lovell and actor Tom Hanks — for producing an extraordinary film about America's early years in space and its national resolve under pressure.

The Apollo 13 movie brought American space awareness to the highest levels since the great space race of the 1960's and the Challenger tragedy in 1986. Director and master story-teller Ron Howard and actor Tom Hanks joined forces to produce an exceptionally emotional and inspiring film. Apollo 13 is about America, NASA, and the remarkable men and women who dedicated their lives to making this country number one in space. This story represents all that makes America great and proud, and astronaut Jim Lovell represents the best of that team. The film would not have been possible without NASA and its tremendous cooperation.

The film was a smash hit because people see adventure in space. It generated significant interest and activity from the grass-roots to the U.S. Congress. Ron Howard, Imagine Entertainment, Universal Studios, and Tom Hanks are to be commended for this extraordinary achievement. The United States Space Foundation is proud to recognize Apollo 13 The Movie with this prestigious award.

1996 EDUCATION PARTNERSHIP AWARD

The United States Space Foundation Education Partnership Award was established to recognize exceptional achievement in promoting excellence in education. If America is to remain competitive in the global marketplace by retaining a position of leadership in science and technology, our educational systems must become more effective.

Our young people must be motivated to achieve in education to prepare themselves to live and prosper in the high-tech society of the information age.

To meet this challenge requires significant direct involvement of others in partnership with educational institutions. The Education Partnership Award is presented to those who have demonstrated this involvement working with the United States Space Foundation and who have achieved extraordinary results. Previous winners are: Allied Signal, 1991; U.S. Air Force Academy, 1992; NASA, 1993; The Aerospace Corporation, 1994; and Team Vandenberg, 1995.

THE 1996 EDUCATION PARTNERSHIP AWARD WINNER
ESTES INDUSTRIES

The 1996 Education Partnership Award is presented to ESTES Industries for its strong support of K-12 education programs across the country. ESTES Industries has been providing easy-to-use and exciting model rockets and supporting materials for educators since 1957. ESTES Industries is dedicated to improving science awareness and education, and largely thanks to their efforts, more than 15,000 science curricula across the country use model rocketry.

ESTES Industries recently signed a partnership with the United States Space Foundation to work cooperatively towards improvements in space and science education across the United States.

SPACE ACHIEVEMENT AWARD

The United States Space Foundation Space Achievement Award is established to recognize outstanding achievement in space policy, space professionalism and/or space-related business.

The future of space exploration and exploitation will require the best ideas in technology, industry, and policy. As humankind leaves earth to inhabit space and other worlds, the lessons of history, science, and the principles of law and government must go with them.

The Space Achievement Award is presented to those who have demonstrated their dedication to the evolution of America's space endeavors. Last year's award was presented to Air University.

1996 SPACE ACHIEVEMENT AWARD WINNER
AMERICAN ASTRONAUTICAL SOCIETY

The 1996 Space Achievement Award is presented to the American Astronautical Society for taking the lead in establishing a National Committee on Space that produced the Space for America statement. This statement will assist our national leaders in setting a strategic course for our nation s space activities over the next century and show why we should facilitate growing space activity to help meet our future needs.

The American Astronautical Society is a national professional society exclusively devoted to astronautics. Through their publications, meetings and symposia, the AAS provides for a continuing exchange of interest among those whose careers and interests are with astronautics.

CORPORATE MEMBERS

The United States Space Foundation is proud to have the strong support of corporations and individuals who share the vision of an aggressive, successful American space program leading the world. They believe this vision is an essential component in ensuring American business leadership in space and technology critical to keeping our nation successful in an ever more competitive global economy.

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PARTNERS ($10,000 AND UP)
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Virginia Swigert*
Ruth Taylor*
Vernon Taylor*
Sal J. Valentino
Jules Watson

*Deceased

LIFE MEMBERS

William D. Cammarano
Frank S. Day
Keith Ketelsen
Dr. John L. McLucas
Donald E. Smith

To learn how to participate as a corporate or individual contributor, please contact the United States Space Foundation. We will work together to achieve mutual goals.

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Air Force Space Command
NASA Johnson Space Center - for Moon Rock
NORAD
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SPACE TECHNOLOGY HALL OF FAME DINNER

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TUESDAY EVENING OPENING CEREMONY

Rockwell

RECEPTIONS & LUNCHEONS

Tuesday Opening Reception

HUGHES ELECTRONICS

Wednesday Reception

PRATT & WHITNEY Space Propulsion Operations

Thursday Symposium Luncheon

SPECTRUM ASTRO

Thursday Space Technology Hall of Fame Reception

LOCKHEED MARTIN

REFRESHMENT BREAKS

SPACEPORT SYSTEMS INTERNATIONAL

PRC

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ITT Aerospace/Communications Division

SPACE NEWS

UNITED STATES SPACE FOUNDATION
VOLUNTEERS & STAFF

Volunteers are key to the success of the United States Space Foundation's endeavors. Hundreds of volunteers work with the Foundation throughout the year. Nearly 200 volunteers are assisting in the 12th National Space Symposium. We salute and thank them!

VOLUNTEER COMMITTEE CHAIRMEN

Dave Brescia	*Speaker Response Team*
Keith Calloway	*Transportation Co-Chair*
Diane DeGeer	*Transportation Co-Chair*
Bob Ewell	*Question and Answer*
Dean Feller	*Speaker Response Co-Chair*
Marty France	*Speaker Support Co-Chair*
Rick Hargrave	*Media*
Sheila Lemberger	*Transportation*
Cynthia McKinley	*Speaker Support Co-Chair*
John Neri	*Student Tours*
Jim Rix	*Information Booth*
Pat St. John	*Space Support Forum*
Bret Stoneking	*Security Co-Chair*
Vicki Stoneking	*Security Co-Chair*
Brad Thorne	*Speaker Response Co-Chair*
Frank Wisneski	*Exhibit Support*

STAFF

MANAGEMENT TEAM

Richard P. MacLeod	*President*
Jack Flannery	*Executive Director*
Chuck Zimkas	*Director of Operations & Plans*
Doris Ralston	*Assistant Director of Operations & Plans*
Jerry Brown, Ph.D.	*Director of Education*
Darlina Swartz	*Assistant Director of Education*
Beth Ann Lipskin	*Director of Communications, Marketing & Development*
Holly S. Roberts	*Director of Finance & Business*
Barbara Lauriski	*Space Discovery Store Manager*

STAFF MEMBERS

Carol Butler	*Assistant Space Discovery Store Manager*
Barbara Colclough	*Budget Manager*
Fred Colclough	*Computer Systems Manager*
E. Penryn Flemyng	*Education Program Manager*
Debbie High	*Customer Service Representative*
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Pam Matthews	*Executive Secretary*
Faye Nicholson	*Receptionist*
Jane Rasplicka	*Staff Accountant*
Nicola Sanchez	*Accounting Intern*
Jason Theen	*Education Resource Assistant*
Sarah Tozier	*Administrative Assistant*
Chris Walker	*Communications Intern*
dj Williams	*Volunteer Coordinator/Administrative Specialist*

Opening Ceremony—A Dramatized Montage of Tributes

Moderators:
Dr. Jerry Brown
Director of Education
U.S. Space Foundation

Alla Pfantsch
Russian Instructor
U.S. Air Force Academy

E.P. Flemyng
Education Program Manager
U.S. Space Foundation

Welcome:
Richard P. MacLeod
President
U.S. Space Foundation

Tribute to Apollo 14 & 15:
General James T. Hill, USAF (Ret.)
Chairman of the Board
U.S. Space Foundation

Honoree for Apollo 13 Movie Team:
Captain James A. Lovell, Jr., USN (Ret.)
Commander, Apollo 13
President
Lovell Communications

First Shuttle 15th Anniversary Tribute:
Thomas H. Kennedy
Center Director
L.A. Basin Data Services Center
Rockwell Space Systems Division

Joint Venture in Space:
Dr. Buzz Aldrin
Lunar Module Pilot, Apollo 11

Mission HOME:
Captain James A. Lovell, Jr., USN (Ret.)

Editor's note: The moderators for the opening ceremony (in astronaut suit costumes—one U.S., one Russian) are: cosmonaut Katya (Alla Pfauntsch), and astronaut Roger (Dr. Jerry Brown). Mission Control is an off-stage "big voice" (E. Penryn Flemyng) that helps with announcing and dialogue. An educational skit is performed for the audience that includes a golf cart masquerading as a lunar rover

Roger: Fore!

Katya: Four? Roger, you had at least a six! And the last two holes you had three over par.

Roger: Well Katya, here in America, fore is a golf term, and that means watch out, 'cause my ball's gonna be coming somewhere in your area.

Katya: In Russia, cosmonauts do know how to count and they do not forget how many shots they had on the last two holes.

Roger: Oh, yeah. Well, we're really lucky that Alan Shepard on Apollo 14 taught us how to play golf in space. He was the first man to play golf in outer space. Great interstellar golf!

Katya: Well that may be an American first, Roger, but Russia was the first nation to put a satellite into orbit in 1957. And this week, by the way, is a special anniversary for the space program. Do you remember which one that is, Roger?

Roger: Of course I do. It's the 15th anniversary of America's first Space Shuttle flight.

Katya: Oh, you Americans have such a short view of history, Roger. April 12th is the 35th anniversary of the first man in space. Yuri Gagarin, a Russian, made that historic mission.

Roger: You're right, Katya, and when we stop to think about it, that wasn't all that long ago. As they say in America, we've come a long way, baby.

Katya: Hey! Mission Control, who are all these people and why are they listening to us? Are they cleared?

Mission Control: Well, Travolta One, you have strayed off course a bit (no pun intended) and you've ended up at one of America's finest golf resorts. But in America, we tend to mix business with pleasure—which you and Roger seem to have caught onto very well—and here tonight, is the opening ceremony for the 12th National Space Symposium. These people are among the world's leaders in space and have gathered to discuss the important issues of our future in space. It might be something you two would be interested in.

Katya: That sounds pretty heavy! But, who's in charge of all that? In Russia, always there is someone in charge.

Mission Control: The United States Space Foundation is sponsoring this program, and all the key participants from government and industry are represented. This year is extra special because we also have the United Nations Conference on Space Technology Spinoff Benefits, with representatives from countries around the world here with us.

Roger: Hmmm. That sounds even more impressive. Mission Control, who is this United States Space Foundation? Do you have something that can tell us about them?

Mission Control: Roger, Roger. Here is a short video to do just that.

Editor's note: The video, Promise of Space, *is shown. Following are quotes and a narration from that video:*

"Space encompasses everything that you think about."

"Space is just such an exciting topic."

"NASA can be so professional in the way it does its business that it makes the exciting mundane. We're trying to make it exciting again for the American people."

The United States Space Foundation was founded in 1983 with the goal of promoting national awareness and support for space endeavors. Most of the people in America today don't wake up thinking about space. That wasn't true 25 or 30 years ago.

"As a child I was enraptured with the Mercury, Gemini and Apollo missions, and assumed everybody else carried that level of excitement."

"I think we need to work on the next generation."

To reach the next generation, the U.S. Space Foundation reached out to America's teachers with an innovative, one week course.

"My kids love space."

"More than 5,000 teachers have been through our training program."

"So the questions that I was thinking about and learned about the answers to in "Getting Comfortable Teaching With Space, I was able to bring to the students."

"How do you get into space? Can we live in space? Would you like to go to space when you grow up? How do you think you'll get there? And it starts them thinking about those ideas."

"Kids need role models. Astronauts are great role models. They're real heroes and heroines. They risk their lives for what they believe in."

"This is where it starts. Their creative ideas that start now will grow."

"When you've got excited teachers and excited kids, you get excited parents. It works."

Many people don't know much about space beyond Neil Armstrong landing on the moon. So the U.S. Space Foundation opened a space store to reach out to the public. Here people can learn about spinoffs, technologies that were developed for use in space and adapted for use here on Earth.

"Cordless drills originally were designed by the Black and Decker Company for use on the moon. What we wanted to do was drill down through the moon's soil, but we didn't have any electric lines running across the surface of the moon. So what they did was put batteries in these drills and use them on the moon."

"The American people experience everyday tremendous benefits from the space program and most don't even know about it."

"If you look at medical science, for example, one of the main spinoffs that has recently come about is the cool suits. Cool suit garments which were designed

to keep the astronauts cool in the high heat space environment are now being adapted down here on Earth for individuals with multiple sclerosis, for individuals who work in high heat environment like firefighters."

"Spinoffs have far exceeded what NASA thought they would originally do."

"The best example of using space for national security recently was the Gulf War. It was one of the most intense wars we've had in this half century, and it was decisive and it was space that made it possible."

Space technology spinoffs have reached every corner of the globe and now the U.S. Space Foundation reaches space professionals around the world.

"Conquering the final frontier is drawing experts from the space industry to Colorado Springs."

"The National Space Symposium has become the mecca for the professionals in space throughout the world."

"Our annual National Space Symposium is a Who's Who in space. The top people are there. They're speaking, they're accessible, you can come and hear the latest thinking, the latest controversies."

"The visionary people who started the Space Foundation believed that the American people had to know more about their own program."

"The U.S. Space Foundation is about excitement, it's about realism. It's about what really happens in our daily lives."

"I think space opens for us a huge vista of energy and resources, and it allows mankind to do what mankind does best, which is to explore the unknown. That's why we should be looking toward the future in space. Space is our future."

Katya: Wow! That was pretty good. In Russia, we also believe space is our future. You know, maybe we need a space foundation over there to bring all these people together to play golf.

Roger: Katya, I think you missed the point. They are here to mix business with pleasure, not to mix pleasure with business or pleasure with golf. Anyway, you'd think this United States Space Foundation would have somebody here to tell us about who they are and what they do, wouldn't you?

Katya: Yeah. Mission Control, what about that?

Mission Control: Roger, Roger—and Katya. Ladies and gentlemen, the president of the United States Space Foundation, Mr. Richard P. MacLeod.

Mr. MacLeod: Thank you, Mission Control, and good evening, ladies and gentlemen. On behalf of our distinguished board of directors and our staff and many volunteers, welcome to the 12th National Space Symposium. It's called "Space: Enhancing Life on Earth." That's our theme of this year's symposium. International cooperation is the underlying principle. As exemplified by our dynamic duo of cosmonaut and astronaut who are moderating this evening, space has become more than ever, a global endeavor. It is truly an international pursuit.

As Neil Armstrong said when he made that first step onto the moon, "It's a giant leap for mankind." Space indeed holds the future for all of humankind and now, nearly 40 years after that first Sputnik, we are at the threshold of some marvelous adventures in space. And the most exciting part is that we have made this transition from the early days of the great space race between competing superpowers, to international cooperation so more resources are focused in a truly global effort.

On that note, I would like especially to welcome our United Nations Conference participants and other international guests here tonight. With a special welcome to the conference host, Dr. Adigun Ade Abiodun of the United Nations' Office of Outer Space in Vienna. We're also honored to have with us U.S. Representative Douglas Peterson from Florida.

A special welcome to our Colorado Springs community guests. The support for the Foundation locally is important and we offer this evening as a small token of our appreciation.

I'd like to recognize now, Lt. Gen. Paul Stein, superintendent of the U.S. Air Force Academy, and his wife, Carol.

Reflecting the community support that we have, and perhaps representative of a great spirit, I'd like to give special recognition now to Mr. John Thorpe, chairman of Analytical Surveys Inc., and his wife, Rosemary. They established a charitable remainder trust to equally benefit three universities and the United States Space Foundation. This is a great example of the tangible financial support as well as the moral support we receive from our community and which we prize. We hope that others will follow their example.

Of course, the participants of the symposium are what this is all about, so a warm welcome to all of you. We have an impressive line-up of sessions with the leading space decision-makers from around the world. They're here to challenge your preconceptions over the next few days. And with all the available space sold out last September, the exhibits this year are bigger and better than ever. You can see them during the reception following this program.

The U.S. Space Foundation is fortunate to have a truly distinguished board of directors, many of whom are here tonight. They give their time and finance their own travel to come and help us with their own thoughts and with their introductions to others. To each of you, our directors, thank you for everything that you continue to do and will do in the future.

Finally, America indeed needs real heroes rather than just sports figures and movie stars. Kids need role models. Kids and adults need examples of courage and dedication.

Finally, America indeed needs real heroes rather than just sports figures and movie stars. Kids need role models. Kids and adults need examples of courage and dedication. History is full of examples of heroes who have influenced the outcome of world events. Well, we have some of those people here tonight—our American astronauts. A warm welcome to all of you. They will be introduced to you tonight in the course of the program.

With that, Mission Control, over to you.

Mission Control: Roger, Roger. Katya, Mission Control. Dick mentioned the early days of the space program and the race to the moon. In keeping with the symposium tradition of recognizing the anniversaries of those milestones in space history, we have some of the family members of the Apollo 14 and 15 missions here tonight. Would you and Roger please escort them onto the stage?

Katya: Roger, Mission Control. Perhaps you could show this very distinguished audience a brief summary of those exciting times.

Editor's note: At this point a video of the Apollo 14 and 15 missions is shown with Mission Control narrating. Following is that narration.

Mission Control: Well Katya, Apollo 14 launched in January 1971 as the fifth American mission to the moon, with Alan Shepard, Stuart Roosa, and Ed Mitchell. It made the third landing on the moon in the Fra Maro Highlands, the intended destination of Apollo 13. Everyone remembers Alan Shepard's golf swing in which he tried to set a record for the longest drive. In fact, he only had a 20-yard drive.

Then Apollo 15 departed for the moon in July 1971 with Dave Scott, Al Worden and Jim Irwin. Jim Irwin and Dave Scott landed at Hadley Rille and were the first two to drive the Lunar Rover around the surface.

Roger: It's hard to believe that was just 25 years ago. Mission Control, Roger here, do we have anything to help these people remember this fine mission and commemorative event?

Mission Control: Roger, Roger. Ladies and gentlemen, the chairman of the board of the United States Space Foundation, General James E. Hill, USAF, (Ret).

Gen. Hill: Good evening, ladies and gentlemen. Let me add my warm welcome to all of you and reinforce what Dick has already said about the exciting program we have lined up for you this week.

But as we deal with contemporary space issues and debate how best to meet the challenges of the future, it is important to pause and remember those upon whose shoulders we are building our future in space.

The great space race of the 60s and 70s was exciting. It was thrilling. It was adventurous. And it was dangerous and costly. We owe a great debt of gratitude to those who ran that race and to the people who supported them—especially their families.

Tonight, although the Apollo 14 and 15 astronauts themselves could not be here, some family members are. I am proud to present them with the U.S. Space Foundation commemorative trophies for their courage and true dedication to the ideals of our space program. The others will receive their mementos later. Joan Roussa, wife of Stuart Roussa and her daughter, Rosemary.

Mrs. Roussa: Thank you. On behalf of my late husband, who thought there was nothing more important than the exploration of space and was so pleased to be a part of it, I thank you.

Rosemary Roussa: It's a pleasure for us to be here tonight and honor my father on the Apollo 14 twenty-fifth anniversary. We're glad that we can represent him here tonight. Thank you.

Gen. Hill: And Joe Irwin, Jim Irwin's son.

Katya: That was really pretty good. You know, you Americans are really into celebration and recognition. But the 60s and 70s were pretty exciting times for us as well. Something about competition gets people stirred up—right Comrade General?

Gen. Hill: That's right, Katya. But you know, public awareness is important even when we aren't in a fierce competition. The public should know what's going on in space today just as much as they did back then.

The U.S. Space Foundation encourages that in several ways, one of which is through the Douglas S. Morrow Public Outreach Award. This annual award, created in the memory of one our late directors, is presented to the people and organizations that have made a significant contribution to increasing the public awareness of space. This year's award is being presented to the Apollo 13 movie team.

Not since the heydays of the 60s and 70s has such enthusiasm for space been generated as with the remarkable film directed by Ron Howard and starring Tom Hanks. The film epitomizes the spirit of the space race and the character of the men and women who dedicated their lives to its success. It shows the teamwork and resourcefulness that is present even today as we cooperatively pursue each greater space achievement.

Here is a reminder of the film I am sure you all have enjoyed this past year.

Editor's note: A short clip of the Apollo 13 *movie is shown at this time.*

Here tonight to accept the award on behalf of Universal Studios, Imagine Entertainment, NASA, and the entire team is Apollo 13 Commander, Navy Capt. Jim Lovell.

Jim, you and the *Apollo 13* movie team brought America's space awareness to new levels with that marvelous film. More than that, the film's message reminded America of its greatness and reinforced its leadership role in this rapidly changing world.

We all need to be reminded regularly of who we are and where we are headed, lest we become too engrossed in the day-to-day matters and, as a society, lose sight of the important role space plays in our future.

On behalf of the United States Space Foundation, please accept this recognition of the extraordinary contributions you, Imagine Entertainment, Universal, and NASA made to the cause of space awareness.

Capt. Lovell: Thank you Jim Hill. I agree, the *Apollo 13* movie was successful beyond my wildest dreams. When Jeffrey Kluger and I decided to write the book, it was to keep a commitment to Jack Swigert. As many of you know, the U.S. Space Foundation was originally dedicated to Jack's memory. Then, when Imagine Entertainment decided to make a film from the book, of course we really got excited.

Only master storyteller Ron Howard could bring the story to life and recreate the drama as it really happened. And I don't know anyone that could have put more heart into being a young Jim Lovell than Tom Hanks. The thrill of working with those two—and all the others, too—rivaled the actual mission many years ago.

Of course, neither the mission nor the movie would have been possible without NASA and all the professionals who continue to dedicate their professional careers to the important business of keeping America moving in space. We are indeed fortunate to have that kind of leadership and drive as part of our American heritage.

On behalf of all those I just mentioned, thank you very much.

Not since the heydays of the 60s and 70s has such enthusiasm for space been generated as with the remarkable film directed by Ron Howard and starring Tom Hanks. The film epitomizes the spirit of the space race and the character of the men and women who dedicated their lives to its success.

Mission Control: Katya, Mission Control.

Katya: Roger, Mission Control, go ahead.

Mission Control: We Americans do seem to view that Apollo era as the heyday of the space program. What was Russia thinking at the time?

Katya: Well, we of course had planned to be the first on the moon. But then, we refocused our efforts to much longer-term experience, learning how to live and work in space. Our Soyuz spacecraft was very much like your Apollo module. And we were perfecting our automatic docking capabilities in space.

Roger: It was only a little over 20 years ago that

America and Russia accomplished the historic first handshake in space. Yeah, I remember it was Tom Stafford, Vance Brand and Deke Slayton, and they were in an Apollo capsule with a Soyuz spacecraft docking up there in orbit. But in those days neither country really had much trust in the other one.

Katya: And it would be years later before true cooperation happened.

Roger: Well, while the Russians were concentrating on living and working in space with their cosmonauts in their space station, we were really working on a reusable space vehicle. America focused on this space vehicle which we now call the shuttle. But as with most pioneering efforts, it took until 1981 before John Young and Bob Crippen could actually get that shuttle into space—Columbia—and it was a marvelous machine.

Mission Control, do we have anything to remind this fine group of people about the excitement that mission caused?

We are living in very exciting times for space exploration. Not just because we are becoming more capable in getting there, but rather because we are no longer competing in non-productive ways, we are now cooperating on an international level better than ever before.

Mission Control: Roger, Roger. House lights are coming down.

Editor's note: A video clip on the 15th anniversary of the first shuttle flight is shown.

Mission Control: Ladies and gentlemen, from Rockwell Space Systems Division, Mr. Tom Kennedy.

Mr. Kennedy: It's hard to imagine but it's true. That first shuttle flight took place 15 years ago this coming Friday—and what a thrill it was.

In the 1970s our national space interest had shifted from space exploration to space use, and the translation of technology into practical products and services.

To do this new job, NASA needed a new vehicle—one that could fly over and over and carry working crews and tons of cargo into Earth orbit. Reusability, versatility, reliability, and efficiency were the requirements. Space Shuttle was the answer.

The Rockwell team was given the major task of producing a new breed of spacecraft for the nation. We developed and built the six shuttle orbiters and main engines, but that's only the beginning of our contributions. We also helped NASA integrate the shuttle system, maintain the technical integrity and configuration, meet the logistics requirements and provide operations support for the shuttle fleet.

The 76 shuttle missions since April 12, 1981, attest to Rockwell's unique role in America's space triumphs as the premier supplier of space systems and services which have substantially advanced the frontiers of space.

And now, Dick will you please join me on the stage?

In commemoration of this 15-year milestone, Rockwell is pleased to present to the United States Space Foundation this 1:50 scale model of America's Space Shuttle to use in advancing its important mission of promoting national awareness and support for America's space endeavors.

Editor's note: The shuttle model is unveiled at this time.

Mr. MacLeod: Thank you, Tom. Rockwell has been a key partner in America's space effort and we appreciate all the great support you've given the U.S. Space Foundation over the years. We will certainly put this newest contribution to good use.

Katya: Wow! I thought the Russians spent a lot of time looking back at the past. Do you spend lots of time looking into today and the future? After all, that's where we're all going to spend the rest of our lives.

Roger: That's right, Katya, but remembering the past is important to doing the future right. And this has been sort of setting the stage for what I understand Mission Control has in store for us next.

We are living in very exciting times for space exploration. Not just because we are becoming more capable in getting there, but rather because we are no longer competing in non-productive ways, we are now cooperating on an international level better than ever before.

Mission Control, are you still there?

Mission Control: Roger, Roger.

Roger: Can you pull up another video and inform the folks what I'm talking about?

Mission Control: Roger, here's another video.

Editor's note: At this time a video, "Joint Venture in Space" is presented. Following is the narration from that video.

These groups of engineers are more than 8,000 miles apart, working together on the same problems, to devise and build a docking system that will join America's Space Shuttle Atlantis to the Russian Space Shuttle, MIR, in an historic series of missions that have already begun.

A rendezvous and docking in space has all the elements of a graceful ballet, until you consider the size and weight of the dancers and their fragility in this hostile environment. Current plans for Russian and American cooperation in space are long term. This time, the rendevous and docking of Atlantis and MIR will join Russia and the United States in the greatest international joint venture of all time. Multiple space missions between American shuttles and the MIR Space Station that will lead to construction of the International Space Station, with partners from a number of nations around the world. And this time, Bruce Brandt and Vladimir Syromiatnikov are working together again to design and build the vital docking system. Brandt as chief engineer of the Oribter Docking Module for Rockwell, the U.S. contractor, and Syromiatnikov as chief of large deployable space structures and electromechanical systems for the Russian RSC., Energia, a sub-contractor to Rockwell.

Perfecting such a sophisticated device across half the world has not been easy. Both the shuttle and MIR are equipped with the Russian designed system. Development testing of dynamic performance led to modifications for damping, to accommodate the large masses of the orbiter and the MIR. Mechanical cycling and loadings revealed several problems that resulted in redesign, and the system electrical integration required changes so that existing U.S. and Russian hardware could be compatible.

The Space Shuttle commander must align the shuttle docking mechanism with that of the MIR, maneuvering the massive shuttle with its thrusters and using this docking target as his guide. The mechanism is in the ready-to-dock position. As the shuttle approaches the MIR, thrusters on the shuttle accelerate the big craft to bring the docking quarts into contact at the final moment. Hundreds of hours of simulation and tests by both American and Russian engineers and technicians are helping guarantee mission success and to bridge the huge separations of time, distance and language.

There are no boundaries in space, and from space no boundaries visible on Earth. Russian and American spacecraft will meet in friendship and cooperation in this joint venture in space.

Mission Control: Ladies and gentlemen, one of the first two men to walk on the moon, Astronaut Buzz Aldrin.

Dr. Aldrin: Thank you, Mission Control. Good evening, everyone. We've spent some time looking back at our brief history in space tonight and as our good friend, Roger the astronaut, here said a few minutes ago, that's important to doing the future right. That video did a marvelous job of demonstrating how we are indeed learning from the past and doing better in the future. International cooperation is how our human species is going to advance in space. And I couldn't be happier to see America's finest up there docked with the MIR Space Station working and learning together. As most of you know, Colorado Springs' own Ron Sega and his wife Bonnie Dunbar have both visited MIR in this last year. Ron just returned from his last mission there a week ago Saturday. He really tried to be here tonight but his debriefing schedule just wouldn't allow that. And Bonnie was here—I talked to her earlier today—but she's now en route back to Houston for an early work call tomorrow morning.

A rendezvous and docking in space has all the elements of a graceful ballet, until you consider the size and weight of the dancers and their fragility in this hostile environment.

On their behalf, and really I think I speak for all the astronauts, current and of my generation, let me say what a marvelous thing it is to see Russia and the United States cooperating today, rather than competing as we did in the past. I can't stress enough the importance of our continued pursuit of space accomplishments as a human species.

And no event does it better than this National Space Symposium. The theme, Enhancing Life on Earth, and the international flavor this year, particularly with the United Nations Conference integrated into the program, is what it's all about. And I must commend the United States Space Foundation for its great work in pulling it all together. Working together toward a brighter future is what it's all about. Not just for the fortunate few like Ron Sega, Bonnie Dunbar, Jim Lovell and me, and, of course, Katya and Roger, but as nations of this global village so that someday the human species will have a much better life. As the theme of this symposium puts it so well, space is enhancing life here on Earth. And our living and working there is what will continue to make life better and better. It's a pleasure and a privilege for me to be here tonight, and I'm looking forward to the next few days of discussions. Thank you very much.

Katya: That was just beautiful! I couldn't have said it better. I couldn't have said it at all just a few years ago because our countries didn't have the openness and interest in cooperation, right?

In any case, it's such a shame more people don't have an opportunity to hear and understand how important it is for us—for all of us to work together and push the boundaries of technology. If there were only a way to get the story to more people . . .

Yes, Apollo 13 brought three astronauts home safely. But for average Americans, what does the space program today bring home to *their* families, to *their* world? What promotes *their* values?

Capt. Lovell: Well, Katya, There is a program designed to do just that. Planning for it was initiated by the United States Space Foundation here at this very symposium last year. An alliance, including the U. S. Space Foundation, the National Space Society and 16 of the leading aerospace companies, is implementing this program through an international professional communications firm, Fleishman-Hillard. I am the chairman of this new multi-year program called Mission HOME—Harvesting Opportunities for Mother Earth— and we just had the kick-off event starting this program at the Air and Space Museum in Washington, D.C., two weeks ago.

Katya: That sounds wonderful. Can you tell us more about that?

Capt. Lovell: I'm glad you asked. America's space community—civilian, military, commercial—has committed itself to a new, multi-year program of appreciation and support called Mission HOME. As an astronaut who had some pretty exciting times up there, I know the American public finds the space program very exciting. But after a shuttle launch, or a dramatic new discovery by the Hubble Telescope—or even after a couple of white knuckle hours watching *Apollo 13*—for most Americans it's back to the real world, their jobs, and their hectic day-to-day lives.

Yes, Apollo 13 brought three astronauts home safely. But for average Americans, what does the space program today bring home to *their* families, to *their* world? What promotes *their* values?

Those of us in the space community, know the answers. We know that every dollar spent in this day of strict priorities and stricter budgets returns much more to our lives and to our society. But do others know that? Have we made ourselves clear? Have we demonstrated our value well enough to earn the support we deserve? We owe it to ourselves and the public to be sure the answer to those questions is a resounding "yes."

This program is a challenge to all of us. It is our call to action. Space is critical to our future. Our challenge is to show that however far we reach, however distant the frontiers we cross, the mission of the U.S. space community can be found right here at home. Every mission outward is a mission home.

Bringing home a richer, better, safer, healthier, more secure life. Predicting local weather. Assuring national security. Providing news from around the world and supporting business transactions between global markets. Hastening advances in medicine and technology. These are the everyday dividends of space.

However, now more than ever . . . the space community must prove its value to a skeptical American public, distracted by competing priorities and accustomed to the miracles of space. Only by engaging in a national dialogue can our mission succeed.

That is what Mission HOME intends to do—to take space to the American people—to build understanding, enthusiasm and support for our U.S. space efforts. Our goal is not only to teach Americans about space, but to learn from them how space endeavors can do a better job of increasing human knowledge and improving life on Earth.

As chairman of the Mission HOME program, I am confident that we will be able to earn America's support as we move into the 21st century. And we will have a lot of help in this cause. We are in the process of assembling an advisory board that represents a true cross section of America from all walks of life—medicine, sports, business, education, science, politics, defense, and entertainment. And I plan to work with this group to achieve three key goals.

First, to inform Americans of the many ways space improves our lives here on Earth.

Second, to rekindle the excitement of discovery and the desire to push back the edge of our knowledge.

Third, through the town halls and other public dialogues, to give the American public more input into the programs and goals of the space community.

If America backs away from space, in any way, we will pay a high price. We will cede leadership to others in perhaps the No. 1 can't-miss growth industry of the 21st century. We will jeopardize our ability to protect U.S. priorities in the new world order. Space is the greatest bridge to a peaceful world that we will ever know. Space technology—and its potential to improve human life—is the Peace Corps of the 21st century. It is perhaps the most valuable tool America has to offer developing nations. And we should do that.

The teachers of this nation have found that space is a great educational tool. Their programs are not designed simply to make future astronauts or space scientists, but to take advantage of the natural fascination that kids have for space. If we don't use space effectively at home, we will deny ourselves a vast opportunity that is improving life in many, many ways here on Earth. But perhaps most important of all, we will back away from the single biggest challenge of all time—the ultimate quest to take humankind far beyond our planet. We cannot default on our pioneer legacy—we must continue to lead the quest for knowledge that defines humankind.

And, with this Mission HOME program, we are taking specific steps to ensure that space endeavors remain an integral part of the American experience.

Now here's a short video that captures the flavor of this exciting new program—Mission HOME. Mission Control, can you run that last video clip here for us, please?

Mission Control: Roger, Jim. Here it comes.

Editor's note: The Mission HOME video is shown at this time with quotes from John F. Kennedy, Ronald Reagan, newsmen and astronauts, plus newsclips from various launches.

Capt. Lovell: To conclude this evening's opening ceremony, we want to have a little fun. When I travel around the country talking with the American people, I have found that space is still fun and is very exciting. And when we did the kick-off event at the Air and Space Museum a couple of weeks ago, we had some fun with a countdown. A group of school children were on hand to help.

Mission Control, since kids represent our future, can you help me get a group of them out here to assist me with a countdown?

Mission Control: There is nothing Mission Control wouldn't do for you, Jim. You know that from personal experience, don't you? OK, kids, let's get on out here and help Capt. Lovell with his latest requirement.

Editor's note: At this point group of children form Foothills Elementary School in Colorado Springs surround Jim, Roger, and Katya at center stage.

Roger: This is our future—kids, children of all ages, from all countries. This is the future looking at you and we hope for them a better life just as your parents have worked for a better life for you.

Capt. Lovell: OK, kids. You ready for the countdown?

Mission Control: Jim, shouldn't everyone join in on this one?

Capt. Lovell: Absolutely. Why don't we start with one of my personal heroes, one of America's first moon walkers. Buzz, why don't you come up here?

Katya: And Gen. Jim Hill, the chairman of the U.S. Space Foundation. General, come up here.

Roger: And Mr. Dick MacLeod, president of the United States Space Foundation.

If we don't use space effectively at home, we will deny ourselves a vast opportunity that is improving life in many, many ways here on Earth.

Mission Control: The families of the Apollo 14 and 15 missions.

Katya: Mr. Tom Kennedy from Rockwell Space Systems Division.

Capt. Lovell: Mission Control, as chairman of the new Mission HOME campaign, I'd like to ask you to initiate the countdown to "Take Up Space."

Mission Control: Roger, Jim. Ladies and gentlemen, boys and girls, please join astronaut Jim Lovell and all his colleagues on stage with him in a countdown to "Take Up Space." Ready? Ten, nine, eight, seven, six, five, four, three, two, one, zero—take up space!

Editor's note: A slide saying "Take Up Space" on screen flashes as the countdown finishes.

Mission Control: Uh, oh! Colorado Springs, we have a problem. All personnel must immediately evacuate the stage area. I say again, all personnel must immediately evacuate the stage area. And everyone remain calm and remain in your seats. We have just received notice of an alien spacecraft making an approach to the stage landing site.

Editor's note: A spacecraft (Hystar) appears from the back of the room and flies to center stage where it is *engulfed in smoke and light.*

Mission Control: Uh, Roger, Katya. We are receiving signals that they want you to join them on some galactic links to improve their understanding of this strange earthly activity called golf.

Editor's note: The moderators "board" the spacecraft.

Mission Control: Ladies and gentlemen, boys and girls, We need one more countdown to launch this craft with our two wonderful moderators, Roger and Katya, to Take Up Space please. Ten, nine, eight, seven, six, five, four, three, two, one, zero.

Mission Control: Ladies and gentlemen, that concludes the opening ceremony for the 12th National Space Symposium. Thanks to all of you for joining us here tonight. Thanks to some of America's true heroes for taking part in our tribute to this country's achievements in space. And especially thanks to Rockwell for co-sponsoring the opening to make it possible to give meaningful tribute to those we honored tonight.

Now please join us next door at Colorado Hall for a reception among the latest aerospace exhibits on display.

Using Space to Enhance Life on Earth

Opening Remarks: **Steven P. Scott**
Program Development Manager
Rockwell Space Systems Division

Introduction: **Richard P. MacLeod**
President
U.S. Space Foundation

Keynote Address: **Dr. Krishnaswamy Kasturirangan**
Chairman
Government of India, Department of Space,
Indian Space Research Organization

Mr. Scott: Good morning. On behalf of the United States Space Foundation and all of our sponsors, welcome to the 12th National Space Symposium. I'm Steven Scott from Rockwell Space Systems Division, and I'll be your program moderator over the next three days as we explore this year's exciting theme of "Space: Enhancing Life on Earth." The Foundation would like to thank our sponsors for last night's activities, Rockwell for the opening ceremony, and Hughes for co-sponsoring the reception. But first, a message from one of our sponsors.

Editor's note: A video on Rockwell's space related industry is shown.

Mr. Scott: Thank you. Now let's take a quick look at what's in store for us for the rest of the week. This morning, in our keynote address and first session, we'll take a macro look at space applications. This afternoon we'll take a more detailed look at Earth sensing, communication and navigation applications, followed by a very interesting session on why it's important to reinvigorate the space industry with "better, cheaper, faster" methodologies. Our reception this evening will be co-sponsored by United Technologies and the Space Foundation.

Going onto tomorrow's agenda, Gen. Joseph Ashy has assembled a number of key Department of Defense leaders who will guide us through discussion of global security interests in space. For lunch our featured speaker is NASA Administrator Dan Goldin, who no doubt will have some provocative insight on the future of the U.S. civil space program. The afternoon session will start off with a look at the International Space Station, as well as some space launch capability issues. The evening reception will be sponsored by Lockheed Martin, as well as the U.S. Space Foundation. Then we have the Space Technology Hall of Fame dinner and induction ceremony, where the address will be made by the distinguished chairman of TRW, Joe Gorman. Capping off our session on Friday we have presentations by Lionel Johns, better known as "Skip," and Sen. Jake Garn. We will also be recording a radio-TV program called "Tech Nation," hosted by Dr. Moira Gunn.

Before we begin, let me open with this thought. In the early '60s there was a cartoon family that epitomized the theme of this conference, which is "Space: Enhancing Life on Earth." For this family, space and everything associated with it was mundane. They had conquered the final frontier. People lived and worked in orbital stations, honeymooners went to Venus instead of the Poconos. The family I'm talking about of course is the Jetsons. For a generation the Jetsons helped shaped America's views of space and what life would be like in the 21st century. Computers, communications robotics and access to space would clearly play a dominant role in our day-to-day existence. As we now look back over the last 30 years, we can chart our progress. We've made unbelievable strides in computer technology, satellite communications, and robotics, but easy access to space is still slightly beyond our reach. Maybe our early visions of space were too grandiose, but with the accomplishments of Apollo, the nation believed anything was possible. These cartoon characters may seem fictitious, but they helped form our early visions and thoughts. And that's exactly what we're doing here—helping to shape a vision, looking ahead. Over the next three days, we'll take a realistic look at what we're doing in space today as we work to constantly reshape our vision of the future. With that, let us begin the 12th National Space Symposium. Here to introduce the keynote speaker is the president of the United States Space Foundation. Ladies and gentlemen, please welcome Dick MacLeod.

Mr. MacLeod: Thank you. Our first speaker today is Dr. Kasturirangan. For simplicity I will call him Dr. Rangan. He will expand on the conference theme in his keynote address. He's currently the chairman of the Indian Space Research Organization, chairman of the Space Commission of India, and secretary of the Department of Space of the Government of India. Dr. Rangan is a well known space scientist and technologist of international repute. He has led the Indian Space Program through a series of successful launches. These include four communications satellites, five remote sensing satellites, and a scientific satellite. The latest being the successful launch of IRSP3 aboard the

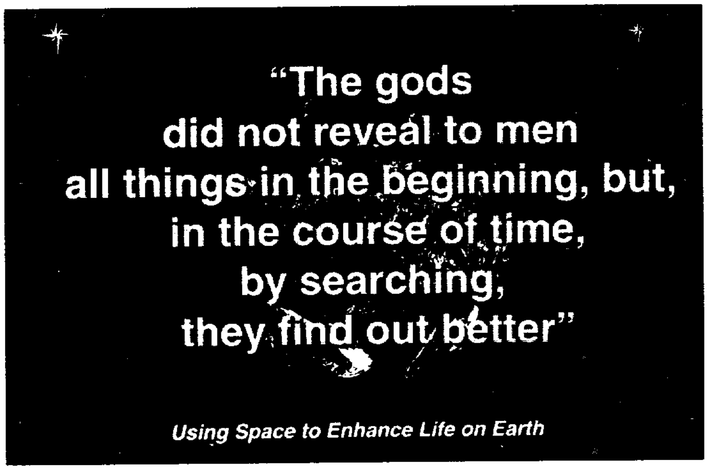

Fig. US-101

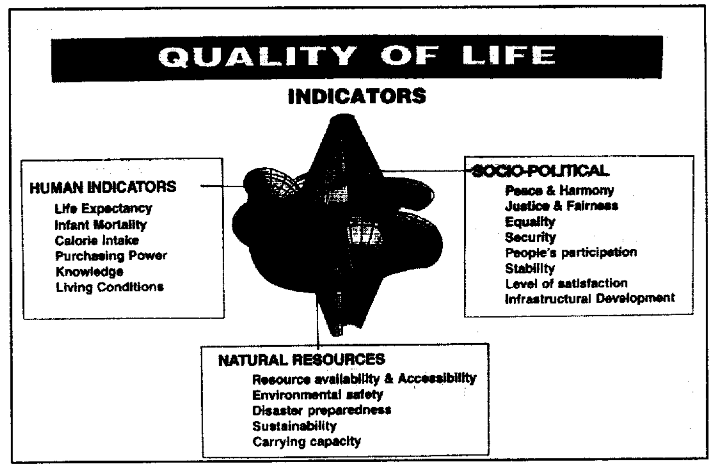

Fig. US-102

Indian polar satellite launch vehicle. As a gifted leader, he has placed a strong emphasis on orienting the Indian Space Program towards socio-economic development of his country, making it a model for developing nations. When I visited last September, we talked exactly about that, the fact that they have representatives from every department of their government in their own agency, and vice versa. They work hard at applications, enhancing life on Earth. Dr. Rangan.

Dr. Kasturirangan: Thank you, Dick, for the kind introduction. Mr. Aldridge, Dr. Silvestrini, Mr. Minor, Mr. Gianelli, Mr. Takada, distinguished members of the audience, ladies and gentlemen, I believe it is my proud privilege to be invited to the U. S. Space Foundation to address this very distinguished gathering today as the keynote speaker. I would like to express, using this opportunity, my gratitude to the U.S. Space Foundation and the other co-sponsors of this meeting, and in particular, Dick, for giving me this opportunity.

The theme for this talk, "Using Space to Enhance the Life on Earth," is certainly timely. Something which is of concern, and we need to really emphasize this aspect of the concern, as well as the strategies and directions one should look for to deal with this issue of enhancing the quality of life on Earth, in the context of several emerging technologies.

Man, whose ancestry could be traced across the whole geological era into a creature not greater than the diminutive rat, and whose intellectual powers began to be strikingly prophetic only during the last ice age, deserves the generic title he has given to himself, "the homo sapien"— man-the-wise. While primitive man was happy when his basic needs were taken care of, using what was available in nature, the increasing demand on natural resources along with the instinct to improve the quality of life forced man to use his intelligence and skill. Quests for scientific exploration followed; important discoveries were made. The use of science and technology for improving the quality of life became a pattern. In the 20th century, one of the greatest and most significant acts of humans has been the use of space in this context, not only for scientific exploration, but also for such other areas like meteorology and weather systems, extracting information on other sources, improving human connectivity, and so on and so forth. It is in this context that we look at what we are doing currently, particularly in the case of developing countries. We have adopted these techniques for ensuring national development. I could not do more, at this stage, to do justice to this aspect of aspiration than to quote from the observations of Xenophanes, who made this statement 2,500 years ago: "The gods did not reveal to man all things in the beginning, but in the course of time, by searching, they find out better *[Fig. US-101]*." So that is the constant drive to Earth's improving the quality of life. And in that case, then we should really look at: what is the quality of life? The quality of life, of course, in a different era and a different context assumes a different meaning. It can be as varied as an individual and a society, or as complex as the human body itself. What we'll try to do here is to bring out some aspects of this *[Fig. US-102]*. In fact, for the primitive man, the quality of life was nothing but meeting his basic needs. The standards of measurement of the societal well-being, as well as means of improving the quality of life, has undergone dramatic changes with time. A look at the global scenario brings this aspect—the variation and the quality of life due to varied reasons, ranging from cultural and socio-political factors, to environment and technological considerations. That's what we tried to put in this particular slide, the human indicators that would define the quality of life, some of the social aspects, the natural resources aspect, things like the life expectancy or the infant mortality, the living conditions, or in the case of natural resources, the resource management, the environmental implications, disaster preparedness, and when it comes to socio-political aspects, peace and tranquility and infrastructure and so many other aspects. We have tried to put together here a kind of scenario which puts the quality of life and the perspective which most of the people would accept as possible indicators.

Taking from this, what kind of challenges today does humankind face? We go through a set of challenges that humankind is facing, the context of which we will look into many of the aspects of the space techniques today. The first in that series of challenges deals with the human population. The world population, as we all know, doubled from 2 billion to 5 billion in the 1950 to 1987 time frame. It is expected to reach 6.4 billion by the end of this century. What is interesting is the fact that the 300 million population in the beginning of the 1st century would have increased 21 fold by the time we enter the 21st century, and half of it will turn out to be in the urban areas. Apart from the increase in numbers, the proper development of this human resource is a major issue. In developing countries, on an average, student enrollment is less than 70 percent, and only 50 percent of them reach the secondary level. The percentage of students who reach the tertiary level is hardly 6 percent of the primary enrollment. Added to these are the poor student-teacher ratio and the low investment in education. While UNESCO recommends 4 percent of GNP as educational expenditure, in reality it varies from 0.5 to 12 percent. The fact that the population in 2000 AD will consist of 2.5 billion children in the age group of 5 - 24, calls for the adoption of modern technologies such as space based distance education to realize the goal of universal education.

While concentrating on formal education to the children, we need to recognize the need for informal education to other sectors too, particularly women. There are a number of examples where women's education has brought tremendous improvements. For example, in an assessment that has been made with respect to Brazil, the uneducated women have something like 6.5 children each, whereas women with secondary education have only 2.5 children. Similarly, in Liberia, it was found that women with secondary education are 10 times more likely to use family planning services. In another study among Kenyan women, it was observed that education of farmer women could increase agricultural production by 24 percent. Thus, informal education is an important element in our struggle towards enhancing the quality of life.

Let us take the resource consumption scenario, again coming out of the population increase. One can see that the ground water withdrawal increased almost 36 times in the period 1800 - 1990, whereas sediment load in the major and small river basins went up by 3 and 8 times respectively around the same period. Then we have degraded land, which increased 3 times from 1700 - 1990. During the last 90 years, industrial production was increased by 100 times, whereas the forest cover got reduced by 15

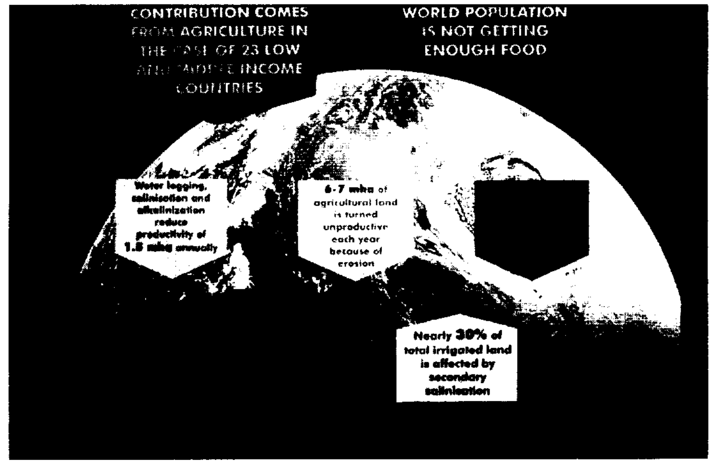

Fig. US-103

percent. Accordingly, there was considerable increase in methane and CO_2 emission. These statistics depict only a glimpse of the adverse impact of resource consumption on the environment and ecology. This is another major problem that faces humankind today in the context of the increasing population.

On the dependence of mankind on the land resources, no explanation is required *[Fig. US-103]*. On the one hand, 19 percent of the world's population is not getting enough food. On the other side, we have 30 to 50 percent of the GDP which is totally accounted for in terms of agriculture in many of the developing countries. What is more significant is the fact that continued use of land with poor agricultural practices, like the use of fertilizers, and improper irrigation systems, and so on, have resulted in considerable land degradation. It is significant to note that something like 1.2 billion acres of land over the last 45 years have become degraded, which is roughly the area of India and China put together. Further, water logging, salinization and alkalinization reduce productivity of 1.5 mha annually while 6-7 mha of agricultural land is turned unproductive each year because of erosion and 15 percent of the total land resources is affected by human induced degradation. Protection of the land resources, particularly to meet the food requirements, assumes paramount importance.

Management of our water resources is yet another formidable task in ensuring a better quality of life. Global water withdrawals has increased 36-fold in three centuries, and it is projected to further increase by 30-35 percent by 2000 AD. It is surprising to note that the irrigated agriculture accounts for 70 percent of the withdrawal and more than 60 percent of irrigation water is wasted. There is an urgent need, and considerable scope exists to conserve water by adopting a more scientific approach to water resource development and management.

Let us look at a similar impact of the human endeavor and proposed activities in the context of the

Fig. US-104

biosphere *[Fig. US-104]*. We saw the increase in the carbon dioxide—almost 33 percent over the last few decades. The increased methane production from rice fields and other sources by fossil fuel burning increased by a factor of two. If one looks at the implications of this, the model shows the that global warming is expected to be around 0.3 degrees celsius per decade over the next century or so, and then the global mean sea level may rise by 8 to 29 centimeters by the year 2000 to 2020. Another possible implication of increased greenhouse gases and the corresponding increase in the global temperature is interestingly the local increase in the temperature that could force vegetation and associated animals to shift their altitude of habitation. In fact, there's an interesting study which shows clearly the projections based on species area relationships in the U.S.A. that the resulting decrease of the habital space will result in the loss of 23 percent of butterflies and 24 percent of mammals for mountain ranges. So that is a kind of implication in the biodiversity that such shifting factors found would happen. And there results a need for a periodic monitoring of this aspect of the changes in the biosphere.

Yet another challenge in our efforts towards improving the quality of life is providing necessary health care. It is an astonishing fact that three-fourths of the diseases that affect people in the developing countries are preventable. On the other hand, average health expenditure of developing countries is just 4.2 percent of GDP. If one looks at the population per doctor, it is something like 6,670 in most of the developing countries, and contrast this with something like 380 per doctor in developed countries. Then we have the problem of unhygienic environments leading to serious health hazards affecting over 60 percent of the urban population. It's interesting to note that in these underdeveloped countries, only 54 percent of the population has access to the health care. A number of diseases like malaria are spread by insect vectors that live in typical ecologies. And lastly, almost half a billion people, 1 out of 10, are now suffering from some kind of tropical disease. This scenario calls for adequate health care to cope with the large population and also the problem of degrading environment, sanitation, and so on.

It is in this context we look at where we stand today against these challenges that face humankind. The preamble to the Agenda 21 says, "Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill-health and illiteracy and the continuing deterioration of the ecosystems on which we depend for our well-being. However, integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own; but together we can—in a global partnership for sustainable development." So this is the message, and it is against this, what do we see as a promise that space holds?

At the outset, under this promise, we look at some of the educational aspects. We have operational space systems today that offer at least four ways in which education has been propagated: the distance education, the developmental communication, interactive training, and community education for better resources management. There are a number of examples where space systems have been used effectively in the context of these four classes of education such as the use of tele-education in the U.S.A. Of course, my country's own educational television programing is another great example. In India, already more than 24 hours of educational television programs a week are now done through the space system, and more recently we also have had one dedicated communications transponder which is used for training and developmental communication. In fact, this has been used for several aspects of training and developmental communication such as adult education, education and application of the skills of the shop floor people, the education and the application of middle school teachers, and so on. So in all this context, this kind of training and developmental communication system transponder has been used. Another important example of education using the space system is China. Twenty-two hours of television programs are offered for college students in the current system. There are 1,200 local television relay stations, 7,600 satellite ground receiving stations, and 66,000 community viewing centers. So there is a massive program in China to deal with educational and literacy issues, and the use of space system today is one of the potential ways in which China is moving forward in meeting its ever increasing demand with respect to education and literacy. Something like 1.175 million students, or 37 percent of the total, have graduated from "television broadcasting college" in 10 years. So this is one aspect of the promise that we have in the use of satellite systems.

Now let us see the space technology option to address the agriculture related issues *[Fig. US-105]*. We saw earlier the problems of land degradation, problems of poor agricultural yield and productivity, and problems arising out of this in terms of the lack of availability of food for almost 19 percent of the population today. So here there are several issues which could be tackled by space systems. Some of the issues that are being addressed are the identification and reclamation of cultural wasteland, diagnostic analysis/monitoring for scientific management of irrigated commands areas, crop monitoring, etc. We now have systems which can monitor the crop with respect to its yield, area, and so on. Space systems could be effectively utilized to get advanced indications regarding the crops that would affect the overall crop yield, and for monitoring the degraded wastelands. Then there are other areas related to the land classification according to their capability/suitability to ensure that the land use practice adopted is in tune with the terrain characteristics.

However, integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future.

I will dwell a little bit on what we have done in India with respect to some of the problems related to land use as well as agriculture. Thanks to the remote sensing capabilities, we have today a system by which we have a classification of the wasteland in the country. Roughly about 16 percent of the area of the country is what is classified as wasteland. This 16 percent of the area is classified into 13 categories. And it is found that at least 60 percent of this 16 percent is cultural wasteland which could be reclaimed for productive agriculture. We find that with this classification today, a massive program of reclamation of wasteland, which is at least 60 percent of the total wasteland of the country, is in progress. Then we have a crop yield prediction system, which provides acreage and expected production, at least one month before the harvest with an accuracy of 90 percent level, for the large wheat growing areas as well as rice growing areas, which constitute something like 80 percent of the country's crop area. Diagnostic analysis of the 64 command areas is in progress, and this is a very important aspect of remote sensing applications aimed at scientific management of our command areas, par-

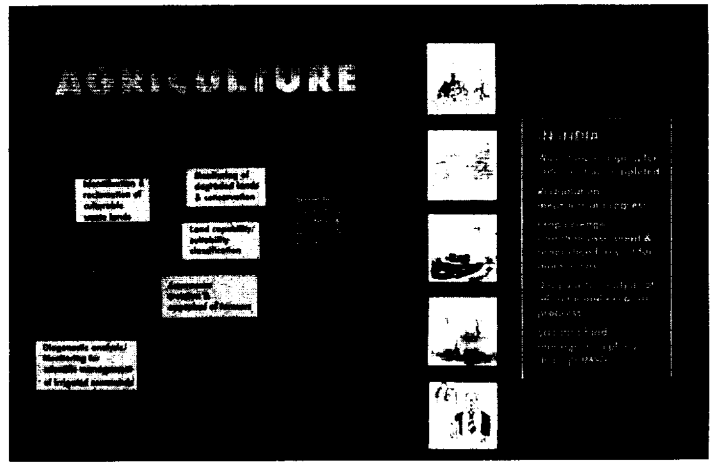

Fig. US-105

ticularly to reduce the gap in irrigation utilization, to arrest degradation as well as to arrive at optimal cropping pattern. So these are some of the important aspects on which today an agricultural system using space is becoming a reality. It is in fact used routinely in the context of India for many of these aspects which I just mentioned.

Space technology has been an effective tool to address the issues related to water resources. We have several aspects of the water resources problem, ranging from extremely high withdrawal of ground water, improper management of surface water, and so on, and the question is how does one deal with this in the case of optimal utilization along with exploration of alternate sources for the water. Here are some of the aspects on which the remote sensing systems have been operationally used. One is the water resources assessment. We have in India a major effort towards mapping of surface water bodies. This is now being routinely done—both in order to estimate the extent of the area of water coverage and also to compute the total storage capacity. The ground water targeting is another major area in which quite a lot of work has been done in India, particularly with respect to the creation of hydro geo-morphological maps, and these kind of maps have been used to identify ground water potential zones where we are likely to have a high probability of tapping the water. I should say that from conventional means our success rate was something like 40 to 45 percent, whereas when the hydro geomorphological maps generated out of space imageries were used along with conventional geophysical surveys, our success has gone up, almost up to 95 percent today, and this is based on something like 200,000 wells that have been dug all across the length and breadth of India. The snowmelt runoff is another thing in which quite a lot of countries have difficulties. In the context of India, we have a full operational snow melt run-off prediction system. They're able to predict the total amount of water that will flow into reservoirs, with certain accuracy, which is acceptable to the

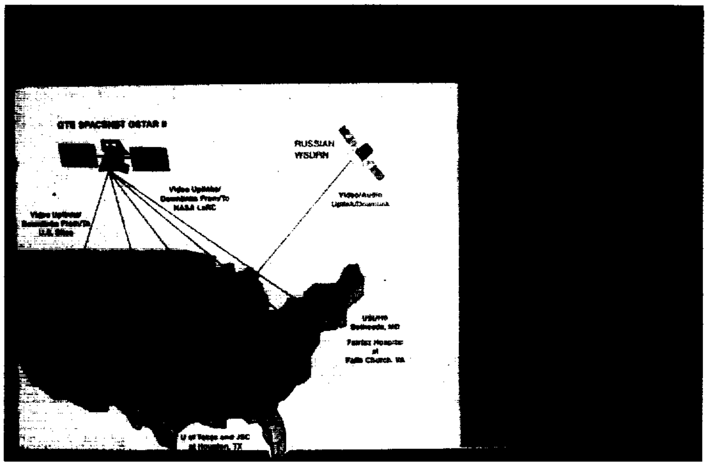

Fig. US-106

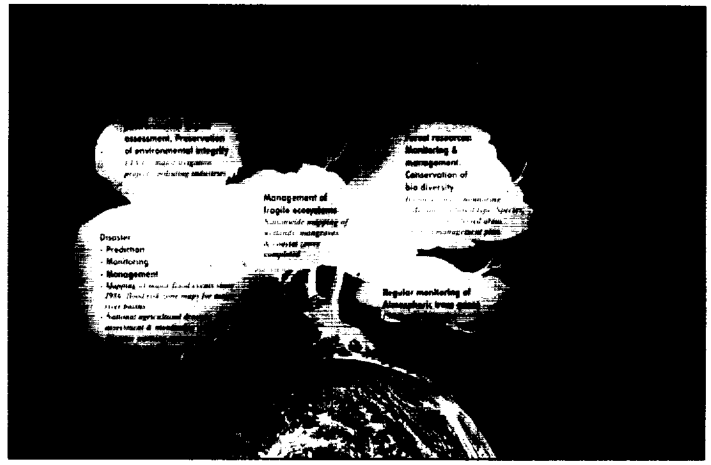

Fig. US-107

hydrologists and is done well ahead of the actual event. Then water quality mapping, water conservation, and harvesting, which is another major thing by which we have been also able to identify areas where the harvesting is possible by constructing appropriate structures so that water can be channelized for ground water recharging. And then the better water use for irrigation efficiency through scientific management of irrigated command areas. These are some of the important aspects of the work on which today the remote sensing is being used on a routine basis, and most of these have been of a very high satisfactory nature and are being routinely used by several of the user agencies in the country.

We have seen the extremely complex problems associated with health care that are related particularly to developing countries and many of the least developed countries *[Fig. US-106]*. It is gratifying to note that space capabilities have been efficiently used in addressing some of these issues. But I must mention in this context that 25 years back, through three adorned telecommunications satellites, NASA set off the first experiment in tele-medicine and that was a pathbreaking effort which has been later taken by several countries. And in today's context, at least in three areas, space for health care becomes relevant. One is the use of remote sensing and the GIS system to monitor the ecologies that support insect vectors which spread vector borne diseases such as malaria, lymphatic paralysis, and so on. The second is the developmental communication, of which we mentioned earlier, which could be effectively used to bring back health consciousness in the poor and uneducated. And the third is what tele-medicine offers—new vistas to overcome the inaccessibility of expert treatment. So in all the three areas today there have been successful efforts, even though much needs to be done in this context, and the U.S. has taken a lead in implementing one of the very important projects that was carried out, that of creation of the space bridge to Moscow during the Armenian earthquake. Norwegian tele-medicine policies are examples of what has been possible with space tele-medicine. The prospects for the future on a wider scale are there—particularly in the context of the availability of conventional systems to provide health care at the required level—with the quality as well as the quantity that one needs in the global context.

The next is a promise that comes with respect to the environment *[Fig. US-107]*. The environmental impact assessment and preservation of environmental integrity is one of the important things. In fact one could use the space system today to assess the environmental impact, particularly when you want to start industries that may have an adverse impact on the surrounding ecosystem, especially on the ground water. Then is the management of the fragile ecosystem for which identification of the biological species and quantification of the changes become essential. In the case of the forest resource management, today we have quite a number of operational systems which have been cleared all over the world. We have examples in Brazil, and we have in India today a monitoring system for the forest, by which every two years we update the forest extent of the country. We have now extended this capability of the forest mapping to timber volume estimation, identification of forest species, forest density mapping, and so on. So the periodic and the timely assessment of the forest wealth today has become possible with the requisite precision and accuracy, thanks to the space borne systems for monitoring this. And of course we have the civil systems on the satellite today which monitor atmospheric trace gases. And particularly in context of the integrated geosphere, biosphere program where the long term implications of these kind of greenhouse gases is being looked at from the angle of the changes in terms of the climatic systems and the resulting impact on the biodiversity. But this is a very important element of input that is today generated by the space system. On the environmental front, there are substantial things which are currently being carried out in the context of using the space system for environmental monitoring and quantification, as well as to

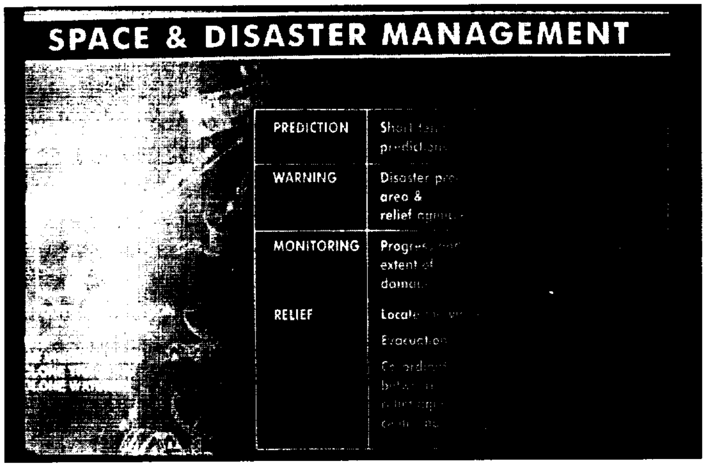

Fig. US-108

Fig. US-109

arrive at preemptive steps to arrest further environmental degradation.

The adverse impact of the increased anthropogenic activities on the environment is compounded by natural disasters *[Fig. US-108]*. In 1991 alone, if want to see the numbers in terms of the impact of such kinds of natural disasters, the economic loss due to disasters was something like $44 billion, and according to the International Red Cross, the number of people who have been killed because of various disasters is really astonishing: in the case of drought it is 1.3 billion from 1967 to 1991; in the case of cyclone, it is something like 0.8 million; in the case of earthquake it is 0.6 million; and in the case of floods it is something like 0.3 million. But the maximum number of events are flood events which have a tendency to affect many countries. According to the Red Cross and Red Crescent Societies, 1400 flood events were recorded between 1967 and 1990. So it is a known fact regarding the need for warning, monitoring and relief, in disaster prone areas. The relief agencies need the communication capability of space systems to reach quickly the disaster affected areas. In the case of monitoring one uses the remote sensing satellite. For example, satellite based early warning of drought is something which has always had an impact in India. We have a drought monitoring system around the satellite using the vegetative index. And then you have the relief related activities where the communications related capabilities like the mobile search and rescue satellites come into picture. In India, disaster warning systems have been set up on the eastern and the western coasts of our country, both of which are susceptible to large cyclonic systems. We have a cyclone warning center in the east coast of India near Madras, which tracks this kind of cyclone up to 400 kilometers. But the INSAT system, which carries a very high resolution radiometer, starts tracking the cyclone much ahead of time, and since it has the capability to take the measurements every half an hour, one can track the development of the cyclone as well as its path to make a reasonable computation of the region along the coast where it is most likely to affect people and property. Using the communication capability of the same satellite, we selectively address those areas of the population where the cyclone is likely to hit so that preemptive action with respect to the protection of life and property could be taken. So this is a perfect example of the way we have been using space system for disaster management. During one of the cyclone events in May 1991, on the east coast of Andhra Pradesh, something like 170 thousand people were evacuated in time to save their lives as well as their property, using the INSAT system, both using the space imaging capability of the VHRR, as well as the space communications capability of the INSAT satellite.

While looking at the issues and the space capabilities to address them, it is a matter of extreme happiness that the global community has started looking at many of these problems together. The seriousness which most of the governments have been following these kinds of problems is very well evident from the number of Earth summits we have been having *[Fig. US-109]*,which include the International Convention to formally combat decertification, the Vienna Convention and its model Montreal Protocol dealing with ozone. And then we have the Social Summit itself, the Biodiversity Convention and the Committee for Earth Observation Satellites. This global concern and unity provide us ample opportunity to work together towards improving the quality of life.

Having discussed the issues and the capabilities of space systems in addressing these issues towards enhancing life on Earth, we need to look at the emerging global scenario in space technology development and its applications. No doubt, Earth observation and monitoring as an integrated system, space exploration, global connectivity, and space colonization are going to be the frontier activities. Many countries have adopted the satellite based systems for Earth observation and monitoring, and it is going to be only increasing, and one can see here the results in

Fig. US-110

terms of resource information, which will be more detailed, more frequen, and over a wider range to enable sustainable natural resource management at cadastral level. Today most of our mapping is done not in the scale in which one can generate cadastral maps, and if one looks into the planning aspect and one has to go down to the lowest administrative entity, there is a need to go to the cadastral level, which is today becoming possible thanks to the resolution capabilities of the space system. The space systems are going to be more effectively used for frequent and accurate monitoring of the environment, management of natural disasters, and so on. So these systems will get strengthened and expanded as the years go by with several of the satellites or big systems monitoring these kinds of problems. And then you have the global connectivity. We didn't say much about it, but one is very familiar with the connectivity in the context of individuals, community, national, and international systems, the increasing personal and mobile communication use, the use of communication for education and tele-medicine and interactive tele-training, which will end up in a vibrant small-office/home-office market, and so on. Space systems will become active carriers of information leading to things like information superhighways and it is a matter of happiness that a lot of research is going on in this country as to how to strengthen these systems so that they become much more effective and are able to meet more of the demands that are being projected in the context of several other activities. And one doesn't stop at this. One is looking much further ahead in the context of space exploration and space colonization where the zero-g processing of materials would become relevant in the context of several special materials, including pharmaceuticals. The spirit of exploration will never die, and one has here the space exploration which will deal with all the aspects of the universe beyond us, our planetary neighbors and the planetary systems. So these are the frontiers which would take us further as the years go by, keeping in mind the fundamental questions which are clearly addressed by these two areas towards the enhancement of the quality of life on the Earth.

I did mention that many of the activities in our country use remote sensing as well as communication satellites. I should also mention that establishment of space systems in our country had its precursors in our cooperation with NASA. In fact, three major experiments which we did in the '70s were the reasons why we could confidently get onto these systems. One is the use of the advanced technology satellite, the ATS-6, which NASA located over the Indian Ocean for us to conduct one of the most important sociological experiments, the satellite instructional television experiment, which brought for the first time in our country an aspect for later developmental communications using satellites. So that was a major experiment conducted over a year, highly successful, well evaluated by the sociologists, and it fully justified a total system, considering the length and breadth of the country. The area, as you know, is 3.2 million square kilometers and has a population which is today more like 900 million, so to that extent there was justification for a system and that gave us the INSATs, and the earlier satellites in the INSAT series were bought from Ford Aerospace. The second generation INSATs today are built by us, and four of them are currently in operation. They provide the wider telecommunication and television services and from the general sector dealing with only the development of communications. Today the INSAT system also provides quite a lot of entertainment. In fact, currently the INSAT system services the needs of something like 85 percent of this 900 million population, spread over around 65 percent of the area of the country, and at present we are building the INSAT-2D and more advanced versions like the INSAT-2E. These are multi-purpose systems. Besides the television broadcasting and telecommunication capabilities, they also have the very high resolution radiometer which can take pictures with respect to the cloud movements in that part of the globe in half-hour intervals, so that the information related to the cloud movements, temperatures, precipitations, and many other meteorological perimeters can be derived. An equally important aspect is related to remote sensing. Here again the pioneering cooperation that we had with NASA, first in the use of a Hasselblad camera system to look at the coconut wilt diseases in the southern state of Kerala. Subsequently, India was one of the first few countries to go to the use of Landsat for more sensing applications. Both gave insight into the importance of remote sensing systems for India to deal with problems of management of natural resources.

Today we have an operational system, and five of the Indian Remote Sensing satellites are in orbit: IRS-1A, 1B, 1C, P2 and P3. These five form a constellation of satellites which provide information both with respect to the land related applications, the ocean related applications, and to some extent, the environment related applications *[Fig. US-110]*. And what is significant is that this started as a cooperation with NASA in the use of Landsat. Today we have come back, and in cooperation with EOSAT we are trying to see how best the information that is available from these satellites can be made available to the global remote sensing community. Here are some of our future programs. These satellites primarily will address more demanding requirements from the ocean as well as a cartographic applications community, and finally looking into the possibility of going for a high resolution space based system for applications related to soil, agriculture, and many other areas. This is generally the pattern. One of the interesting aspects of the use of these satellites particularly relates to the use of remote sensing for local specific development. Here what we tried to do is to adopt an integrated approach. Over the years, we have successfully operationalized a number of applications on a thematic basis using the satellite data, like the applications for forestry, geology, hydrology, and so on. In this particular case we integrate all this thematic information for a particular area and then try to look at the soil condition, the moisture level, the ground water availability, the surface water availability, the vegetation status, and so on, and then try to view local specific prescriptions which will deem more how to harvest water, how to improve the water management, what kind of vegetation, or what kind of use of the land would enable the land to be used on a sustainable basis. This kind of information then is integrated along with other information, like the meterological information, as well as the socioeconomic parameters using a geographic information system. The developmental plans are user friendly, and are used directly by the lowest administrative levels in the states, and the kind of transformation that has been seen over the last two years in the application of this concept to some of the areas in the country is tremendous. The biggest problem was water availability, the land misuse, and the scarcity of water harvesting structures, including those for ground water recharging. They were identified using the satellite imageries and the carrying capacity of the land in this region was also evaluated using satellite imagery. The vegetative cover and the dynamics of that was also evaluated using satellite imagery. The prescription was given to the local people and has been implemented by the district administration along with the local people who own the land, so that there is no conflict between a suggestion that is made and its implementation *[Fig. US-111]*. And this concept we have now extended to something like 174 districts in our country, which is almost 45 percent of the area of the country, and these are all problem area districts, whre there are large amounts of degraded land, non-availability of water for agricultural activities, and so on. Nearly 45 percent of the land area today is being covered under

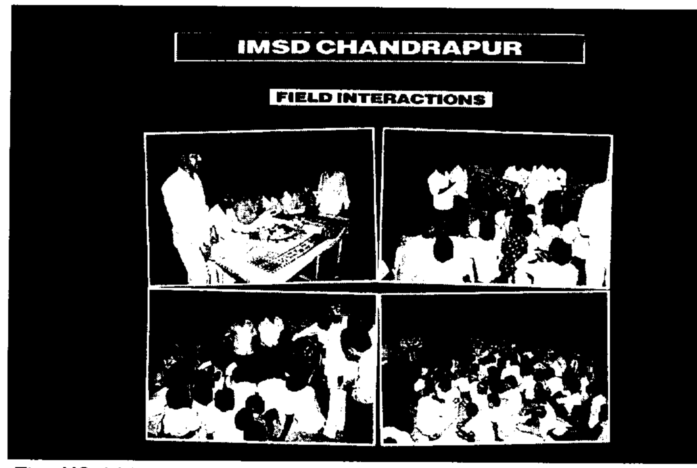

Fig. US-111

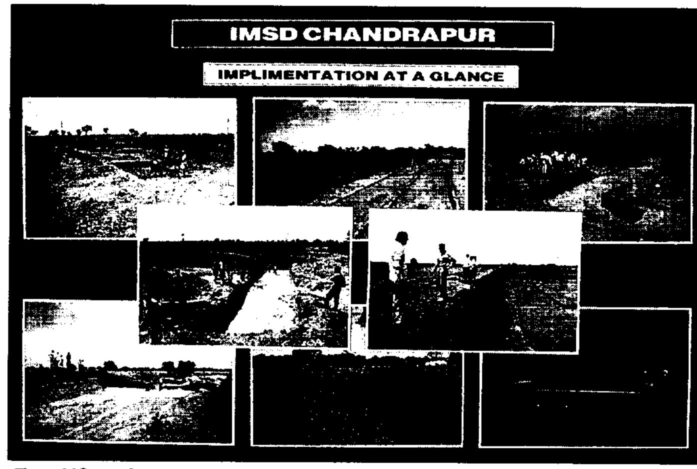

Fig. US-112

this integrated mission for sustainable development *[Fig. US-112]*. This is one of the very good examples of the grassroot level of application of space for development in the context of the country's needs.

Let me summarize here. As the years go by, how does the system emerge? The technological push adopted by some of our countries has really slowed down their efforts towards improving the quality of life. It is very clear that going for an application-driven approach is extremely important and relevant in the context of enhancing life on the Earth. The future is also moving towards more inter-connectivity between space systems, which means the use of communication and remote sensing together in looking at specific problems. So the inter-connectivity and cooperation between disciplines, as well as synergy, need to be achieved. The cooperation among nations should expand to identification of priority areas for concerted global efforts. This is another major area that is certainly going to be there on the international agenda, and already there are quite a good number of things that are being done. For example, under the international geosphere, biosphere program that looks at the Earth as a total system with biological, chemical and physical characteristics, considerable efforts are being made to arrive at an integrated way of looking at the system. But similar things will happen in the case of the global connectivity and space exploration, and in India we'll just not be left behind in the context of global efforts and international cooperation. One should also keep in mind that a large number of people still do not have the benefits of space capability and the benefits in the context of using the space capability for their own special needs. Like some of the needs that we saw in the context of India. There is certainly an urgent need to build an indigenous capability in developing countries, particularly with respect to their ability to use existing space systems for their own developmental efforts. When this has to be done many times, the problems are the ones which are related to the political will—and equally important is the question of availability of funds. The suggestion of setting up a global fund to assist less developed counties assumes significance. Looking towards a future vision, in the past the visions have come from countries like the U.S. The space vision. I cannot do anything better than quote some of the fine space pioneers in this country and also in the erstwhile Soviet Union. Neil Armstrong said, "That's one small step for a man, one giant leap for mankind." And the first astronaut of the Soviet Union said, "And tomorrow, settlements on the moon, voyages to Mars, scientific stations on asteroids, contact with other civilizations. We shall not envy the people of the future. They are lucky, and things about which we can only dream will be ordinary for them." So between them they're really pregnant with meaning with respect to the vision for present as well as vision for the future. Many of the countries have picked up elements of this vision through their own visionaries to make sure that the best capabilities of space are used in the context of their own developmental needs. But then we have said this, which is a broad vision, and when it comes to a down to Earth kind of a thing, I can only say with respect to what Carl Sagan, one of the famous planetary scientists in this country, said, "There are worlds on which life has never arisen. There are worlds that have been charred by cosmic catastrophes. We are fortunate: We are alive. We are powerful. The welfare of our civilization and our species is in our hands. If we do not speak for Earth, who will? If we are not committed to our own survival, who will be?" That is a sense of enhancing the life on Earth. Thank you.

Space Applications and Cooperation

Master Moderator: **Steven P. Scott**
Program Development Manager
Rockwell Space System Division

Chair: **The Hon. Edward C. "Pete" Aldridge Jr.**
President and CEO
The Aerospace Corporation

Panel Participant: **Dr. Krishnaswamy Kasturirangan**
Chairman
Indian Space Research Organization

Speakers: **Dr. Arturo Silvestrini**
President and CEO
EOSAT

Robert Minor
President
Rockwell Space Systems Division

Michael Gianelli
Vice President and General Manager
Government Operations, Hughes Space & Communications

Akiyoshi Takada
Deputy Director General of the Communications, Policy Bureau
Ministry of Posts and Telecommunications, Japan

Mr. Scott: Now let me introduce the chair of our first session. The Honorable Edward C. Aldridge, better known as Pete, is the current president and CEO of The Aerospace Corporation. He's also a director of the United States Space Foundation and is widely recognized as having been a leader in shaping our nation's unmanned space program for the past two decades. As such he is a natural candidate to lead our session on current and future space applications. Ladies and gentlemen, please welcome Pete Aldridge.

Mr. Aldridge: Good morning and welcome to the panel on Space Applications and Cooperation. We have four very distinguished and knowledgeable people who can speak with authority on this topic. But before introducing them I'd like to set the stage for their presentations. We are in a new and ever changing environment with regard to new directions in space and the prospects for expanded international cooperation. We're more dependent than ever upon each other for success in space, from the sharing of launch vehicles, launching satellites built and used by many nations, to the use of components and technology from all parts of the world for several of our missions, especially the International Space Station.

And we're depending on resupply to the Space Station for successful launch and deployment from all of our Space Station partners. The expanding global marketplace for space systems and the information that these systems provide will give new opportunities for economic expansion of the space industry directly and of other industries indirectly by the application of information supplied from space. We're on a supersonic trip into the information age which will result in worldwide requirements for interoperable and interconnected networks, communications platforms, and standards of communication among the various systems and the various nations that supply them.

Cooperation among the industries will be inevitable as we search for the best products at the cheapest prices from this growing worldwide marketplace of rapidly advancing technology.

One of the more interesting aspects of international cooperation in space is evolving from the national security imperatives. As worldwide interests merge and coalition forces become more commonplace in areas of mutual interest, we are seeing a growing acceptance of the use of national space assets of several nations being combined in support of international peacekeeping operations. The recent report on the intelligence community by former Secretary of Defense Harold Brown confirmed the validity of an integrated and international space intelligence system for support of global awareness and peacekeeping operations. I hope tomorrow's session on national security will have some discussion about this topic.

Last year the American Institute of Aeronautics and Astronautics (AIAA) held a workshop on international space cooperation, in which some 15 nations participated, and stated as one of its findings that, and I quote: "The global political, industrial, and social economic climate makes wide-ranging cooperation not only possible, but what is new is that international cooperation may now may be a necessary strategy to achieve the goals set out for space-related projects."

With this background, I would now like to introduce our speakers. The first speaker will be Dr. Arturo Silvestrini, president and CEO of EOSAT, who will speak on Earth sensing. Dr. Silvestrini has more than 40 years of professional experience, most of which is in aerospace-related industries. He was born in Italy and received his doctorate degree in electrical engineering from the University of Rome.

The second speaker is Robert Minor, president of Rockwell's Space Systems Division, who will speak on the subject of navigation satellites. Mr. Minor received his bachelor of science degree in electrical engineering from Southern Methodist University and continues to study at UCLA's graduate school of engineering. He joined Rockwell in 1963, initially working on the Apollo program. Then he joined the Space Shuttle program at its inception. He became vice president and general manager of Rockwell's Houston operation, providing on-site support to NASA for shuttle operations. In 1988 he was appointed to his current position, where, in addition to shuttle support, he is responsible for advanced technology programs.

We concluded it was time to encourage governments to exchange more information and resources in Earth sensing.
— Dr. Silvestrini

Third is Mike Gianelli, vice president and general manager of Hughes Space & Communications Company. Mike is replacing Don Cromer, who was originally on the program, who very happily launched one of the Hughes satellites on the Soviet Proton rocket just yesterday—successfully, I understand. Mike will speak on communications satellites.

Mr. Gianelli earned his bachelor's degree in aerospace engineering from Notre Dame, his master's degree in mechanical engineering from University of South Carolina, and a master's degree from Pepperdine University. He has been with Hughes for 23 years and currently has responsibility for government operations, including business development and programs.

And fourth is Akiyoshi Takada, deputy director of the communications policy bureau, Ministry of Post and Telecommunications in Japan. Mr. Takada will also speak on the subject of communications satellites. Mr. Takada obtained his education from Tokyo University Law School and immediately entered the Ministry of Post and Telecommunications in 1968. He moved through the organization until reaching his current position in 1993.

Editor's note: The introduction of Dr. Silvestrini was made by Mr. Aldridge in his opening remarks

Dr. Silvestrini: Good morning, ladies and gentlemen. I will speak on Earth observation but I would like to give you the feeling of why we have this panel—and actually why we have the panel that will follow us. Three years ago, under the leadership of Pete Aldridge, we had a conference symposium, in beautiful Hawaii, to talk about international cooperation in space. This was the first one, in which we talked about which space applications we considered most likely to be enhanced by space cooperation.

I was on the space applications panel led by Roy Gibson, who is going to be the chairman of the following panel, and co-led by John McLucas. We concluded that three applications must be considered: communications, which was already well developed, Earth sensing, and navigation. Earth sensing covers disaster monitoring as well. We concluded that there was not enough attention from the governments of the space-exploring nations to applications of Earth sensing which were not just scientific. We concluded it was time to encourage governments to exchange more information and resources in Earth sensing. We concluded that without the participation of industry in Earth sensing, there would be no way for Earth sensing to be a real application to benefit mankind. We invited ourselves (everybody was represented in our group: academia, government, United States, and of course, industry) to organize meetings to implement the recommendations. I tasked myself—and Roy Gibson did the same thing—to work to expand the vision for industry, and for industry to participate with industry in other countries and with other governments. Three years later we have seen some results of that. Some are due to our activities and some, of course, were naturally occurring. Where are we now?

CEOS, the Committee for Earth Observation Satellites, which is basically formed by representatives of governments, has opened its door, at least to some extent, to private industry. Not completely, but they have shown the sign that they will do it. We have had many initiatives, especially in the United States, in Earth sensing, new systems for most (I am talking about Space Imaging, Orbimage, Earth Watch, and the like), where you have seen that partnership extended outside the United States significantly, in Europe, in Asia, in the Middle East. You have seen multi-national cooperation between government and industry of several nations. We, EOSAT—with the U.S. government—started 12 years ago in this cooperation. EOSAT was only American, was between Hughes and RCA at the time, but now with Lockheed Martin and the U.S. government for Landsat. We have seen SPOT also with the government in France. We have seen Radarsat. Now we are seeing the best of them all, the Indian Program. EOSAT started with Landsat and EOSAT is again at the forefront. We are cooperating with the Indian Space Agency in distributing the most

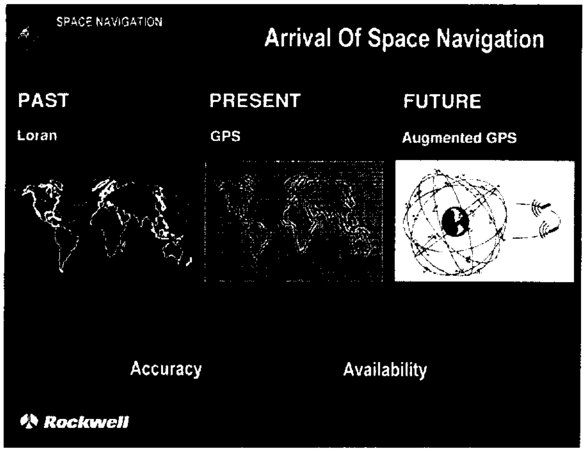

Fig. SA-101

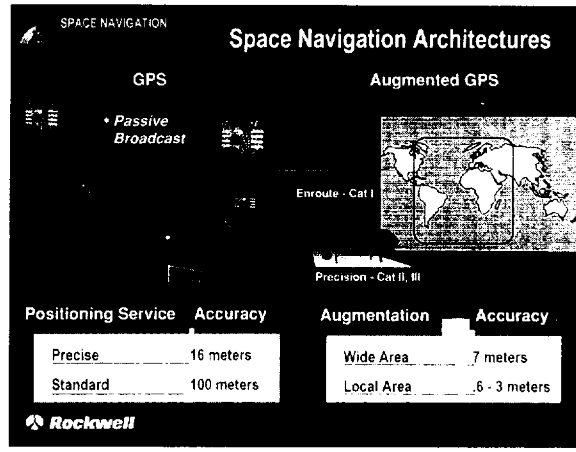

Fig. SA-102

advanced Earth sensing data to the users.

In terms of participation of private industry in the activities of the space-training nations represented by CEOS, I would like to mention that EOSAT has started the formation of associations of private users of Earth sensing in Europe and North America, and is doing the same in Asia, South America, and Australia. Roy Gibson will give you a lot more details on the activity we have done. And this is a common activity between us, Roy Gibson, and SPOT. Yes, SPOT, our so-called enemy, that is not an enemy.

Let me conclude with a couple of observations on the India Space Program—on things that Dr. Kasturirangan has not said because he's probably modest. First of all, I have heard several times in the past comments asking how can a country like India afford a space program. I have been there many times and let me tell you, I have never seen a country that has the space program so integrated with their life—not politics, but life. And I think that is the reason the Indian space program there, at least the part I have seen better—Earth observation—is so strong and so mature. It is not like ours. Every year we don't know if Landsat will go up or down, or if we will lose the money or somebody invents something else. The Indians have a long-term program because the life of their nation depends on space. What they do every year is to adjust maybe 10% of their budget for that year, but they don't cancel things. Governments may go, but not the space program. That's serious.

That satellite they launched just a few months ago is giving us the best results that we've ever seen in commercial satellites. There is an exhibit outside, you can look at it. It is the most advanced non-military satellite and is going to be available for everybody. This is the conclusion of my speech, don't worry about its length. When I saw their centers I saw thousands of young people, well dressed, extremely well spoken, well educated, and enthusiastic about the space program, working eight, 10, 12 hours a day. Do you know what I thought? Because I worked with NASA, even before NASA at the beginning, I saw NASA again. They like the old, real NASA. I wish we had here the enthusiasm that these guys have. Thank you.

Editor's note: Introduction of Mr. Minor appeared in Mr. Aldridge's opening remarks.

Mr. Minor: Good morning. I would like to talk to you this morning about the way we see the direction of space navigation, well into the next decade. This vision is a compilation from interviews and discussions with system users, system architects, and system operators, as well as considerations from the many studies of GPS and congressional hearings.

Our company has a long standing commitment to space navigation and GPS, dating back to the early 1970s. Two weeks ago we successfully launched, and are in the process of deploying, our 25th Block II operational satellite. All 25 satellites are still operating, some dating back almost seven years. The entire GPS team, including the U.S. Air Force, Aerospace, U.S. Naval Observatory, IBM, and Rockwell was honored with the presentation of the Collier Trophy in 1992.

Focus your attention on two main areas today: the future applications and our challenge to maximize the system utility. Looking at navigation history *[Fig. SA-101]*, even the past few years have seen orders of magnitude improvement in accuracy and availability, compared to terrestrial-based systems, such as Loran. We will look at some of the ways space navigation is revolutionizing life on Earth. The Presidential Decision Directive of March 29 reaffirmed continued U.S. support for free access to the signals, calls for an annual determination on continued use of selective availability, and established a permanent Interagency GPS Executive Board.

Let's just briefly define some terms for our talk *[Fig. SA-102]*. There are many architectures for space navigation, and all vary depending on the application. Basically they fall into two architectures: the basic GPS

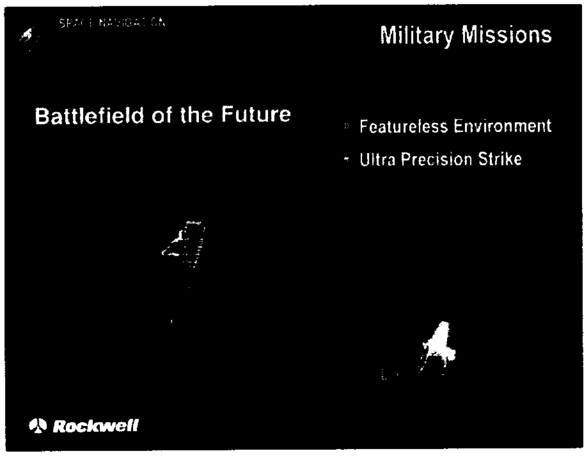

Fig. SA-103

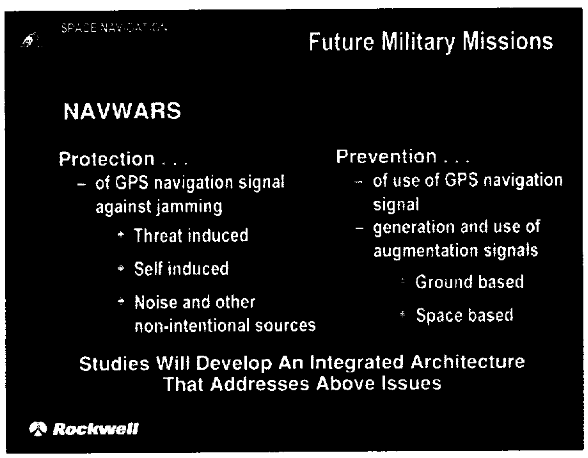

Fig. SA-104

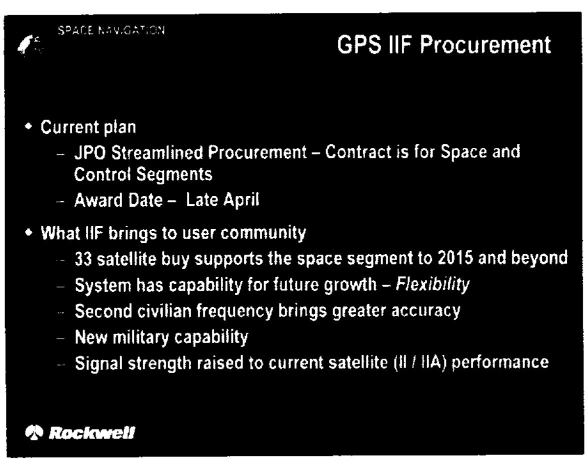

Fig. SA-105

and augmented GPS.

As originally designed, the system was and still is a stand-alone system. However, because of the terrific appetite for accuracy and profits, new ingenious architectures have driven the system way beyond anyone's imagination of just a few years ago.

Some of these augmentations represent concerns to the U.S. military and our allies because of the global availability of precise accuracy. For example, the wide area broadcast for the Eastern U.S. air space also

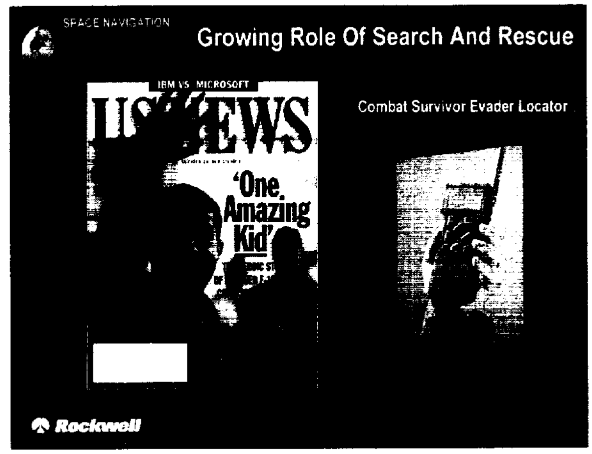

Fig. SA-106

provides 7-meter accuracy to all the Near East countries, including Iraq. This presents a dilemma that I will touch on later.

I'm going to talk about three categories of GPS applications: military, civil, and commercial. Because of the limitation of time, I will not be able to talk about all the important applications but will focus on those that seem to have the greatest promise into the next century.

Let's first take a look at some military missions. Theater conflicts of the future *[Fig. SA-103]* will be fought in unfamiliar featureless terrain, much like conflicts and wars of the past. GPS provides a new force multiplier, as was proven in the Gulf War. Precision guided munitions will enable more effective strikes and less civilian collateral damage.

All of this will need to be accomplished in an environment of what is now being called NAVWARS. NAVWARS *[Fig. SA-104]* is a solicitation out of the GPS joint program office. This will begin as an architectural study to define ways to protect the U.S. Department of Defense and allied interests, as well as preventing use of GPS by our adversaries, while still providing access to allied and civil users.

At this point let me mention something about the next block of GPS satellites *[Fig. SA 105]*. The GPS joint program office is currently in source selection for the next 33 satellites and ground segment. An award later this month will demonstrate to our allies and the rest of the world our commitment and leadership to this system.

The new functional capabilities contain the following. The system will have built-in added capacity, or flexibility, for new capabilities for added missions in the future. It will also contain a second civilian frequency that will improve civilian accuracy. And, finally, it will increase signal strength.

This is a great picture up there *[Fig. SA-106]*. This was a very happy day for the military—a GPS-aided rescue. Rockwell was recently awarded a con-

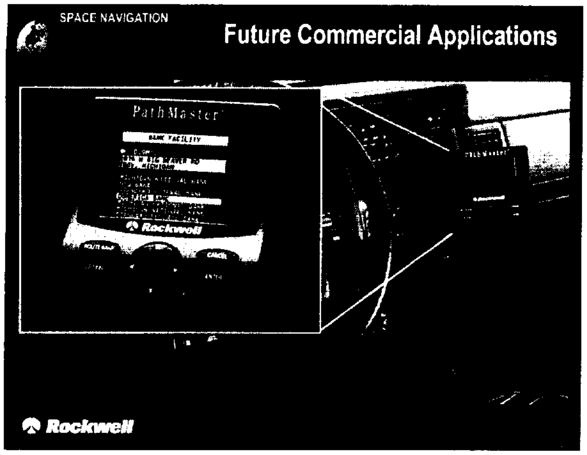

Fig. SA-107

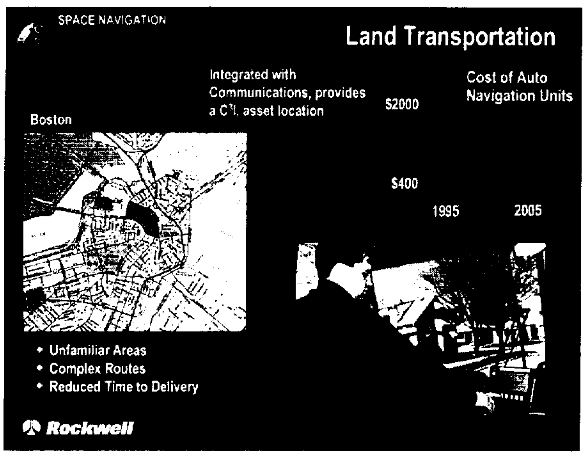

Fig. SA-108

tract for production of the Combat Survivor Evader Locator (CSEL) to enable more effective rescues, such as that of Capt. O'Grady in Bosnia.

CSEL had been under study for several years—Capt. O'Grady brought this idea home. The first production calls were for 11,000 of these units to be built. And I am sure there will be more that will follow.

Let's now look at how space navigation is affecting our lives in the commercial arena *[Fig. SA-107]*. Two areas of land transportation *[Fig. SA-108]* are currently benefiting from GPS: trucking and auto. However, for units to become part of our everyday lives, the cost must come down—and because of supply and demand the cost probably will. In less than 10 years, the cost of GPS auto receivers will enable this system to be optional equipment on every auto at an affordable price. With GPS, navigating complex central cities of the world will be much easier.

Combining GPS with remote sensing enables something called precision farming *[Fig. SA-109]*, which places the right amount of nutrients in the right place. This will improve crop yields, reduce ground water pollution, and reduce costs of farming. While the concept of precision farming is in the proof-of-concept and demonstration phases, it appears that this is a breakthrough technology for the farming community.

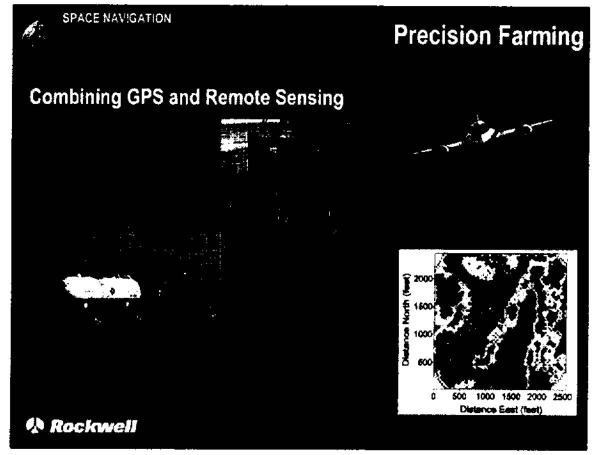

Fig. SA-109

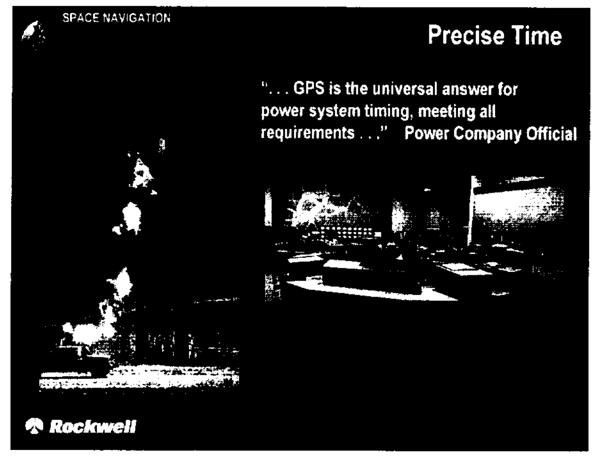

Fig. SA-110

A residual benefit of GPS is the global acceptance of it for time transfer *[Fig. SA-110]*. The time accuracy of GPS enables the isolation of line breaks to the nearest utility pole. Telecommunications is relying on GPS for timing on a global basis as digital communications become prevalent. This enables an increase in system capacity.

Civil Applications *[Fig. SA-111]* represents an area where rich rewards of GPS are taking place, in lives saved and dollars saved. A couple of years ago in southern California there were some devastating fires. As we tried to apply GPS to other applications we went and talked to the firefighters and asked them, "How do you keep up with your resources? Your trucks, your airplanes, your people?" They pulled out a 3X5 card and said, "This is the way we do it." And we said we have a better idea for you. We are in the midst of working with these people today for an application of GPS and other products to make sure the firefighters are as technologically advanced as we see in some of the other applications that are coming up.

Applications to aviation have been under study for 15 years *[Fig. SA-112]*. The FAA's Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) have architectures that will

Fig. SA-111

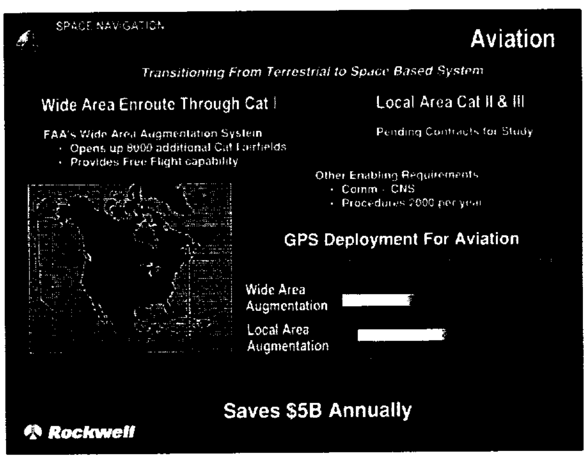

Fig. SA-112

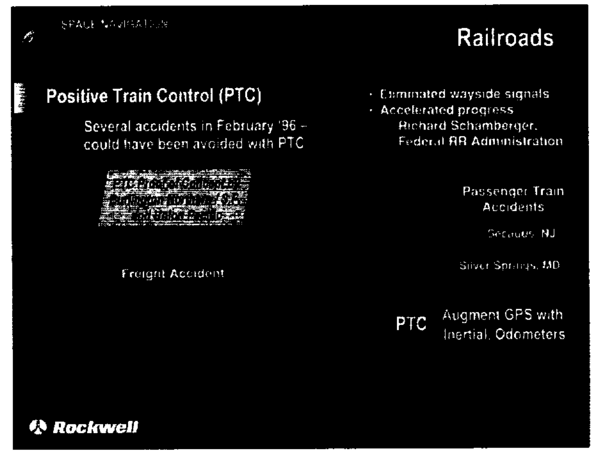

Fig. SA-113

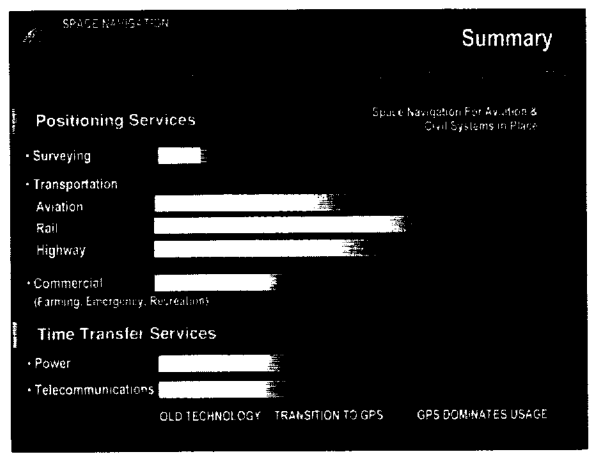

Fig. SA-114

meet future system capacity needs, improve safety, and return cost savings in fuel and time. However, there remain large development, deployment, and political challenges in this arena. This is an area where cooperation between government, airlines, and GPS providers will enable sole means service by the year 2010 or before.

The railroad system *[Fig. SA-113]* is in the proof-of-concept phase. It faces the same challenges as aviation applications, that is, government regulation for safety reasons and military signal protection. According to the Federal Railroad Administration, several recent railway accidents could have been prevented with Positive Train Control using GPS. I think we will see that in the future.

I've presented some of the applications that we believe will grow significantly in the next decade. However, to do so they need to contend with the GPS dilemma: expanding system utility while protecting the military mission. The resolution of this dilemma is through continued U.S. system leadership, providing free access in order to discourage other countries from developing their own system, developing methods to protect the U.S. military signal, and preventing use of the signal by the threat.

Let me briefly summarize *[Fig. SA-114]* by presenting a timeline of some of the major applications that we have talked about. First, surveying was the first widespread use of GPS and has already made the transition from its old technology to GPS. Transportation applications have been under study for years. The major transformation will occur with the introduction of WAAS in the late 1990s and LAAS in the early years of the next century. Full sole means use is planned for 2010. Rail services are still in the proof-of-concept phase but will likely catch up by 2010, forced by safety considerations. Highway usage will be driven by the reduction in user equipment cost with widespread use by 2005. Commercial applications and time transfer services are virtually in place at this time. GPS is truly a great system, and Rockwell is proud to be a part of it.

Editor's note: Introduction of Mr. Gianelli appeared in Mr. Aldridge's opening remarks.

Mr. Gianelli: Good morning, ladies and gentlemen. It is a real pleasure to be with you this morning to engage in a dialogue about a subject that we all hold near and dear . . . SPACE.

In this morning's session on Space Applications and Cooperation, I've been asked to discuss communications. Let me begin by stating, without equivocation, that communications and navigation are the only viable commercial uses of space in existence today. Of the two, communications is the space application that continues to shrink our world and drive international cooperation as few commercial undertakings can.

You might say that the globe began shrinking in the 15th century with the advent of movable type and the printing press. Ocean liners, and later air travel, accelerated the narrowing of the geographic gaps that separate the nations of the globe. The telegraph, telephone and eventually transoceanic cable drew the world into an even tighter circle.

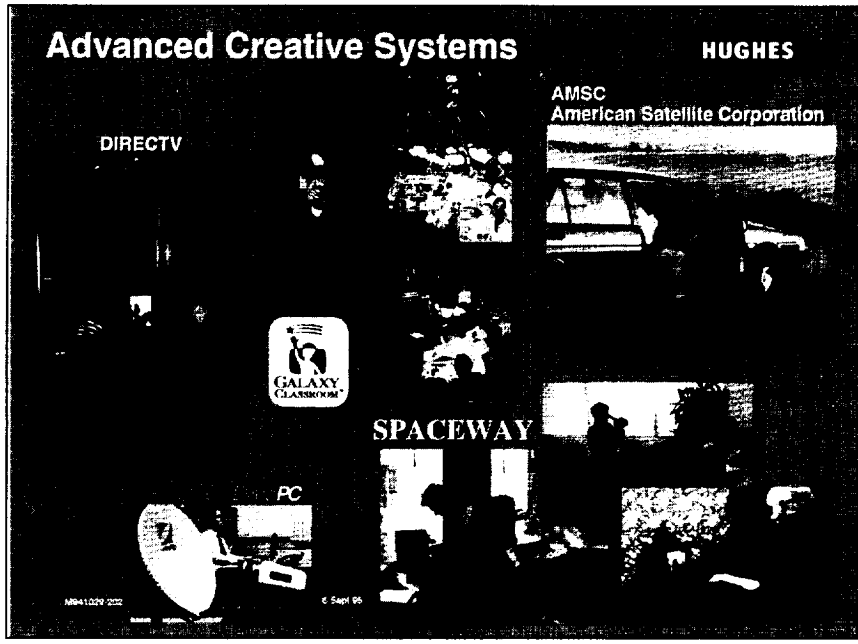

Fig. SA-201

It wasn't until 1963, however, with Hughes' invention of the geosynchronous communications satellite that a truly new millennium in telecommunications capability emerged. Syncom, from its position 22,300 miles above the equator and moving at the same speed as the Earth rotates, forever changed our lives. Today, the phrase "live via satellite," is seldom used even as we witness the world's events in real time, because satellite communication is so commonplace that is almost taken for granted. So we don't say "live via satellite," any more than we would say "calls via telephone."

It is this concept of a shrinking world that has created the global village that encourages, in fact demands, that the peoples of the world cooperate for their mutual benefit. I'm pleased to say that communications satellites have fueled the concept of the global village as few other inventions have, and they have thus played a major role in creating a world without boundaries.

Before addressing the issue of cooperation, I'd like to spend a few minutes discussing the various applications which communications satellites serve. When you say communications satellites, the first thing that comes to mind is television program distribution. News, sports and weather. . .all staples on the information and entertainment menus of people around the world.

While it's easy enough to comprehend that television programming is one of the primary uses of satellites, we don't often think of satellites as being the source of a number of newspapers and magazines. Nor do we often think that when we put down a credit card to make a purchase at a department store our transaction is likely being approved via satellite.

Likewise, thousands of stock and bond transactions each day, as well as numerous hotel and airline reservations, are transmitted via satellite. And a number of large corporations around the globe use satellites to control inventory, conduct training and conduct research.

Here in the United States, the Commonwealth of Virginia and several other states use sattlelites for distance learning, and a number of satellite-delivered learning programs are offered for elementary school students to enhance educational opportunities for our nation's children. One such program, the Galaxy Classroom, is sponsored by Hughes. Satellite-based telemedicine programs are enabling expert medical diagnosis and treatment assistance for those living in remote areas that are medically under-served.

The blueprint for the future is being created today and without question, the three fastest growth areas for satellite communications are direct-to-home television, mobile communications, and broad-band services. Few, if any, Americans haven't heard of DIRECTV or the DSS System *[Fig. SA-201]*. With the small 18-inch dish and DSS set-top receiver, more than 1.3 million American families are receiving up to 200 channels of television programming in their living rooms direct from spacecraft flying 22,300 miles over the equator. Viewers can select pay-per-view hit movies that start as often as every half-hour and sports programming along with news, financial and market information, history, travel, crafts instruction, etc., when they want it.

In Europe, the Society of European Satellites is providing direct-to-home delivery of television and radio programming through its Astra fleet of satellites.

And direct-to-home services are emerging in Latin America, Japan, Indonesia, and Malaysia.

The first satellite dedicated solely to mobile communications in North America was launched last year. Later this month, another Mobile Satellite will join it, providing seamless mobile communications capability for travelers in automobiles, trucks, boats, and aircraft throughout the United States, Canada, and Mexico.

Last year ICO Global Communications, an Inmarsat affiliate company, ordered 12 high-powered satellites that will provide hand-held mobile communications services around the globe. That system will become operational in 1998, a little more than two years from now.

And remote sensing imagery will tell farmers the best times to plant crops to increase crop yields. By understanding long range weather patterns, these farmers could avoid planting seeds that would be washed away by heavy rains before they have a chance to take root.

Hughes and several other companies have applications pending before the FCC to build and operate fleets of high-powered Ka-Band satellites that will provide high-speed data transmission and a full range of interactive services, including personal teleconferencing and medical imaging, to a global community. When these satellites are launched, the Global Information Infrastructure will be in place. Here, once again, we see on-board digital processing technology developed for the military being used as the backbone for a highly complex commercial application.

Collectively, these new applications hold tremendous promise for the world's developing nations. The technology that enables mobile communications and private networks can be used also to provide instant communications infrastructure to developing nations.

For example, using satellites and a small Earth station, a village in central Africa can establish economically viable telecommunications links with the outside world in a matter of days, instead of the years and millions of dollars it would take to lay cable to establish similar capability. A regional government can use small inexpensive dishes linked to digital satellite systems to establish multi-site educational facilities. Using such systems, governments can provide enhanced educational opportunities to their children by offering a wide range of subjects taught by a small core of master educators.

Medical imaging technology that will be available through Ka-Band satellite systems I mentioned earlier will serve as the backbone for telemedicine services for remote regions. Through the use of such systems, doctors, nurses, and other paramedicals can obtain expert advice from specialists around the globe. With microcameras and small affordable uplink dishes, surgeons could remotely guide procedures that save lives.

And remote sensing imagery will tell farmers the best times to plant crops to increase crop yields. By understanding long range weather patterns, these farmers could avoid planting seeds that would be washed away by heavy rains before they have a chance to take root.

Thus far, I've talked about some truly exciting and promising new applications. Global cooperation, however, is required in order to maximize these services, and cooperation is the second part of my discussion with you today.

Cooperation is not new in civil and commercial space activities. Certainly foreign scientists and engineers have been frequent passengers on the U. S. Space Shuttle fleet, often conducting experiments that could lead to full-blown commercial uses of space. And American astronauts have also flown in the MIR Space Station.

Likewise, other nations have cooperated to provide emergency landing options for shuttle crews. And a number of nations have participated in joint operations with NASA.

In the commercial communications satellite industry, international cooperation was present from day one. The world's first commercial communications satellite, Early Bird, did, in fact, belong to the world community. Operated by Intelsat, the international telecommunications satellite consortium, the Early Bird satellite, which was launched in 1965, ushered in the new millennium I referred to earlier. Today, Intelsat is made of more than 120 of the world's nations, in cooperation to serve the communications needs of the world's peoples.

The Intelsat consortium was created to provide satellite communication services to the nations of the world. It was quickly realized, however, that ours was also a global maritime community and that satellites could also provide communications services to ships at sea.

In 1976, three Hughes-built Marisat spacecraft were launched creating the world's first non-military mobile satellite communications system. Today, Inmarsat's global commercial mobile satellite communications fleet provides telephone, telex, facsimile, and data transmission services, including distress and safety communications services to ships at sea and to mobile users both on land and in aircraft aloft.

Headquartered in London, Inmarsat is a consortium of more than 60 member countries.

In the cases of both Intelsat and Inmarsat, the satellites purchased by the consortia have been built using components from around the globe. Cooperation, however, is not solely the province of the international communications consortia nor should it be the tool that enables technologically advanced nations to exploit the developing world. Cooperation must provide global benefit.

For example, as part of the contract to build Indonesia's first domestic satellite system, Hughes agreed to train Indonesian engineers and technicians in satellite design and assembly. That cooperation has carried over through each of the two successive generations of Palapa satellites. Today Hughes is involved in an effort to upgrade the science curricula of Indonesian universities to enhance the country's technology development plan.

In fact, engineers from Canada, Brazil, Mexico, Thailand, China, Japan, Malaysia, Australia, Hong Kong, and Indonesia have all worked alongside Hughes personnel in our facility in El Segundo to produce the satellites we have built for their countries.

The explosion in satellite communications applications I spoke of earlier is driving cooperation in ways previously unthought of. As the world moves rapidly toward the privatization of telecommunications infrastructure, new opportunities provide—often demand—a new kind of cooperation between suppliers and service providers.

While it may be immediately clear that few service providers have either the engineering expertise or the facilities to build their own hardware, we often overlook the fact that this rapid expansion requires greater access to space than at any other time since satellite communications began. Not only do we need more launch vehicles, we need different kinds. More efficient, more affordable access to space is the linchpin in every model for the expansion of satellite communications services currently on the drawing board.

Fortunately, in the last few years we have seen ventures emerge that promise to meet this increasing demand. But these new ventures, while challenging from an engineering perspective, are also extremely expensive, and that is where cooperation is helping to accelerate this trend.

McDonnell Douglas has decided to build a new version of its venerable Delta rocket called the Delta III. To make that decision economically viable, McDonnell Douglas needed a guaranteed initial market for its new product. Last year Hughes entered into an agreement to buy 10 Delta III launches and to take options on more. That decision allowed McDonnell Douglas to proceed with this project and now the first launch of a Delta III is planned for 1998.

Likewise, when Boeing decided to develop a totally new launch concept called Sea Launch, it could do so only with the cooperation and participation of an extensive team of international partners. But again, predictions for success required a guaranteed initial market. In December, Hughes struck a deal with Sea Launch to purchase its first 10 launches and took additional options.

These deals don't represent corporate beneficence. They are the foundation upon which we are securing our future as a satellite manufacturer and service provider. We will use some of these launches to expand our current service business, while others will provide prospective customers an economical, efficient route to orbit.

As the world moves rapidly toward the privatization of telecommunications infrastructure, new opportunities provide—often demand—a new kind of cooperation between suppliers and service providers.

Just as new launch vehicle development requires cooperation, the increasingly private service provision industry also often depends on cooperative alliances for success. Earlier I mentioned AMSC and ICO Global Communications as providers of new mobile communications services. Both of these organizations had capital-intensive establishment and expansion plans. In order to pass the first hurdle on the path to long-term financing, both needed a series of initial investors. The same was true of Motorola's Iridium project. In each case satellite manufacturers provided some initial funding guarantees to jump-start those projects.

Just as it was in the early days of satellite communication, international cooperation remains the crucial ingredient in the recipe for the future success of the commercial communications satellite industry.

For the world to enjoy the rewards of the technologies I have described will require international cooperation not just among the manufacturers and service providers, but cooperation among and within governments as well.

As international systems such as the global mobile personal communications system come on line, the satellite communications industry finds itself where the airlines were years ago—in the position of having to negotiate landing rights. For these systems to be most effective, they must be available to the world's citizens without border considerations.

Which brings us to the point of standards.

Global systems can only work if the user community adopts product and system standards which apply internationally. Mobile telephones that work in New York should also work in Tokyo. Data transmitted from Senegal should be easily received and used in Istanbul. The challenge facing our industry is the design and delivery of seamless end-to-end systems.

To help bring focus and attention to these cooperative issues which we face as we move toward global mobile personal communications systems, the International Telecommunications Union will hold its first World Telecommunications Policy Forum this October in Geneva.

The primary focus of the forum, a three-day gathering of private and public sector leaders, is to reach agreement on policy and regulatory measures, at the national, regional, and international levels, required to facilitate deployment of the systems and to promote access to the services they offer at the most reasonable rates possible.

Communications applications and cooperation is truly a closed loop system. The applications drive cooperation and cooperation can in turn drive the creation of even more effective beneficial applications. While we may be a world of many nations, we are, in fact, a global village created under the umbrella of communications. Thank you.

Editor's note: Introduction of Mr. Takada appeared in Mr. Aldridge's opening remarks. The text following was provided in the paper/presentation entitled, "Development of Satellite Communications and Promotion for International Cooperation in Japan" by Akiyoshi Takada.

Mr. Takada: Thank you very much, Mr. Chairman, for your gracious introduction. I'd like to start by thanking my U.S. Space Foundation hosts for inviting me to this beautiful city, Colorado Springs. I am very pleased to be given the chance to speak on Japanese satellite communications.

In today's presentation, first I'd like to explain about the development of Japanese satellite communications. Next, I'll speak about the international joint satellite experiments related to GII (Global Information Infrastructure) and about the importance of the role of satellites for human resource development and the improvement of infrastructure in developing countries. Last, I'd like to talk about trends in the promotion of advanced R&D in Japan.

The history of satellite communications in Japan started with the launch of CS (Medium-capacity communications Satellite for Experimental Purposes) in December 1977, which was 15 years behind the United States. This satellite was developed by NASDA (The National Space Development Agency of Japan). However, most of its parts were based on technology introduced from the U.S. Moreover, the satellite was launched by a Delta 2914 rocket. As the following chart shows, Japan has acquired the technology of satellite development and has developed satellite communications while learning from the U.S., especially from NASA.

Communication Satellite	Launched Date	Launch Vehicle	Price (hundred million yen)	Contractor
C S — 3a	1988. 2.19	J A P A N	2 5 2	J A P A N
C S — 3b	1988. 2.16	J A P A N		J A P A N
J C S A T — 1	1989. 3. 7	E S A	unknown	U S A
J C S A T — 2	1990. 1. 1	U S A	unknown	U S A
SUPER BIRD-A	1992.12. 2	E S A	unknown	U S A
SUPER BIRD-B	1992. 2.27	E S A	unknown	U S A
N — S T A R a	1995. 8.29	E S A	unknown	U S A
N — S T A R b	1996. 2. 5	E S A	unknown	U S A
J C S A T — 3	1995. 8.29	U S A	unknown	U S A

Concerning the use of satellite communications in Japan, until the first half of 1980, NTTPC (Nippon Telegraph and Telephone Public Corp.) and government bodies such as the National Police Agency were the main users of satellite services. In 1985, when the principle of competition was introduced in the field of telecommunications services, two satellite communications carriers newly appeared.

Currently, JCSAT of Japan satellite systems and SUPERBIRD of SCC and NStar of NTT are under operation. N-Stars has started to provide a domestic mobile satellite communications service. A digital multi-channel broadcasting service is just around the corner. We are now entering a second development era for satellite communications as illustrated in the following chart.

Broadcasting Satellite	Launched Date	Launch Vehicle	Price (hundred million yen)	Contractor
B S — 3a	1990. 8.28	J A P A N	3 7 4	J A P A N
B S — 3b	1991. 8.25	J A P A N		J A P A N
B S — 3 N	1994. 7. 9	E S A	unknown	U S A
B S A T — 1 a	1997. plan	E S A	unknown	U S A
B S A T — 1 b	1998. plan	E S A	unknown	U S A

On the other hand, concerning the world, as a result of the initiative taken by the United States vice president, Mr. Al Gore, in advocating GII, many countries are now in the process of establishing their own national information infrastructures.

The significance and importance of the GII is, I believe, that anyone can take advantage of an advanced info-communications services anywhere, helping to increase communications between people and people, and between country and country. The goal is that mutual understanding will grow all over the world and contribute to world peace. In addition, the advanced information infrastructure will bring about a new multimedia industry and contribute to more employment opportunities *[Fig. SA-301]*.

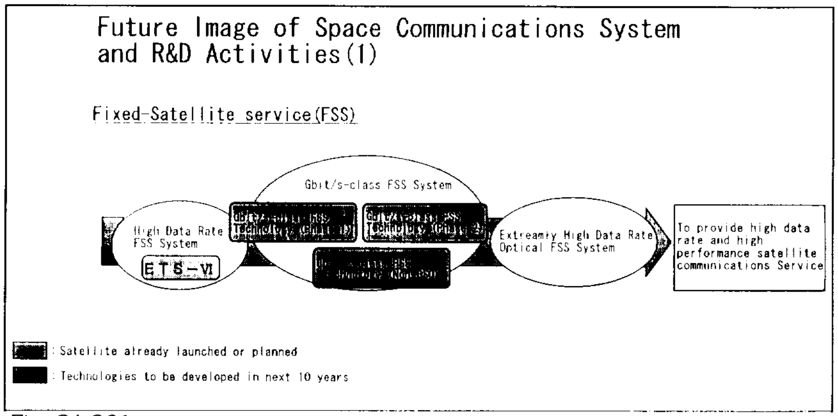

Fig. SA-301

In this context, much is expected of satellite communications because of the testified advantages, especially regarding wide coverage, flexibility of establishing communication links, mobility, and so on. Satellite communications are sure to play an essential role in the GII.

During the G-7 Information Society Conference in Brussels in February 1995, 11 international joint projects were adopted towards a speedy establishment of the GII.

In Japan, we promote each project in cooperation with other G-7 countries, and above all in satellite communications, we are promoting the Japan-US Transpacific High Data Rate Satellite Communications Experiments Project under the framework of GIBN, Global Inter-operability for Broadband Networks, which is one of the 11 joint projects.

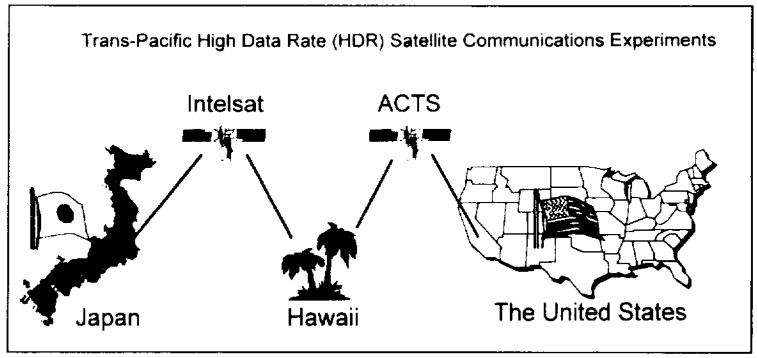

Fig. SA-302

A configuration of these experiments is shown *[Fig. SA-302]*; Japan and Hawaii are connected by INTELSAT, Hawaii and the U.S. mainland are connected by ACTS (Advanced Communications Technology Satellite.) The first experiments on this project are ATM-LAN interconnection at 45 Mbps and High Definition Video post production processing at 45 Mbps and 156 Mbps.

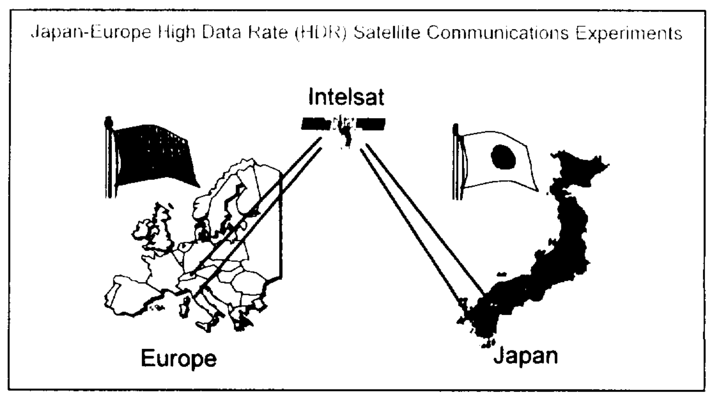

Fig. SA-303

We think it is important that such projects are promoted not only bilaterally like Japan-U.S. but also globally. In this context, the quadrilateral meeting on International Joint Experiments for Satellite High Data Rate (HDR) Communications proposed by my ministry, was held in Hawaii in November 1995 with participants from Japan, U.S., Europe, and Canada. In this meeting, we agreed to cooperate in establishing the GII through satellite communications. As a result of this meeting, we are to promote Japan-Europe High Data Rate Satellite Communications Experiments Project, and we are now in the process of holding discussions with ESA *[Fig. SA 303]*.

As everybody is aware, 1992 was selected by the United Nations as "International Space Year" (ISY) and a motion was approved suggesting that advanced countries should transfer developed space technologies to the developing countries. Based on the spirit of ISY, Japan started the PARTNERS Project among the countries in the Asia Pacific Region aimed at developing human resources among other objectives *[Fig. SA-304]*.

This project was conducted using the Engineering Test Satellite Type-Five (ETS-V), launched in 1987. The L-Band transponder was used on many experiments such as for Distance-Medicine, Distance-Education, Technical-Science, etc. The following chart shows past and planned launches.

Engineering Test Satellite	Launched Date	Launch Vehicle	Price (hundred million yen)	Contractor
E T S—V	1987. 8.27	J A P A N	1 5 0	J A P A N
E T S—VI	1994. 8.28	J A P A N	4 1 5	J A P A N
E T S—VII	1997. plan	J A P A N	3 2 1	J A P A N
COMETS	1997. plan	J A P A N	4 4 2	J A P A N

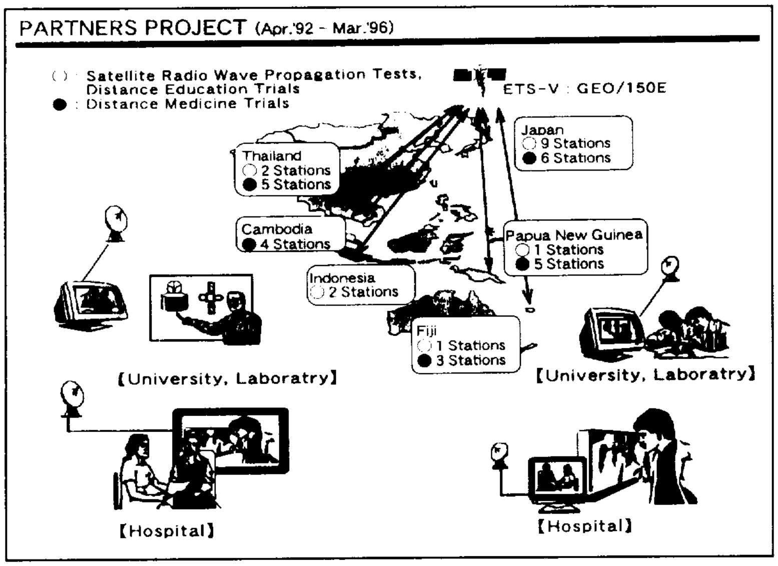

Fig. SA-304

In the U.S., there is a similar project conducted by the University of Hawaii called the PEACESAT Project, which covers the South-Pacific region. These two projects are closely related. Over the past three years, experiments conducted as part of the PARTNERS project indicate that satellite communications are effective in the fields of Distance-Education, Distance-Medicine, etc. In addition, the PARTNERS project was highly regarded by the participating countries.

The ETS-V is coming to the end of its life. The experiments were finished at the end of March 1996. However, there are many expectations for a continuation of the experiments in the countries of the Asia Pacific region. Therefore we have decided to conduct the next project called Post-PARTNERS project, which will utilize a private sector satellite, and we are now in the preparing stage *[Fig SA-305]*.

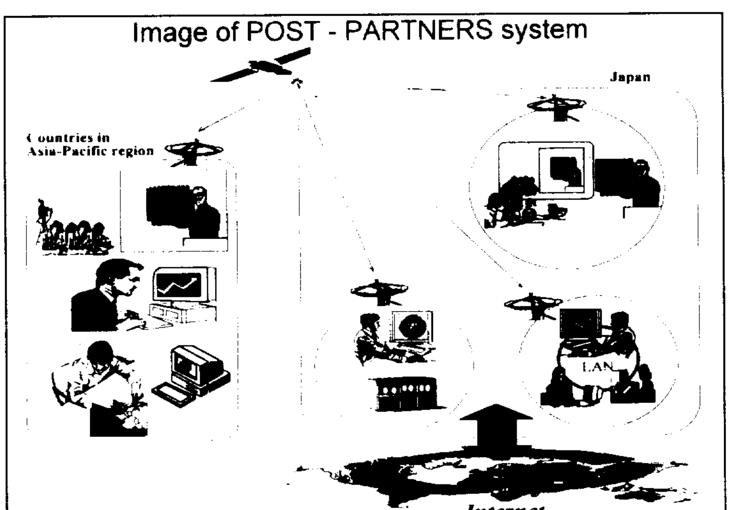

Fig. SA-305

The Information Society Ministerial Conference will be held in South Africa this May, with participants from developing countries. It is true it is very important to build a future Global Information Infrastructure using advanced techniques, but communication systems that are inexpensive and simple are required for developing countries which do not have sufficient public telephone lines. For example, a system which can be connected to the Internet conveniently might be of more importance than a high-tech system. As a result, systems such as the PARTNERS Project Systems have a role to play in the future GII.

The progress made to date in satellite communication technology is outstanding. It is not only quantitative, such as the increase of the capacity of Intelsat, but also very qualitative, which can be seen from the appearance of global satellite communication networks using non-geostationary satellites.

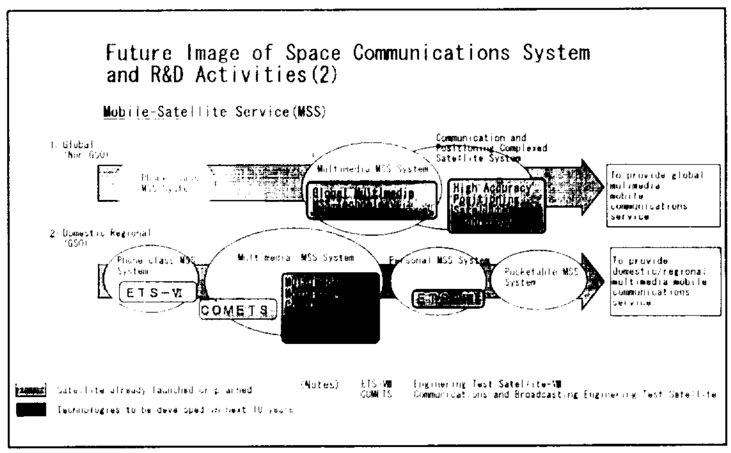

Fig. SA-306

Japan has been promoting research and development of satellite communication technology for 20 years. Based upon that experience, my ministry asked the Telecommunications Technology Council in January 1995 to report on the future direction of space communications systems and R&D promotion reflecting the changes now taking place around the world. The conclusions will be made public in May. The council notes that the meaning of R&D for satellite communication is:

- to create new services;
- to make revolutionary progress over a wide area of technologies; and
- to contribute not only to domestic but also global information infrastructure.

The council also predicts the future images of fixed-, mobile-, and broadcasting-satellite services. The summary is as follows *[Fig. SA - 306]*:

- With fixed-satellite services, the capacity and performance will be high. And Gbps class satellite technology and on-board ATM switching technology will be developed.

- In the mobile-satellite service, the non-GSO system which provides global services and the GSO system which provides domestic or regional services will be operated. And a multimedia system including visual communications will be promoted.
- In satellite broadcasting *[Fig. SA-307]*, high performance systems such as HDTV and ISDB which can provide multimedia service will be operated.

Japan shall try to improve its technology to create new services, to promote R&D, and to contribute internationally, based on the conclusion of the council which will issue its report in May.

In closing, I would like to express my great appreciation once again to the US Space Foundation for the privilege of taking part in this famous symposium. I would like to use this occasion to express my sincere wish that satellite communications continue their swift development, along with ever-advancing space technology. Thank you very much for your kind attention.

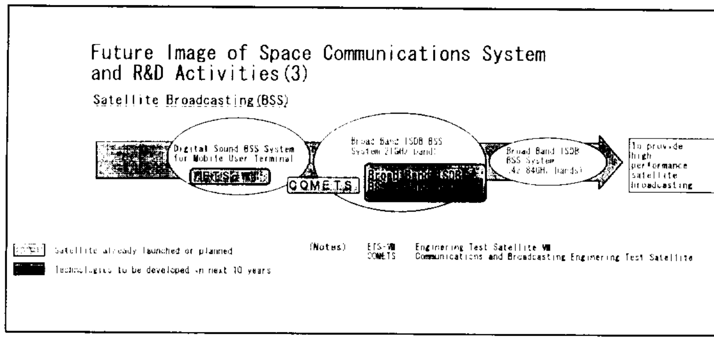

Fig. SA-307

Q&A

Mr. Aldridge: First question I'll read—I'll just come to them as I go—"due to the limited area in the geosynchronous belt, is the future of global communications moving to larger constellations of smaller more-capable payloads such as Motorola's proposed Iridium constellation?" I think what you're asking is that, again, are we going to think about lower altitude distributed communications systems—is that the future of global communications? Is there anyone in particular who would like to respond to that?

Mr. Gianelli: The answer is: It depends. I'll cut to the chase. I think for each application and for each business endeavor, the choice of the constellation is really going to be driven by the application and the economics. For example, the current systems of low altitude systems—the Big LEOS and the Little LEOS—are really driven to provide worldwide mobile communications. Those systems in and of themselves are going to be rather expensive to put up and we'll have to have a fair amount of the constellation in place prior to the revenue stream starting. In contrast, those with some of the GEO-mobile systems, those areas will provide very focused geostationary mobile communications over particular regions. And again, each one of those systems is attempting to solve a slightly different problem. Now with respect to the issue of coordination or the overcrowding of the geosynchronous arc, I think it really boils down to that of landing rights and frequency coordination, which the lower altitude systems are not immune from. I think anyone who's been following these systems in the press sees that there's a lot of negotiations that have to go on to ensure that the spectrum is available and that there aren't any interference issues that are raised. I think it really depends on the economics of the application.

Mr. Aldridge: Mr. Takada, would you like to comment?

Mr. Takada: I believe that communication policy should provide anyone the opportunity to communicate anywhere and anytime. Two, as an objective, we should develop communication links to anyone and anywhere, in the car, on the street, and so forth. To that end, we would have to develop a variety of communication networks using satellites or terrestrial mobile systems fixed optic fiber networks.

Mr. Aldridge: Next question is, "Dr. [Krishnaswamy] Kasturirangan discussed how satellites could improve irrigation and water and snow sensing; specifically what satellites are being used for this purpose?

Dr. Kasturirangan: We are currently using the optical remote sensing data for this purpose. What we try to do is to look at the extent of cover, the recessional feature of the snow as the snow level melts, and then there is a model which is used to estimate the snowmelt runoff that gets into the reservoir. Of course, the questions related to the personal distinction of the snow with respect to its age is another thing for which we need to look at different developments, particularly thermal, IR, and microwaves. The other thing, the we use only optical sensing. Here is actually the question of estimating the level of water, the availability on a periodic basis and then pontification of that using, again, the question of looking at the surface area with the models converting it into volume, and then transferring it into context of the in the downstream for radius agricultural related activators. So this is also done with optical sensing.

Mr. Aldridge: Before we go on to the next questions, Dr. Kasturirangan and Dr. Silvestrini have a press conference and are leaving in just a few more minutes. Are there any questions from the audience that would be specifically addressed that we could respond to now before they have to depart? There are no more here in my stack of questions that I can see. Maybe there are a few coming up. These are specifically for them. OK, Arturo, what will be the future of Landsat 7?

Dr. Silvestrini: I hope that it is going to go up. I have been associated with Landsat 1, 2, 3, 4, 5, 6. I'd like to see a 7. I'm sure that somebody in the administration and Congress will make sure that that thing goes up. I don't know more than that.

Mr. Aldridge: Dr. K., worldwide dissemination of education via satellite requires inexpensive television reception, especially in underdeveloped areas. Is India conducting research into development of very cheap TV receivers?

But there is one aspect which we are looking into, and that is with respect to the use of the communication transponder and the capacity for the communication transponder.

Dr. Kasturirangan: Right now we're in the process of proving of methodology for conducting education experiments, particularly, as I've said, in those three or four areas including developmental communications. And these, of course, do require massive deployment of receiver systems. The current level of receiver systems utilization are on a community basis, for example, a total village consisting of say 300-400 population will use one television for this kind of program. This is the approach so that we can cut down the number. But, still, if you talk of India, you are talking of 600,000 villages—so that is a kind of number then that one talks of. The current system certainly is a little on the higher side, economically. We are not making any special efforts to look into the cost reduction of television, but we are convinced that the first thing we will actually use will be black and white TV. Secondly, if we are able to produce enough numbers, there are probably production methods by which we should be able to cut down the cost. But there is one aspect which we are looking into, and that is with respect to the use of the communication transponder and the capacity for the communication transponder. Here we are looking into the compression of data since we are not really looking into the dynamic aspects of a scene. The compression ratio of between 8 and 16 or even higher is quite feasible for this kind of application. On that part, certainly we are doing some work.

Mr. Aldridge: OK, here's one for Arturo. What sort of effect has been expended for multi-spectral mapping of the ocean? How can we use that data for better ocean resource management, such as fishing, coral reefs and so forth?

Dr. Silvestrini: There are several initiatives that are going on right now, several satellites with ocean sensors. None of them, however, has reached the point where we can say that we are totally confident. Everybody's starting it and I think it's the next step in terms of ocean sensing. Even the Indian satellites have sensors to do that, or will have in addition to what they have now.

Dr. Kasturirangan: I would add a word to what Arturo said about this. Currently on board IRS-P3 we are flying a modular opto-electronic scanner system, which is a 13 channel spectrometer designed and developed by the German Space Agency. This is basically for ocean applications. The more advanced version of this, in terms of an ocean color monitor, is currently under development and that will be followed by a multi-frequency scanning microvave raiometer. This is a 500-meter resolution sensor which is also under development. These we plan to fly in the IRS-P4 satellite. Currently the forecast of potential fishing grounds has been operationalized in India using the NOAA thermal data, and that is very effective because the fish catch has gone up many times. We have recieved reports from the fishermen claiming fish catches increased by a factor of 3 to 4. What this ocean monitor will do is to extend this for deep sea fishing because you really deal with the parameters related to ocean primary productivity. So this we propose to have in the next satellite in the form of an ocean color monitor.

Mr. Aldridge: This one is also for Arturo. What are the major obstacles to the effective commercialization of remote sensing? Very simple question.

Dr. Silvestrini: Believe it or not, I think that the world is going towards commercialization of Earth-sensing much more than it was before. If you look around France, Russia, Canada, and now the Indians, they are all commercializing their data, all of them. We have been doing it for the United States. Now there is a problem here in the United States only. But, thank God, it's limited to a very restricted group of people in the administration who believe somehow that data are distributed free for everybody. And the rest of the world is going the other way. Are they dangerous? Yes and no. For us, no—now. Because we have the data, they don't. But later, they might. They might flood the world with free data, which will kill the commercial efforts of the Indians, the French, and of everybody else. That is the major problem we have. Thank you.

Mr. Aldridge: OK, I think we ought to let Dr. K. and Arturo go. They have a press conference and we'll get on with it. Thank you very much. OK, Bob Minor's got off easy, so far. So the next one goes to him. The GPS system has clearly established a track record for Earth navigation, but what is the future of accurate positional data for space navigation, such as docking, Space Station support, rendezvous or return to the moon?

Mr. Minor: I don't think there's any question if you read all the trade journals and you see what the plans are for the future, and I'm sure for many of these gentlemen here whose companies build a lot of satellites that many space navigation are going to be a very big part. I can give you one that I personally have some knowledge on. On the Space Shuttle today we use some of the traditional methods of doing space navigations, and I know very shortly we're already flying GPS receivers on the shuttle, and very soon we hope to have on board a triple redundant navigation system on the shuttle and I think most of the applications and many future applications on satellites is certainly going to be the navigation of choice also in the satellite world and I don't think that's going to be measured in decades. I think it's in years. Maybe somebody else here would like to add to that, but that's the way I would see that.

Mr. Aldridge: Another question for you, Bob. Will the CSEL system communicate via satellite or ground to air radio? The second part is, if via satellite will there be a civil version for backpackers, hunters, etc.?

Mr. Minor: First, the CSEL—which is a new product and, as we mentioned earlier, Capt. O'Grady helped demonstrate the need for such a thing—is going to be an item that is two-way communications. To give you a little comparison, Capt. O'Grady knew where he was, but the only way that he could tell other people where he was was from an open radio communications. With respect to what we're going to be doing with CSEL, is that this will be a two-way communications. It will be encrypted. It will have an encrypted mode that will keep that person very well protected. It will be via satellite.

Mr. Aldridge: Mr. Takada, do you expect to have much cooperation with the Chinese government in the next few years?

Mr. Takada: I'm not representing the Japanese government on foreign policy. But of course China is an important country in Asia, and we always are seeking to strengthen economical and cultural relations with China. But, unfortunately, up-to-date, in the satellite communications field, we have not heard any news related to future cooperative projects. Thank you.

Mr. Aldridge: Mike Gianelli, you mentioned that the only viable uses of space were communications and navigation. I think you meant commercial in that case. Do you believe that there is a need for continued access to space for other basic scientific research?

Mr. Gianelli: The context of the remarks had to do with commercial uses, where independent commercial entities would actually be able to make a profit and stay in business long term. I think on the navigation side of this equation, in terms of commercial navigation devices for everything from autos to yachts to aircraft, and the telecommunications industry, we've seen that. With apologies to Arturo here, I left out remote sensing because I think the jury's still out as to what's going to happen with remote sensing. There are a number of commercial ventures which are starting up and this is like where the commercial communications satellite industry was almost 35 years ago. Certainly there remains a need for access to space for scientific research, which is really going to define and help develop those new commercial applications.

The GPS system has clearly established a track record for Earth navigation, but what is the future of accurate positional data for space navigation, such as docking, Space Station support, rendezvous or return to the moon?

Mr. Aldridge: This is one that I think that you and Mr. Takada can answer. Due to the long acquisition and development process involved with developing a constellation, is it possible that the global information highway will outpace technological developments of space-based communication capabilities, such as how the 2.8 kilobit fax modem is out pacing conventional phone lines?

Mr. Gianelli: There are a couple questions wrapped up in that. I think the first one has to do with the rate of returns on communication technology as compared to the lifetimes of some of the assets that we're putting into orbit. Your typical geostationary communications satellite will have a lifetime from 10 to 17 years, and if we look at the rate at which we're turning with telecommunications technology, one might argue it's almost every 18 months. So the question is, how do you balance that? And I'm going to submit that that's an architectural issue in terms of establishing the communications architecture and the business plan. You want to make sure that you insulate yourself from that technology wave. I don't see these things as being necessarily competitive, but I see them as being complementary. There's this real thirst out there for bandwidth for every consumer and user and we in the telecommunications industry have to be smart in how we plan these architectures to assure that we can try and stay a step ahead of that demand curve to provide that bandwidth where it's needed and when it's needed.

Mr. Aldridge: When do you expect satellite bandwidth to become a limit to future growth?

I think as the demand increases in urban areas, fiber will satisfy that demand, and in rural areas we have a more distributed user population for the high bandwidth, and satellite communications can provide that quite easily.

Mr. Minor: That's a tough one to really answer. I think that the way that the capability is certainly going from a standpoint of what we're doing, the real issue is going to be: Can we keep up with the applications on the ground to how fast the satellite technology is growing? Both are moving fast and I think both the ground and satellite technology are amazing everybody. I think they're going to stay fairly well in kilter for some time to come.

Mr. Gianelli: If I could, I'd like to add something to that. If you look at what's changed in the satellite communications industry, it started out with point-to-point trunking services. We talked INTELSAT and Early Bird, and now with the advent of fiber, yes, you're going to hear a space telecommunications guy say that terrestrial fiber and space telecommunications are complementary, because the strength of fiber is going to provide an awful lot of bandwidth. The disadvantage is that it takes a long time to put that infrastructure in place. On the other hand, the strength of space communications systems is that it can provide that instant infrastructure to places which it's hard to reach with that mile of fiber. So I see these two technologies are complementary and that comes to the next point: I don't really believe there's going to be a limit on the bandwidth. I think as the demand increases in urban areas, fiber will satisfy that demand, and in rural areas we have a more distributed user population for the high bandwidth, and satellite communications can provide that quite easily.

Mr. Aldridge: I think you've also answered this question. Given the advantage in high rate for fiber optic links, what is the future of satellite communications between fixed points. It is a combination. There are cases where fiber is right, and there are cases where satellites are right.

Mr. Takada: I think the relation between satellite and optical fiber is very difficult for us to foresee and what direction we are going. In my experience, three years ago my ministry made public a plan to establish nationwide optical fiber networks by 2010. After that, the satellite industry people came to complain about that strategy, saying that individual communications will be inevitable in the future. So now we are going to clarify volume of our policy prospective as I explained in my presentation, so next month we will have an intermediate target for the relations between terrestrial and satellite links. Thank you.

Mr. Aldridge: Bob Minor, do you believe that the worldwide navigation system should be managed by the U.S. or be under the control of an international organization?

Mr. Minor: Consistent with the president's policy that he just came out with, I would certainly like to see it, because it can make economic sense to be basically a U.S.-driven system, but as the president said, I think he plans to open that up certainly to a policy board with, I'm sure, a broad area of representation. And hopefully in that respect there will be an international voice about one system that we can all enjoy across this world.

Mr. Aldridge: How can international cooperation in space be accomplished while protecting the intellectual property rights of the participating companies? That is, technology transferred via an international cooperative space program can dilute a company's competitive advantage in the international marketplace.

Mr. Minor: I think the foundation of the cooperation has to be mutually beneficial, and I see this protection of the intellectual property being no different than protection of intellectual property when we do a business deal with a Rockwell or a TRW. When you enter into one of these deals it's because you're going to get more out of it than you're going to give. I believe that that's the spirit we have to enter the international cooperation. It really has to be a two-way street, it has to be a partnership,and there has to be mutual benefit. If there isn't mutual benefit, it's really not a partnership. I think those problems can be worked. They are thorny problems and they take a lot of soul-searching, but I think they're very workable.

Mr. Aldridge: Anyone want to add to that?

Mr. Takada: In trade negotiations, we have many times from the U.S. government themselves in text of property guides so I hope the intellectual property is something like property of all mankind. But we have to respect that property, so I think it's better to have an environment to use more such property for the benefit of all mankind.

Mr. Aldridge: The question of global communication standards is admirable. However, its implementation is extremely difficult, in light of the competition for business negotiations. Should companies developing new systems provide information in open forum to promote establishing standards? How much risk does this incur and how much return is there in doing so? I think what they're talking about here is, how can we best implement these standards in this environment?

Mr. Gianelli: I always start with the customer, and when we talk about these standards, most of the new applications are oriented toward or aimed at the individual consumer. I'm an individual consumer as well as you are. The thing that drives us all nuts is when box A doesn't play with box B. I think if we look to the marketplace, we're going to see that that's what the marketplace is really looking for: standards which are going to promote affordability. This is like the international cooperation question, in protection of intellectual property. These are tough issues to work. There are a lot of equities that get wrapped up here. I think the global mobile personal telecommunications standard is a prime example. I think there are four—or is it five?—mobile phone standards around the world. GSM, the one that's used in Europe, I think, is the most popular, and it sure would be great if you could take your little hand-held cellphone and truly roam worldwide. As a consumer that's what I would want to do. I think if we look to the marketplace, the marketplace is going to demand those types of standards. The creation of proprietary standards or interfaces, while they may give a particular company an advantage in the short term, I think, in the longer term, standards are going to be the way to go. If you look at the personal computer industry, you can see a pretty good example of that.

Mr. Aldridge: Mike, since you're still on, the other question is, what are your views on the licensing approval allocation of radio frequencies for satellite developers?

Mr. Gianelli: We don't favor auctions, because that really puts the leverage in terms of folks that have the most money to put on the table up-front, and I think that's not what the telecommunications industry is all about. We'd like to see a little speedier process. There were some proposals made by the Australian government, or some interest groups in Australia, about actually having some earnest money or due process towards using the slots. I think the orbital spectrum is pretty much like real estate. If you've got the corner lot, you're in control. The process is not perfect, it does seem to work, and I think there are some proposals on the table to improve it.

Mr. Aldridge: Bob Minor, you're now experimenting with the idea of how firefighters can effectively use GPS to track their personnel and equipment. What limitations affect the GPS signal in the time of crisis—smoke, cloud cover, changes in weather, dust debris, etc.?

Mr. Minor: From a GPS standpoint, those kind of situations are very limited to us, and particularly as we look on to the next generation of 2-F satellites that will be, as we mentioned earlier, a second civilian frequency that will help us even more from the ionosphere and those kinds of things that do detract from the accuracy. There are really no limitations there. It's a fantastic system.

Mr. Aldridge: This is to our communications expert. We all see the explosion in communications around the world. The question is, what commercial or governmental activity is needed to ensure the privacy for individuals in satellite-based communications?

Mr. Gianelli: I think what the question is poking at is the issue of export controls for encryption devices, and there has been some progress there. I think again it's an issue of standards and having a governmental policy, and I believe the U.S. government at least does have a policy on export for encryption devices for business and personal use.

Mr. Takada: I think the new technology has presented us with new problems, including the protection of the contents for privacy or protection of children from not getting information. In Japan there are many discussions related to the new services and new technology and so called convergence of communications and privacy. Broadcasting is a public communications. Now we are facing the phenonemon of convergence of communications and broadcasting, so maybe we shall develop a new scheme to deregulate communications in the broadcasting industry.

Mr. Aldridge: I'm going to modify this question somewhat to make it more intriguing. Will Irridium, which means the large LEO low-Earth constellations, put INMARSAT, which means GEO, out of business. I think the debate is that with all these large numbers of low-Earth orbit satellites for communications: Is this going to put the big satellites in GEO-orbit out of business?

Mr. Gianelli: The answer is: It depends. Both systems have some strengths and some not-so-strong areas. As I said earlier, a large system like Irridium will provide relatively disadvantaged users a relatively straightforward way to communicate with the satellite system. Unfortunately, a system like that requires, because of the altitude, most of the constellation to be up and running to be able to provide initial service, so there's a great deal of infrastructure that has to be put up and has to be operating and replenished. On the other hand, I think the question was asking about ICO as well, which is an intermediate orbit satellite system that requires about 10 satellites to have the full constellation, and it can start operation with six of those satellites in orbit. It has some advantages over Irridium with respect to the look angle to the satellite position in the urban area. You'll have a higher elevation angle to the satellite. The investment to start a system like ICO is somewhat smaller than one like Irridium because of the amount of infrastructure that's required. Then if you go to geostationary orbit, you can focus the coverage on a geographic region. When you put the first satellite up the revenue stream can start. There are some real economic and business differences between those three systems. Personally I think there's enough room for all of them to survive and thrive because there is a lot of demand out there for personal telecommunications services. I think the future for geostationary satellites is very bright.

Mr. Aldridge: I have one last question that will be addressed to all three members of our panel. What do you see as the future of commercial space beyond Earth orbit?

Mr. Minor: The first thing that we have to attack before we can talk about commercial applications beyond low-Earth orbit is transportation costs. And if we can't come up with significantly lowering the transportation costs, the opportunity for commercial applications beyond LEO are going to be severely hampered. Certainly putting that aside, we, like a lot of companies, have looked at what are some of the applications. This question is a commercial one and I won't get into the military ones, but certainly things such as lunar mining—certainly as power generation there are some applications here that could be extremely advantageous to us here on Earth. But the major issue is how much does it cost to get there.

Mr. Gianelli: I think Bob said it pretty well—and maybe I'm too pedestrian in my vision here and am maybe focused too much in the near term. I think that to really keep on fielding these applications, the cost for access to space has got to come down, and, as I said earlier, in my remarks that's one of the reasons why we're doing a number of these partnering deals to increase the competition and have different approaches. I personally have not given a lot of thought to commercial applications beyond Earth orbit.

Mr. Takada: I am not proficient in commercial applications so my hope, from a policy viewpoint, is to provide any kind of services cheaper and cheaper to the consumers.

Mr. Aldridge: Well, in the tradition of the U.S. Space Foundation, we once again will end on time and we appreciate your attention. We appreciate your attention to the panel, and my appreciation to all the panel members for their time and efforts to present their views to this audience. Thank you.

Earth Sensing, Communication and Navigation Applications

Master Moderator: **Steven P. Scott**
Program Development Manager
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Session Chair: **Roy Gibson**
Former Director General
European Space Agency and British Space Agency

Speakers: **Dr. John S. MacDonald**
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David T. Edwards
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CTA, Inc.

W. David Thompson
President
Spectrum Astro, Inc.

Mr. Scott: Welcome back. Let's get going again with this afternoon's session. We'll now expand on this morning's theme of Earth Sensing, Communication, and Navigation Applications. Chairing this session is Roy Gibson. Roy has been director-general of both the European Space Agency and the British Space Agency and brings with him a wealth of international space experience. Ladies and gentlemen, please welcome Professor Roy Gibson.

Mr. Gibson: Thank you, ladies and gentlemen. I am grateful for the invitation to chair this panel and to make some short introductory remarks. Subsequent speakers here are all distinguished practitioners, and each one is going to give us some of his experience—the first three related to Earth observation, two more broadly, and Dave Thompson on communications. The speakers are very well-known, so to try to keep in our allotted time, I'm not going to repeat the introductions. And by that I don't mean any lack of respect for my colleagues. So now let's get down to business.

I want to talk, if I may, about public and private sector cooperation. Mahatma Gandhi was once asked by journalists what he thought of Western civilization, and after considering, he said he thought it would be a very good idea.

We're not quite as bad off as that in public and private sector cooperation, but there is a thought to bear in mind. Space activities are often divided between those financed by the public sector, like space shuttles and science projects, and those in which the private sector has taken the lead—principally the various types of telecommunication satellite programs. But even in the extreme cases, the distinction between public and private is perhaps an oversimplification, because even when the program depends essentially on private sector money, there is generally and inevitably an important public sector involvement; however unwanted this may be.

Even on a national basis, space programs these days can't really go ahead unless there is some contribution, in inverted commas, from the public sector. Even though the contribution may sometimes take the form of extorting for frequency slots, or, at the other end of the spectrum, of fairly altruistically help in showing compliance with international treaty obligations.

Similarly, with international cooperative programs, there's a need for a green light from the public authorities in virtually all cooperating states. When the program only concerns space agencies like NASA or the European Space Agency, they can generally be relied upon to deliver the necessary approvals from the non-space agency people, but it is a process that takes a long time.

Noticeably, in many parts of the world, the authority of the national and even the international space agencies is much narrower than it used to be. In most regions, an increasing number of ministries, departments, and agencies have to be consulted, and this consultation is by no means just a formality. The services provided by satellites—particularly what we now call the applications satellite—nearly always fall into the legitimate bailiwick of an authority other than a space agency. It has thus become a most important function of the larger space agencies to attempt to educate their colleagues in the basic facts of space activities. All too soon these entities are setting up their own bureaus and have their own space gurus. You'll understand that I'm speaking on the basis of European experience, and I don't know to what extent my remarks are relevant in the United States.

In Europe, the commission of the European Union, which is commonly referred to as "Brussels," is also taking a much increased interest in space affairs recently, not excluding defense matters. It's not, at least not so far as I am aware, an attempt to take over the European Space Agency, but simply that such things as industrial policy, industrial trade relations, and telecommunications liberalization which are all subjects that go well beyond the competence, in the legal sense of the word, of the European Space Agency. In fact, a new policy statement is expected very soon from the commission in Brussels outlining its future intentions in relation to all sorts of aspects of space. And I foresee a steady increase in Brussels' involvement.

My feeling is, that unless European ministers get some real proof that Earth observation is moving in this direction, in the foreseeable future they are going to be reaching to turn off the funding tap.

Now whereas the communications space sector has been dominated by the private sector people, with the public sector only involved peripherally, the Earth observation sector is still largely the preserve of the public sector. Remember, I'm speaking mainly of Europe. Earth observation satellites have been virtually all financed either by the European Space Agency or by EUMETSAT, which is the European organization that groups the meteorological services together, or else by the national space agencies, principally the French CNES with its SPOT family.

Although for decades, governments have been encouraging space commercialization (I know it is a somewhat discredited term), the space element has been done by the public sector, and the private sector has been active practically entirely only on the ground, and thus we have developed private companies like French SPOT Image, Swedish SATTELITBILD, and in the U.K. the National Remote Sensing Center, Ltd. And all three of these are charged with processing, archiving, and distributing satellite imagery, and they sell to a variety of customers. We should note, I think, at this stage that a large proportion of their sales are still to the public sector rather than to the private sector.

These three companies, which have been formed in Europe, together with many other smaller value-added companies, seem to make a reasonable living, but we need to remember that their combined turnover is probably not more than $80 million U.S. Eighty million U.S. dollars doesn't go very far in terms of financing satellite systems such as SPOT or the European ERS. These companies have been doing an excellent job in showing how satellite imagery, including radar, can be used. They've certainly increased the user community, but they are still dependent on the satellites' being provided by space agencies.

And this is a snag. In my view, many governments, certainly in Europe, are getting tired of putting R&D money into satellites that are, in fact, operational or semioperational systems. And there is a real danger that this funding source will dry up before we've found an alternative. It would, I think, be unrealistic to expect the private sector to jump in straightaway with 100 percent funding for follow-on systems, such as ERS. Nor am I really sure that we should be aiming to continue with the same sort of multipurpose satellites.

Continuity in my book can only be assured, first, by accepting a transition period during which the public sector provides part of the funding, either in cash or in the form of a bankable guarantee, that it is going to buy the service or the information when it has been produced, and, second, by moving to smaller satellites—smaller satellite systems designed to meet specific user needs. By this I mean, paying customers.

My feeling is, unless European ministers get some real proof that Earth observation is moving in this direction, in the foreseeable future they are going to be reaching to turn off the funding tap.

This is a spirit, I think, in which Radarsat and its marketing arm, Radarsat International, have been conceived. I think Canada has once again got it right; I hope that we in Europe are going to be able to put something similar together. Because there are a lot of complicating factors, not least the fact that there is an increased call for Earth observation satellite data to be classed as scientific and essential for the many big international climate and related programs. It is good to see that these programs are getting such support, but it is extremely hard to reconcile the needs of scientific programs with the imperative to encourage the private sector to invest its money in Earth observation. Scientists are wonderful people but they're not generally flush with funds to buy data.

The Committee of Earth Observation Satellites, CEOS, which Arturo Silvestrini mentioned this morning, is an organization that isn't really an organization. It is more of a club of all space agencies and those who put money into space agencies. It's only now starting to come to grips with the needs of the commercial Earth observation community. This isn't a criticism because it has been doing some excellent work, but thus far, CEOS has been concentrating almost entirely on scientific users. And some of us, like Arturo, people from SPOT Image and others, have been trying to open a dialogue with CEOS in the hope of having the views of the private sector taken into account by the big players in the public sector at a very early stage. Particularly in the field of Earth observation, the future to a large extent, in my view, depends on a better understanding between the two sectors.

For the purposes of dialogue with CEOS and with regional authorities, European companies have joined together under the banner of the European Association of Remote Sensing Companies. And we're hoping similar organizations will be formed in the United States and in other regions, and I know that some progress has been made. In my view, it is only in this way that we can get the private sector to influence the international public sector in Earth observation.

There is of course a whole new field of space activity opening up for cooperation between the public and private sectors—that of defense, including international defense space programs. Progress has certainly been made nationally, at least in some countries, to effect a convergence between the two. I believe in the next year we shall start to see some international initiatives for the same sort. It isn't that the Holy Ghost has come over these people and caused them to get together. It is that money is rather shorter than it was five years ago, and needs are rather larger.

Certainly in Europe, there are signs that national and bilateral or trilateral defense projects are going to give way gradually over the next 10 years to plan European defense space programs and possibly, hopefully, transatlantic ones too. But before this can happen, we've a lot of work to do understanding how best these two species, the civil and the military, can interbreed without producing a monster.

In brief, I believe that the implications in Earth observation by satellite are going to expand in the coming years through a more intelligent cooperation between different countries, but also by mixes of public and private entities. Now we've got some useful examples of what can be done, but I suggest it behooves the private sector to step up the pace. Government departments and agencies have got very important functions and qualities. There is even one of them in England that pays me a pension, and so I shouldn't knock them; but we've all recognized, I think, over the years, that innovation and new style of joint ventures are more likely to spring from entrepreneurial companies than from a government department. And so far we have not been all that active. But it's getting really very late, and I hand over to John MacDonald.

Earth Observation is a global INFORMATION Business

- It begins with a set of measurements which are:
  - taken by instruments which are:
    - carried on spacecraft
- Earth observation measurements combined with other data produce **INFORMATION**

Fig. ES-101

Dr. MacDonald: Thank you very much. In keeping with the theme of the symposium—"Space: Enhancing Life on Earth"—I think many of us believe, certainly I think the people in the first four seats on that panel believe, that spaceborne remote sensing systems will form the backbone of the information system that our descendants will use to manage mankind's affairs on this planet in the future in a sustainable way.

But today as Roy (Gibson) has already outlined, remote sensing, at least in North America and Europe, is at an important crossroads. What I like to call the pretty picture phase of our field is hopefully behind us and the future success of spaceborne observation, at least in North America and Europe, I believe will depend on the degree to which we stop thinking about Earth observation as a space business and start thinking about it as an information business.

Earth observation is a global information business *[Fig. ES-101]*. Space is a means to an end; it is not an end in itself. This global information business begins with a set of measurements that are taken by instruments carried on spacecraft. On that slide in that first bullet the reduction in the size of the fonts as I move down through the sub-bullets is deliberate. The most important thing is the information; the least important thing is the vehicle that happens to carry the instrument there to get the information. Earth observation measurements, when combined with other types of data, produce information. I note combination with other types of data. It is very rare for a set of Earth observation measurements by themselves to solve a problem.

The ultimate purpose of an operational Earth observation system is to deliver measurements, which, when combined with other information, can be transformed into useful information that serves the needs—remember that word, needs—of a community of users

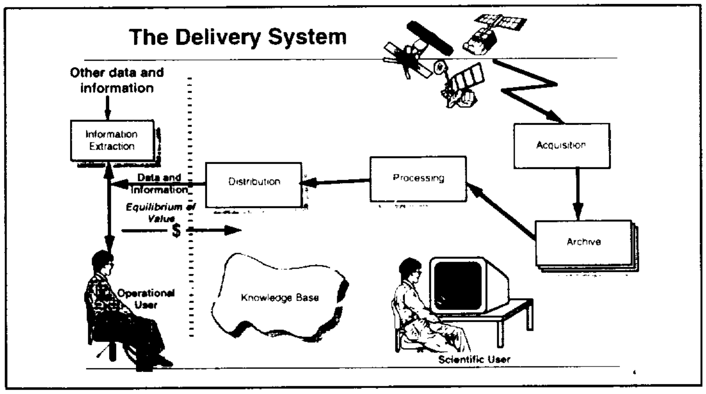


Fig. ES-102

who have an economic, social, or strategic requirement for the information the system produces. That's the objective of an operational system. If, and there is a technical point to be made here, if these measurements are to be successful in accomplishing that objective, they must be accurately calibrated. This implies we must treat them quantitatively rather than qualitatively, and they must be accurately located in a predetermined coordinate system.

I want to just digress for a moment to support something that Arturo Silvestrini said this morning. This is a concept that has always been understood by the Indian Space Agency, ISRO, the Indian Space Research Organization. Like Arturo, I have been interacting with the Indian people for more than 20 years, and I can tell you that they have always had their focus on this kind of concept.

Let me begin the rest of the talk, then, with a couple of definitions. I think it is important that we understand the operational user and the scientific user. The operational user is one who uses information derived from Earth observation data for routine environmental or resource management, strategic or mapping purposes, and so on. Such a person participates directly in the economy. Output from such a person has direct economic, social, or strategic value. Remember the word value. Information derived from Earth observation data therefore has economic, social, or strategic value to such a user. The operational user is a generator of wealth, one who directly tries to improve the quality of life on our planet. Considering the point of view of the system itself, the operational user is a customer, and those of us in the private sector all know that the customer is the most important person you deal with, because customers pay the freight.

The scientific user, on the other hand, is one who uses Earth observation information and data to gain an understanding about how such data can be required and to gain an understanding of how the Earth system functions. Such a user is a generator of knowledge. Such a user is not a customer. The scientific user isn't the customer. The scientific user—because he or she creates the knowledge base—is part of the delivery system. One problem we have here in the United States—and in Canada and Europe—is that we tend to regard the scientific user as a customer, but, as Roy (Gibson) has already mentioned, the scientific user doesn't have very much money.

The next overhead illustrates this in diagrammatic form *[Fig. ES-102]*. Here you have the operational user on the left, and that vertical purple line is meant to distinguish what is customer from what is supplier. You have the spacecraft up in the sky. You have the acquisition system, the archives, the processing, and the distribution systems, the scientific user sitting in there getting data from everywhere trying to figure out how to use this stuff, creating the knowledge base—the knowledge base, by the way, upon which everything else in the system depends.

On the left side, you have the operational user taking Earth observation data and information, trying to extract information by combining the data with information from other sources. There is value in the data and information that crosses that purple line. There should be money going in the other direction, which maintains an equilibrium in value. The concept here: If you're going to build a business, you have to have a market. A business is something that serves a set of needs that have a certain value for which it is compensated. What this concept of equilibrium of value leads to is a potential pricing policy, which is on the next overhead. And it's—what's sometimes called—a two tier policy. Many people in this country think this is a terrible thing to do, but it follows logically from the arguments I have made.

The operational user pays market price, in which the value and the price are in equilibrium. I have friends in the oil industry who think Arturo's prices are cheap, because as one of my friends put it, "If I can save two days on a seismic crew with a few thousand dollars for an image, it more than pays for itself, and I use only about 5 percent of the image." Scientific users, on the other hand, because they are creating the knowledge base, can pay cost of reproduction; they can't afford anything else anyway and the knowledge base has value, provided a) they're doing bona fide research, and b) they undertake to take the results in the public domain immediately. That's the *quid pro quo* for getting free or low-cost data. Remember, the scientific user is not a customer. The scientific user is part of the delivery system.

I mentioned earlier that a technical aspect of all of this is often overlooked. And it is the fact that quantitative measurement is required for both scientific and operational use. Why? Because in order to meaningfully combine Earth observation measurements with data and information from other sources, it must have some physical meaning. You must be able to integrate it into your models. You must be able to position it as accurately as you can, so you can get the information from the same location and compare it. Similarly, you must be able to reliably compare information acquired at different times, possibly with different instruments, and interpret the differences in the context of what else is known about the area of the globe that you are interested in. You can only do this if you calibrate and locate accurately. And finally, you express these quantitative measurements in terms of physical variables that have meaning in relation to the models used to describe the situation at hand and predict future trends.

The next overhead diagrams this concept *[Fig. ES-103]*. Here you have, on the left, physical measurements from remote sensing sources, physical measurements from other sources, and other data—a description of what is. That's what a remote sensing system does; it looks at the Earth and tells you what is. A model of these Earth processes is your thinking space that you're trying to understand. Models are very often built by the scientific community and used by the operational community. The operational user, over there, is perturbing the model, understanding the response, and trying to understand the implications of these things so that action can be taken.

I've mentioned a little about calibration and location *(Fig. ES-104)*. This overhead is one that I put together a number of years ago to emphasize the importance of the digital elevation model. But it also serves—when you've got only 15 minutes—to talk about a couple of other things. On the left, it shows the importance of the elevation model in terms of reflectance modeling, but it also gives you an idea of the complexity of the process of making optical measurements from space. The atmosphere is what you have to look through. You must compensate out the atmosphere if you are going to calibrate the data. It's a solvable problem; it's a complex problem. Have we ever yet, at least in the civilian world, flown a sensor, a high-resolution optical sensor, and at the same time boresighted with it, flown an atmospheric sensor to sense the atmosphere so you could correct for it? The answer is no. I don't know why we're so stupid, but we don't do those things.

The other two graphs up there simply show you the importance of the digital elevation model in getting the geometric correction of the data for the optical case and the radar case. These are vitally important in order to be able to integrate data, as I said before. Do we have elevation models of the world? Not many. Even the DTED-5 isn't good enough for many of the things we try to do even, with the civilian sensors. And it doesn't exist for very much of the world anyway. As for the digital elevation model, we know now how to acquire it from space using radar interferometry. The digital elevation model is absolutely critical to being quantitative about this stuff over the land.

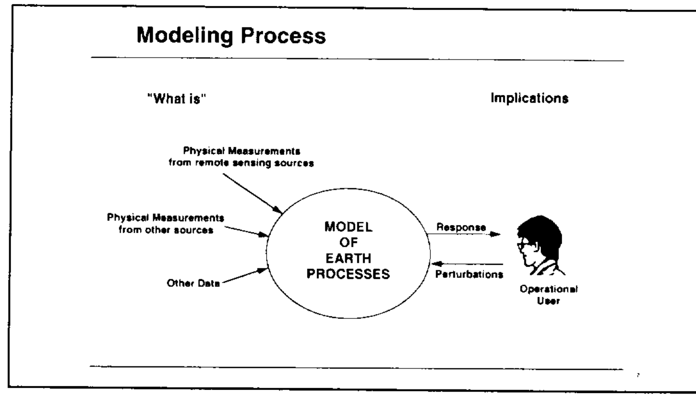


Fig. ES-103

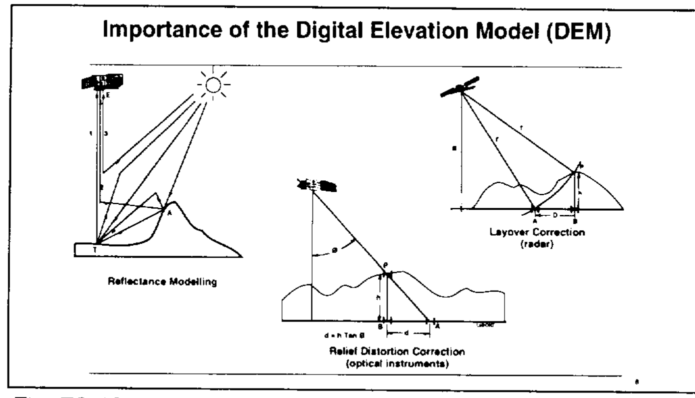


Fig. ES-104

In closing, I'd like to leave you with three questions, and I think we have to ask ourselves these questions as we look to the future in developing Earth observation systems. And we have to ask them in the order illustrated in the callout. The first two go together: What are we going to measure? and Why are we going to measure it? If there is no need to measure it, there's no point in putting up a system. The answers to those two questions are not simple. It takes a long time to understand these things. But I think that now, as a result of more than 20 years of civilian remote sensing at any rate, we do have the ability to ask and answer those questions.

Three Questions:

- What are we going to measure?
- Why are we going to measure it?
- How are we going to measure it?

• Instrument combination → Spacecraft configuration → Orbit (launch)

Once you've answered those two, then you ask the question: How are we going to measure it? That leads to an instrument combination, which in turn leads to a spacecraft configuration to carry those instruments and an orbit to make the measurements in the correct way. And finally the launch system to get it all up there. That's the order in which you should think about these things. What have we been doing for the past 20 years? More or less the reverse of that. We fling something up into the sky and then say, "What are we going to do with it?" So those are my thoughts on the future of Earth observation. Thank you for listening.

Dr. Felsher: The title of my talk this afternoon is "The Remote Sensing Industry," a title certain to elicit from you an appropriate combination of smiles, sighs, or smirks—and, angst, applause, or apathy—depending on your current or past professional lives. In fact, some would insist that its 50-plus years, post-World War II gestation period has not yet come to fruition, and the remote sensing baby is not yet ready to birth, and there is no remote sensing industry. They are wrong, of course.

The remote sensing space segment, those builders of launchers, constructors of spacecraft, and fabricators of sensors, many of whom are represented in this audience, can attest to that fact. Insofar as the ground segment is concerned, by our count—and here I'm referring to the Washington Remote Sensing Letter that I publish—in calendar year 1995 there were 136 symposia, workshops, conferences, conventions, and other open meetings held throughout the world, dealing with remote sensing and GIS applications, research, and technology.

Remote sensing space and ground segment applications cover as broad a discipline spectrum as can be imagined, literally. We deal, in the space segment, with all aspects of engineering and technology, from antennas, to materials, to photovoltaics, to propulsion—and everything in between.

Note that the annual meeting of ASPRS—the American Society for Photogrammetry and Remote Sensing—our professional society, will take place in Baltimore in two weeks, and it will draw more than 4,000 registrants to the Baltimore Convention Center filled with 140 remote sensing/GIS private sector vendors. That, ladies and gentlemen, is indeed the raw material for an industry.

And perhaps of somewhat more significance to the audience before me, here sitting in the shadow of Cheyenne Mountain, is the annual AFCEA Convention—the Armed Forces Communications and Electronics Association's Technet '96, to be held this June at the Washington, D.C., Convention Center. That meeting includes a complete mini-convention, or track, as it's called, dealing exclusively with geospatial information. One portion of that "track" is five complete sessions devoted entirely to a private sector solutions, as related to GIS and Department of Defense activities. That, too, speaks eloquently to the reality of a remote sensing industry, a burgeoning industry whose existence can no longer be ignored.

In that connection, the incorporation of private-sector input into DoD mapping and imaging activities has recently been certified by a report of the Defense Science Board "Task Force on Defense Mapping for Future Operations," released by DoD barely seven months ago. As a member of that DoD task force, I shared with the other members the vision, from the task force report, to "provide digital distributed databases of geospatial temporal information as the foundation for military information systems." And we recommended, as forcefully as we could, that "DoD should shift from a paper map mentality to a digital distributed system," and significantly, insofar as my comments this afternoon are concerned, that DoD should, "exploit the commercial marketplace for imagery, hardware, and software tools, and services."

Beyond meetings, and thus further attesting to the universality of remote sensing, note that some 264 individual short courses were offered last year, around the globe, on topics directly related to satellite remote sensing and GIS. The diversity of these meetings and these courses is enormous. Remote sensing space and ground segment applications cover as broad a discipline spectrum as can be imagined, literally. We deal, in the space segment, with all aspects of engineering and technology, from antennas, to materials, to photovoltaics, to propulsion—and everything in between.

The space segment/ground segment linkage, represented by Earth station designers and builders, incorporates the whole range of computer sciences and engineering, from control and communications to image acquisition and data compression.

But it's in the ground segment that our industry's diversity is so evident and prominent. In the ground segment we deal with all discipline applications from agronomy to zoology. Pick up any general science textbook, look at the table of contents, and any subject therein listed has a remote sensing applications component, one that somebody, somewhere, is today pursuing using overhead imagery. Now, toss in the diverse aspects of multidiscipline and inter-discipline applications of remote sensing, as environmental monitoring, or land-use planning, or facilities siting, or coastal zone management—now mix in the more esoteric political and social sciences, such as economics, demographics, and, dare I say, national security—and we begin to understand and appreciate the sense of incoherence that appears to emerge, penetrate, and permeate though this industry we call remote sensing.

It is this sense of incoherence, stemming mainly from the very diverse nature of remote sensing applications, that has been the major contribution to the very erroneous perception that a remote sensing industry either does not exist, or, because of that very broad sweep of applications, it is so large and divergent as to make it impossible to put one's arms about it, and thus it cannot be grasped.

But I'm ahead of myself. Getting back to the ground segment, indeed, there are more than 400 companies, of all sizes, worldwide, that admit to being value-added remote sensing/GIS firms, and it appears that as a group they are willing to deal with every conceivable application.

And parenthetically, lest the point be lost, allow me to emphasize the fact that as we moved from the 79-meter spatial resolution of the Multispectral Scanner of LandSats -1, -2, and -3; to the 30-meter spatial resolution of the Thematic Mapper aboard LandSats -4 and -5; to SPOT's 10-meter panchromatic spatial resolution; to the 5-meter spatial resolution of India's IRS-1C—each leap in spatial resolution has been accompanied by a significant increase in sales of image information products and services by the private sector, with each step of refined resolution resulting in increased image purchases by existing market components. More importantly, whole new application markets, hitherto not active space imagery customers, have been brought into the fold, as spatial resolutions reached the threshold where the resulting image information could capture events considered significant to these new customers.

What new markets, then, can we expect to emerge over these next several years as the new commercial licensees as Earth Watch, Orbimage, and Space Imaging fly their more capable birds, and we have available 4-meter, or 2-meter, or 1-meter imagery? Yes, these are exciting times.

In addition, coupled with this increase of spatial resolution will be an enhanced multispectral capability as well, promised by Resource21. And beyond these electro/optic enhancements has been the appearance and availability of radar imagery from ESA's ERS-1, and Japan's JERS-1 and MOS-1. Also, Canada's ambitious RADARSAT has successfully flown, and we can now expect a flood of radar imagery to add to our commercial archives.

And of course, concomitant, but hardly secondary, has been the rapid development of software designed to digitally fuse, and otherwise seamlessly merge images from disparate image sensors. Now, couple all this with the computer revolution that has placed on our desktops an image interpretation and analysis capability reserved but a decade ago for mainframes, and we begin to truly appreciate the fact that, yes, the remote sensing industry baby is not only full term—it's here, it's hungry, and it's beginning to howl.

Which brings me to NARSIA. The North American Remote Sensing Industries Association is brand new. We're just starting out of the blocks. We have a letterhead and we have business cards. And we are drawing corporate members from across that broad space and ground segment spectrum of industries noted earlier. NARSIA membership includes spacecraft and sensor builders, such as Hughes Aircraft Company. It includes such current data providers as EOSAT and SPOT. It includes such future data providers as Space Imaging, Inc. And it includes value-added firms as diverse as Autometric, Inc., MRJ, Inc., PlanGraphics, Inc., and SAIC.

I'm going to wind up this talk by telling you a little of what activities NARSIA plans to undertake. And if this sounds like an open and shameless solicitation for corporate membership, rest assured that it is. My own introduction to remote sensing, though it wasn't called that then, was as a graduate teaching assistant in photo-geology at the University of Massachusetts in 1959, where I was introduced to the intricacies of the Kelsh Plotter. Technology has long since passed the Kelsh Plotter by, and the technological wonders that have, since those years been piled one upon the other, have served to move a once research- and national- security driven subject of esoteric exotica full-speed into the public and commercial arena. Where yesterday there was no possibility of privatization or true commerce in remote sensing, today there is no question but that the business of remote sensing is here to stay.

Where yesterday there was no possibility of privatization or true commerce in remote sensing, today there is no question but that the business of remote sensing is here to stay.

The big problem is that the very diversity of the industry and its applications has served to isolate the practitioners. Depending on your place in the space segment/ground segment/end user continuum, this has led to severe disconnects:

• As an example, we have no standards for data acquisition, delivery, and analysis, and hence the topsy-like resulting adoption of ad-hoc data formats.

• As an example, we have no clear definition of the boundaries of our related businesses, hence no feel for the lacunas, the interstices, and the overlapping activities within those businesses.

• As an example, we have no industry-wide, industry-driven mechanism for market research into evolving user requirements; hence no clear industry-wide understanding of current market trends or future market expectations.

• As an example, we have no recognized, influential industry-wide spokesperson who could respond to legislative branch laws and executive agency fiats; hence we have no organized input into the laws and programs most affecting our industry;

• As an example, we have no outreach activities aimed at informing the general public of the benefits already derived through Earth remote sensing, and those yet to be derived by a strong commercial remote sensing industry; hence the historic lack of citizen support as a public constituency and advocate on behalf of remote sensing;

• And finally, as an example, we have no industry-wide formal interfaces with institutions of higher learning; hence no means of instigating, affecting, and assuring an ongoing source of properly trained entry-level professionals who could take their places in our profession.

The panchromatic data is the highest spatial resolution remote sensing data commercially available today, collected on a regular basis.

The first step in alleviating these and other situations facing the remote sensing industry is to organize ourselves, en masse, as a group. And the larger the group, the more certain its voice will be heard. And if we define our group in the manner described earlier, that is, encompassing the space segment and the ground segment components of our industry, and including appropriate input from the end-user community, we will then have one significantly large group. And that group will be NARSIA.

We recognize, of course, that so diverse an organization as NARSIA will grow to be, it cannot count on its membership responding in a uniform manner to every situation. We do expect to encounter sufficient differences of opinion within our membership. Indeed, some tenets may be diametrically opposed. But as there is strength in numbers, so is there strength in the recognition of divergent views within a convergent context. As long as aims, objectives, and goals remain congruent, the tactics and strategies developed to achieve those aims, objectives, and goals can differ, can be discussed, and can be reconciled.

Ultimately, NARSIA's business is the business of doing business in remote sensing. We seek your corporate membership. A past issue of Washington Remote Sensing Letter containing NARSIA information, and a NARSIA application form is available at the literature table outside this room. Please take one with you and convince your management to seek corporate membership in NARSIA. We will be convening our Second Annual NARSIA Congress this summer, on July 25 and 26 in Washington D.C., so please leave me your business card if you wish to be placed on our mailing list to receive more information. I look forward to welcoming you as new corporate members of the North American Remote Sensing Industries Association. Thank you for your kind attention.

Mr. Edwards: Good afternoon. EOSAT and Antrix Corporation Limited, the commercial marketing arm of the Indian Department of Space, have joined forces to make present and future Indian satellite image data available worldwide for at least the next decade. EOSAT collects Indian Remote Sensing System (IRS) data of North and Central America at its Norman, Okla., ground station. EOSAT is also the exclusive distributor of IRS data outside of India's footprint.

IRS-1C, the most robust IRS satellite yet, was launched on December 28, 1995. Three types of data are available: panchromatic data with 5-meter pixels, multispectral data with 25-meter pixels, and wide-field multispectral data with 180-meter pixels. The panchromatic data is the highest spatial resolution remote sensing data commercially available today, collected on a regular basis.

In this presentation, we will look at the Indian Remote Sensing system, learn how EOSAT is fulfilling its commitment to be your one-stop resource for Earth information needs, and illustrate our commitment to provide the international market with additional satellite image data and Earth information.

The EOSAT-Antrix partnership provides major benefits for the remote-sensing community:

• with one phone call, users have access to a comprehensive portfolio of data;

• customers will benefit from more frequent coverage due to the availability of data from several satellites;

• Indian and LandSat data are also compatible for use together in image processing systems because both data sets are in the standard fast formats. This means that both are easily imported to image processing systems;

• with IRS-1C's advanced capabilities, the highest spatial resolution remote sensing data commercially available today provides new mapping capabilities demanded by all users;

• expansion of the number of ground stations receiving Indian data promises users an expanded base of global coverage now and in the future;

• similarities between data from the Indian satellites and LandSat 5 ensure a continuing supply of multispectral data into the next century.

India has a 17-year heritage of using remote sensing satellites for management of natural resources, and you heard Dr. Kasturirangan talking this morning a little bit about the different examples—he used some water examples. Now that they've been using remote sensing from their own satellites they've gone from 43 percent success rates with ground troop type work to 98 percent in terms of finding clean ground water.

The IRS program provides the most reliable and continual source of satellite remote sensing data for today and tomorrow.

The IRS satellite system was designed and developed by the Indian Space Research Organization, the research and development arm of the Indian Department of Space. The system is operated by ISRO, and data reception, recording, and distribution is handled by India's National Remote Sensing Agency *[Fig. ES-201]*.

The IRS system includes a series of five operating satellites *[see table below]* and four follow-on satellites to be launched in the next five years. IRS-A is decommissioned right now, but it still could collect data if there's a need in the marketplace for it. IRS-1D, identical to IRS-1C, will be launched in 1997 or earlier if market demand requires it. Three more P-series satellites are planned for launch from now to 1999.

Operating IRS Satellites

- IRS-P3 launched March 21, 1996
- IRS-1C launched Dec. 28, 1995
- IRS-P2 launched Oct. 1994
- IRS-1B launched Aug. 1991
- IRS-1A launched March 1988 (can collect data; now decommissioned)

Since the launch of IRS-1A in 1988, the IRS series has continuously collected high quality data. The data provide the synoptic view, repeat coverage, and multispectral information valuable for mapping and monitoring natural resources (water, vegetation, soils, and geology) and in helping to resolve resource management problems.

IRS-1C data are currently being received at the Shadnagar station, which covers all of India, and all or portions of surrounding countries (portions of Iran, Oman, Cambodia, and Laos; all of Pakistan, Afghanistan, Bangladesh, Burma, and Thailand), and at EOSAT's Norman, Okla., ground station, we acquire data of nearly all of North America, including southern Canada, Mexico, and most of Central America *[Fig. ES-202]*. The German station up in Australia is going on-line this month; actually as I'm speaking now, the

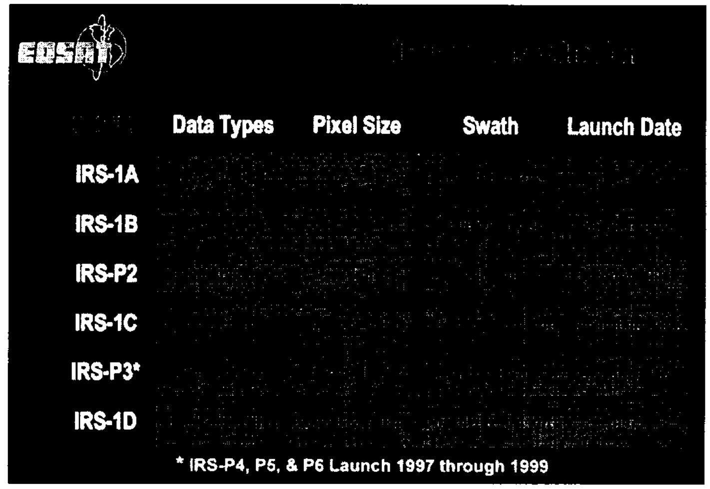


Fig. ES-201

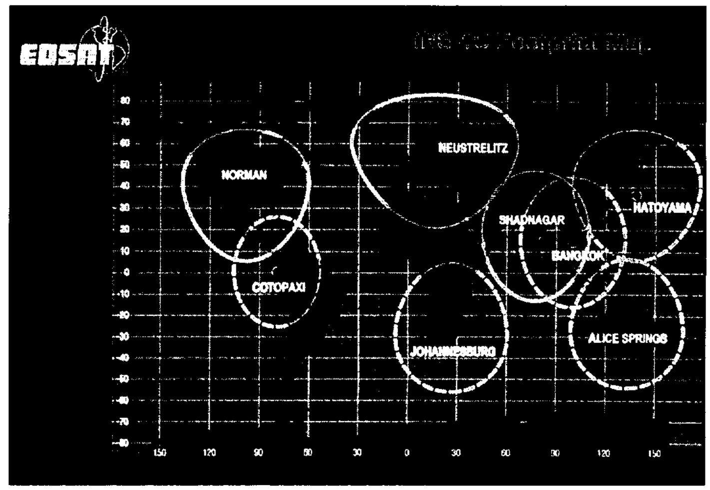


Fig. ES-202

installation is going on for the software. We have complete coverage several times over of IRS-1B data for the Norman footprint and are beginning to build the IRS-1C archive.

Ground stations that will be operational to receive 1C data in 1996 include Japan, Australia, South Africa, Thailand, and Ecuador, as you see illustrated up here, to be receiving by the end of this year. EOSAT is holding discussions with the other members of the global ground station network and expects as many as 10 will be on-line in 1997.

In addition, EOSAT's capability to deploy portable ground stations worldwide to collect IRS data (as well as LandSat and current radar satellites) will quickly expand the global archive of available data.

The IRS- 1C satellite circles the Earth in a near-polar, sun-synchronous orbit at an altitude of 817 kilometers, crossing the equator at 10:30 a.m. *[Fig. ES-203]* It carries three types of imaging systems:

• PAN: high resolution panchromatic data with 23km and 70km swath

• LISS-3: high resolution multispectral with 142km swath

IRS Constellation of Satellites and Sensors

Satellite	Altitude	Equator crossing	Design life	Launch	Instrum.	Spectral bands	Spatial resolut.	Swath	Repeat coverage or revisit
IRS-1A	904km	9:40 am	3 years	3/17/88 launched	LISS-1	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	72.5m	148km	22 days
					LISS-2 (A & B)	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	36.25m	74km	
IRS-1B	904km	10:35am	3 years	8/29/91 launched	LISS-1	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	72.5m	148km	22 days
					LISS-2 (A & B)	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	36.25m	74km A + B=	
IRS-P2	817km	10:30am	3 years	10/94 launched	LISS-2 (A & B)	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	32x37m	67km 131 km A & B	24 days
IRS-1C	817km	10:30am	3 years	12/28/95 launched	LISS-3	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23.5m 23.5m 23.5m 70.5m	142km " 148km	24 days
					WiFS	0.62-0.68 0.77-0.86	188m	774km	5 days
					Pan	0.50-0.75	5m	70km	<5 days
IRS-P3	825km	10:30am	3 years	1996	MOS-A	0.75-0.76 in 4 bands	2.5 x 2.5km	248km	--
					MOS-B	0.40-1.01 in 13 bands	720 x 580m	248km	--
					MOS-C	0.60-2.30 in 2 bands	1 x .7 km	248km	--
					WiFS	0.62-0.68 0.77-0.86 1.55-1.70	188m	774km	5 days
					X-ray Astronomy payload				
IRS-P4	--	--	3 years	1996	Ocean Sensor				
					LISS-3	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23m 23m 23m 70m	142km " " 148km	24 days
IRS-P5	--	--	3 years	1997	MAPSat				
IRS-P6	--	--	3 years	1998	Environm				
IRS-D	825km	10:30am	3 years	1999	LISS-3	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23m 23m 23m 70m	142km " " 148km	24 days
					WiFS	0.62-0.68 0.77-0.86	188m	774km	5 days
					Pan	0.55-0.75	<10m	70km	5 days

• WiFS: a low resolution multispectral with broad-area 774km imaging swath.

The Panchromatic sensor has 5.8-meter resolution (pixel-to-pixel spacing). The LISS-3 sensor has green, red, and near-IR bands with 23.5-meter resolution and a SWIR band with 70.5 -meter resolution. The WiFS sensor has a red and a near-IR band with 189-meter resolution. Panchromatic products have 5-meter pixels; LISS-3 products have 25-meter pixels; WiFS products have 180-meter pixels.

The IRS-1C sensors provide a complete range of datasets for numerous applications: high resolution data with narrow-swath coverage combined with low-resolution data with broad area imaging. This design characteristic favors land use/land cover monitoring in parts of the world where small, fragmented agricultural fields are spread across expansive countryside, requiring both an overview capability to assess regional conditions, and a fine-resolution capability to monitor health of individual crops and estimate crop yields.

With its first satellite launched more than eight years ago, the IRS program has documented thousands of data applications in experimental and operational projects. Urban planners and environmental managers are expected to benefit immediately from the panchromatic sensor. The high spatial resolution of the panchromatic band will allow differentiation between small features located close together, as often is the case in urban areas. The five-day repeat coverage, made possible by a pointing capability, will allow analysis of rapidly evolving environmental situations.

The panchromatic sensor collects data in a visible band. The products have 5-meter pixels with image sizes of 70x70 km and 23x23 km. Stereo images can be acquired with the off-nadir viewing capability. The repeat coverage is 24 days, or five days at the equator with the off-nadir capability (+/-26 off-track viewing).

Stereo imaging will interest those who use stereo pairs to create digital terrain models for three-dimensional analysis. Users will also be able to create digital orthoimages directly from the image sets. Orthophotographs, which are vertically and horizontally corrected images, are the most popular mapping product produced from satellite images.

LISS-3 data provide multispectral data users with yet another tool, very similar to LandSat TM *[Fig. ES-204]*. The similarities in spectral range and spatial resolution of data from LISS-3 and TM make it an excellent complement to TM archive data, providing data in nearly the same spectral bands with improved resolution. LISS-3 provides the continuity for future data acquisition.

The two data sets can be used together by resampling and histogram matching techniques. Both

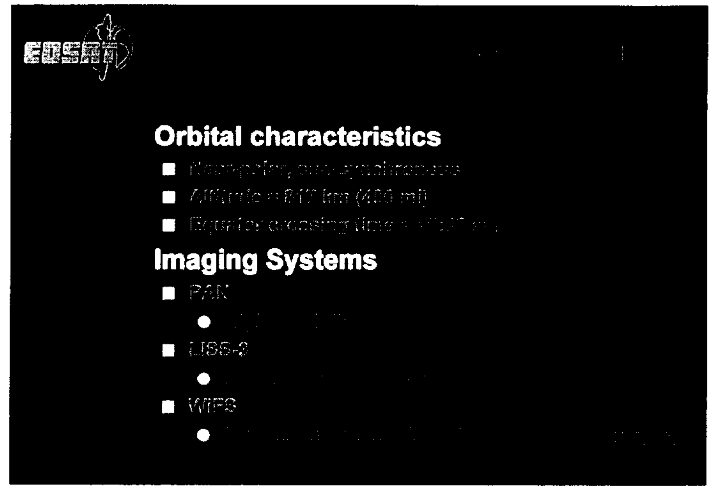
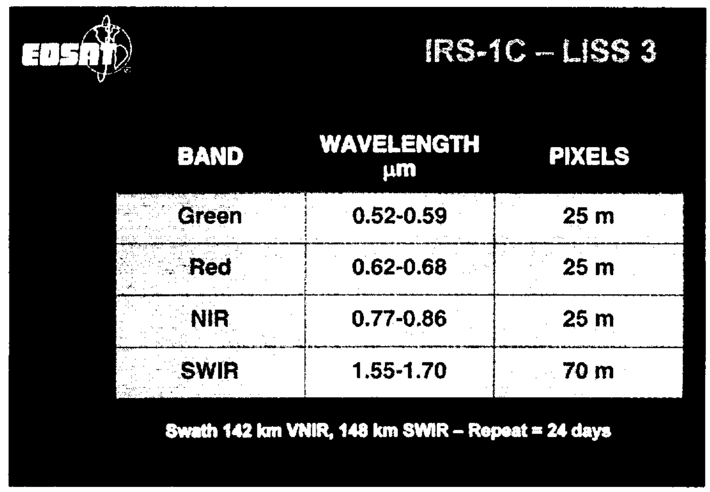


Fig. ES-203



BAND	WAVELENGTH µm	PIXELS
Green	0.52-0.59	25 m
Red	0.62-0.68	25 m
NIR	0.77-0.86	25 m
SWIR	1.55-1.70	70 m

Fig. ES-204

procedures are available on basic image processing systems. We expect new users of IRS-1C data will find its spectral and spatial characteristics ideal for several common applications, including discrimination and mapping of water, vegetation, and land-use and land-cover features.

Like its predecessor, LISS-2, the new sensor has four spectral bands (comparable to TM bands 2-5). The short-wave band will provide significant ability to distinguish very subtle differences in plant species.

WiFS sensor data will satisfy a user group overlooked in the recent flurry of high-resolution satellites planned—regional land managers, foresters, state planners, crop, and other monitoring services who oversee large tracts of land and require broad spatial coverage, and frequent temporal coverage, will be particularly interested in WiFS data. The WiFS sensor has two bands designed for vegetation monitoring (these bands are used to calculate vegetation indices)—a red and near-infrared band—comparable to NOAA's AVHRR data. The pixel size is 180 meters. WiFS collects data of a 740-km wide swath, and has a 5-day revisit capability, at the equator.

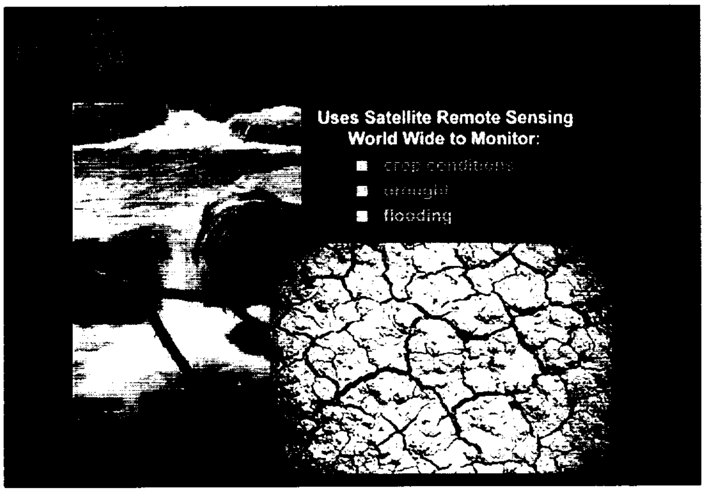


Fig. ES-205

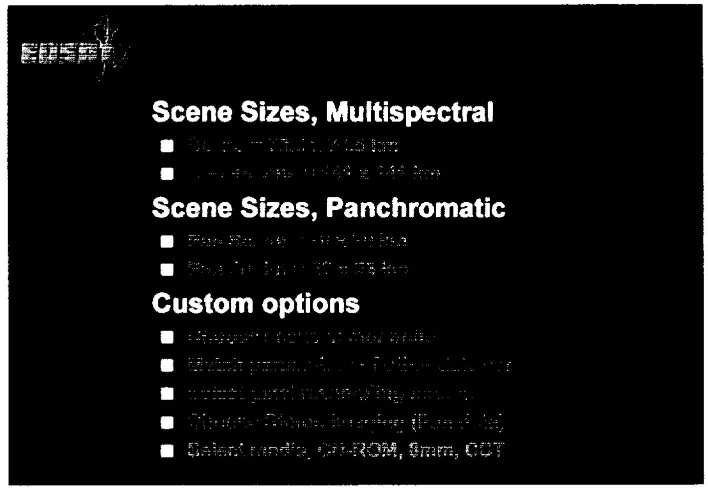


Fig. ES-207

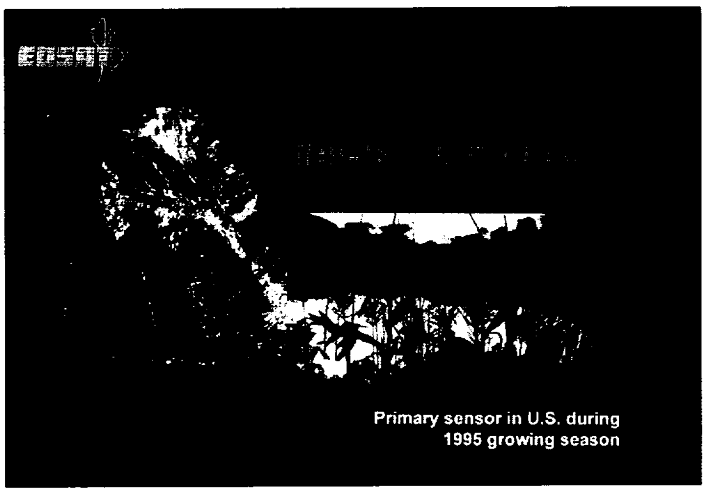


Fig. ES-206

DATASET	PIXELS	SWATH	REVISIT	ARCHIVE
IRS Pan	5 m	70 km	5 days*	1996+
KVR 1000	2 m	40 km	N/A	1984+
TM	25 m	185 km	14 days	1984+
IRS LISS-1	72 m	148 km	22 days	1991+
IRS LISS-2	36 m	145 km	22 days	1991+
IRS LISS-3	25 m	142 km	24 days	1996+
JERS-1	18 x 24 m	75 km	44 days	1992+
IRS WiFS	180 m	774 km	5 days	1996+
JERS-1	18 m	75 km	44 days	1992+
ERS-1 & -2	26 x 30 m	100 km	35 days	1991+

* with off-nadir viewing

Fig. ES-208

The U.S. Department of Agriculture's Foreign Agricultural Service monitors crop conditions worldwide to determine changes in production and to assist in drought- and flood-related relief efforts *[Fig. ES-205]*.

The Foreign Agricultural Service used IRS-1B LISS-1 data as their primary sensor in the U.S. during the 1995 growing season to monitor crop conditions *[Fig. ES-206]*. With its first satellite launched more than eight years ago, the IRS program has documented thousands of data applications in experimental and operational projects. With EOSAT's Norman ground station receiving data since April 1995, many agencies and companies in the U.S. have also used IRS data. The Environmental Protection Agency used IRS-IB to identify and characterize environmental conditions in areas of southwest Colorado (figure here) where natural resources are often damaged by contamination from abandoned or inactive mines, gravel mining and road construction and other activities. The IRS data were used to identify high-priority areas of waste contamination for focused evaluation.

Panchromatic and multispectral data are available in a variety of image sizes with several choices of map projection, ellipsoid, correction level (including pixel size) and format for direct input to GIS systems *[Fig. ES-207]*. Digital data is available on CCTs, 8mm Exabyte cartridges, and CD-ROM. WiFS is available in either individual scenes or as a continuous swath. WiFS can also be purchased as a subscription service, with the option for electronic data delivery.

EOSAT's full product line includes a multitude of complementary datasets to provide clients with their specific data requirements *[Fig. ES-208]*. When you listen to what John MacDonald had to say earlier today, it is so critical if we're going to bring together this fragmented marketplace to one that becomes organized from the standpoint of the information, or like what Dr. Kasturirangan said this morning, pull the application needs for the information and not because of the technological push because we just feel like flying a sensor. We need to be able to have organizations who work together very closely and offer datasets from a variety of satellite systems. Here you see datasets we offer from Japan, from ERS, and even when we don't offer it ourselves, we're one phone call away from helping you go to somebody like SPOT if its a SPOT data you need to solve your problem, RADARSAT and a few other people. And the reason is, we should all be sophisticated enough in this business to not treat it like a hardware competition but get more involved in pulling together a continuity of services associated with forming information from the datasets.

EOSAT's full product line orders may be placed directly with our customer services or through one of our global representatives. VISA and Mastercard are accepted for convenient payment. We also have a global distribution network of more than 125 companies to provide you with the full range of remote sensing data, services and training. Please call EOSAT or check our Internet home page for data samples and more detailed product and service information: http://www.eosat.com.

Sample IRS-1C data is available on EOSAT's home page at http://www.eosat.com *[Fig. ES-209]*. The home page includes information on the IRS-1C satellite, products and prices, worldwide reference path/row maps, and browse services for viewing the sub-sampled images available (to determine the location of clouds) and metadata.

IRS-1D, identical to IRS-1C, is currently slated for launch in 1997 *[Fig. ES-210]*. The satellite will carry tape recorders capable of storing data acquired over areas out of range of a ground station. IRS-P4, P5 and P6 will be launched before 1999.

EOSAT's partner, Antrix and the Indian Space Research Organization (ISRO) are committed to the IRS program, helping to bring yet another source of quality satellite data to users worldwide. EOSAT is committed to:

- offering "one-stop shopping";
- providing users with more frequent coverage due to the availability of data from several satellites (for environmental or agricultural monitoring; as well as better chances of getting cloud-free data);
- providing compatible formats so datasets can be used together in image processing systems (especially useful for merging data sets);
- providing products of IRS-1 C—higher resolution data, increased spectral bands, and more frequent coverage;
- expanding the ground network receiving and distributing Indian data (we will provide you with world coverage of data);
- ensuring a continuing supply of imagery into the next century (so you won't have to worry about where to get your data).

. . . which reaffirms EOSAT's commitment to opening ever more windows on your world. Thank you. I appreciate your time.

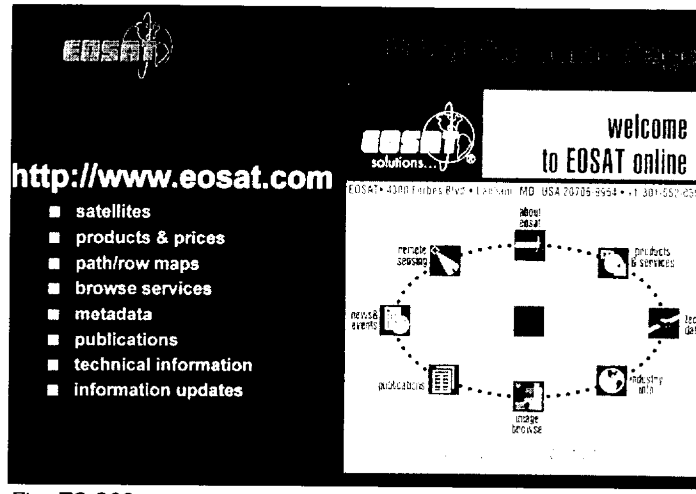


Fig. ES-209

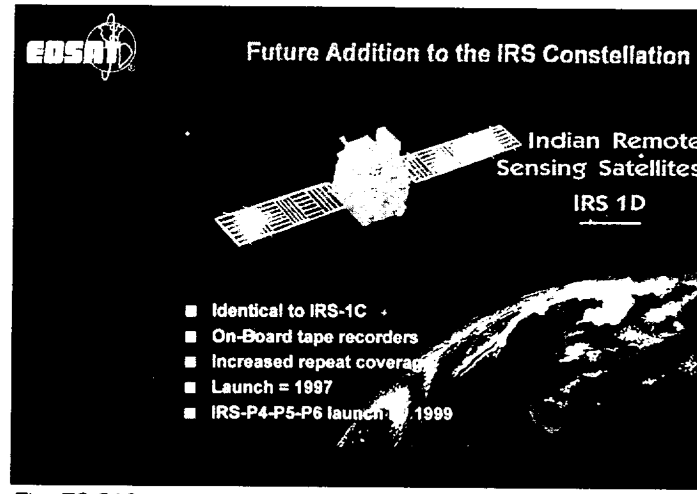


Fig. ES-210

Vice Adm. Ramsey: Good afternoon. I am going to address applications in all three areas: Earth sensing, communication, and navigation. I suspected there were going to be quite a few academics, scientists, and engineers in the audience, so I have included lots of pictures.

The focus of my comments is specifically on small satellites. Small satellites have contributed to demonstrate and provide applications that are competitive in the marketplace and will eventually result in lower cost to users. Now, what is small is in the eye of the beholder. For the purpose of my presentation, it includes satellites that are 150 pounds, like some communications satellites, and 1,000 pounds, like the STEP class satellite.

Small satellite capabilities have significantly evolved over a relatively short period of time. We launched our first small satellite in 1985, and at the end of this year, early spring of perhaps next year, we're talking of launching a small satellite in geosynchronous orbit to provide direct broadcast service to a unique country—Indonesia. We've also, in the same period of time, demonstrated some of these applications that are going to take on ever-increasing impor-

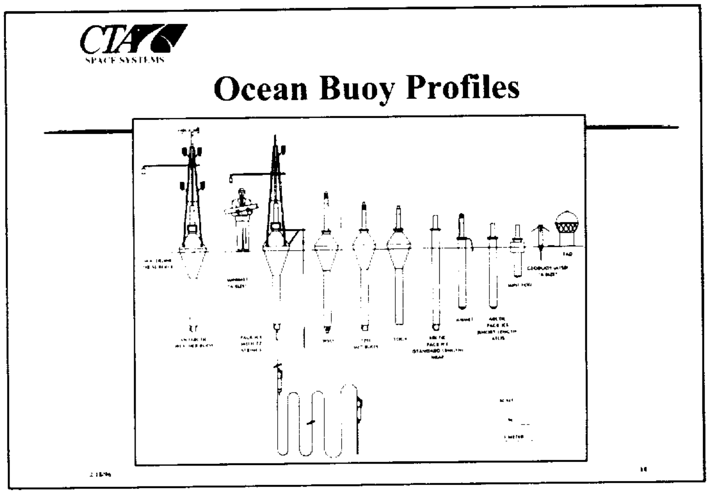


Fig. ES-301

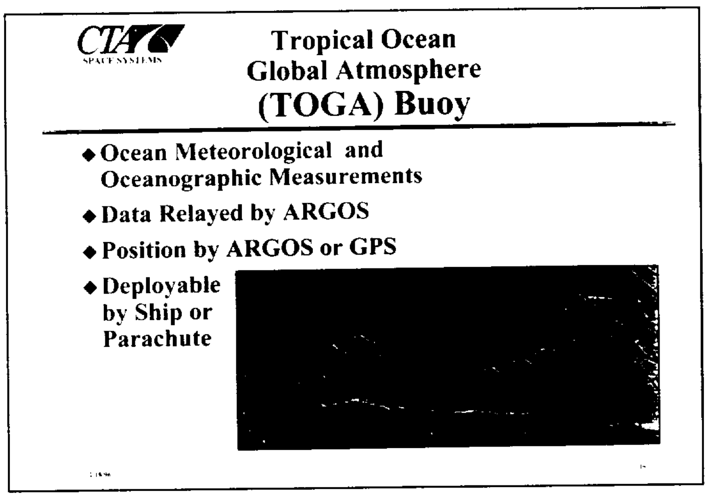


Fig. ES-302

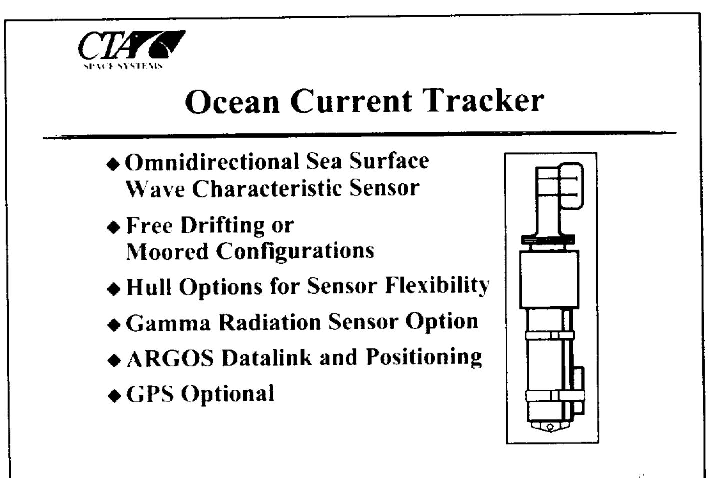


Fig. ES-303

tance as we evolve into the world of low-Earth-orbiting satellites. We've demonstrated stack satellite launches. We've demonstrated co-orbital multisatellite launches—seven satellites in a common orbital plane of 82 degrees.

Now, Earth sensing really falls in two categories, as we view it at CTA, and one of them is sens-

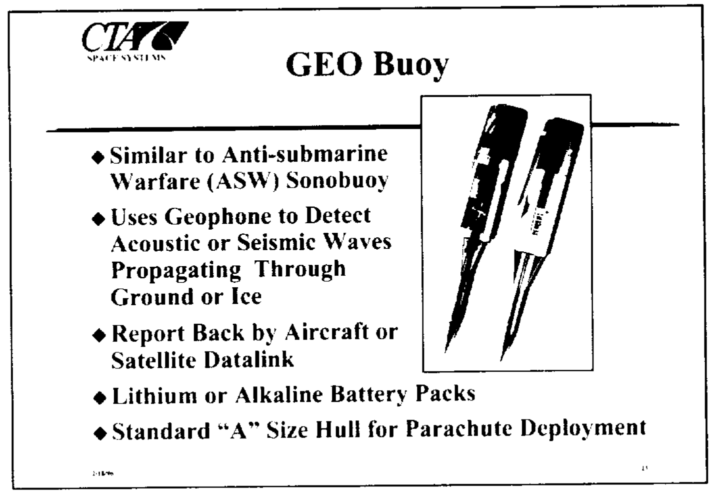


Fig. ES-304

ing the Earth from space, from satellites, and the other is collecting data in space from sensors on the ground. The Lockheed Martin, CTA, Inc., and NASA team is currently building the Clarke satellite that will launch in late summer of this year. And the key point with respect to this symposium is that it will provide a stereo, three-meter, in-track on-pass and also off-track viewing. It will also sense clouds and map cloud cover throughout the world. It's a 620-pound satellite, and it's very low power, about 235 watts. It has a gimble device, which permits stereo in-track and also a second gimble device so you can view off-track, plus or minus 30 degrees. Commercial teammates will exploit this data for their particular areas of market interests—Bechtel, CH2M Hill, and Suel Corp. Remote sensor applications are conceptually unlimited.

What of those applications that we are currently involved in? There is a growing need, it seems, for long-range remote collection of data. CTA has developed a family of remote sensors. I will address in my following comments the TOGA, the TAD, the GEO buoys, and the BWIS (Battlefield Weather Information System). Currently, we have a family of 11 buoys; obviously the fat ones on the left hand side of the view graph are erected or placed by hand *(Fig. ES-301)*. The ones on the right, the thin-sized, fit sonobuoy tubes that can be dropped from the air.

The TOGA buoy is one that's extensively used, and it measures meteorological and oceanographic parameters *(Fig. ES-302)*. Last year was a very active season for hurricanes, as we all know, and we used a lot of these buoys.

The ocean current tracker is a very inexpensive, frequently used tracker *(Fig. ES-303)*. GPS is common in all of today's models. So as they drift around the world in the various currents, major currents, you can get a direct readout of the location very accurately.

GEO buoys are designed to penetrate any type of soil, and they penetrate so that the sensor body, about six inches of it, extends above the soil *(Fig. ES-*

304). We dropped it from atop a six-story building, and it went right into the asphalt without any problem at all. It detects acoustic and seismic waves. We've taken that capability and provided a variation on the theme. In one application, we've provided a different sensor package on the GEO buoy so that it can be used for local weather data collection. You could drop it behind the lines by UAV or by a SEAL team, Rangers, helicopter, or whatever, and it gives you local weather information that would be of an extreme value to land forces and possibly air forces in the area. Another variation on the GEO buoy is a tactical surveillance system. This takes advantage of acoustic and seismic sensor packages through which you can detect possible intrusion or movement and by discreet spectral analysis even provide a degree of discrimination as to what type of vehicle—tank, personnel carrier, etc. is present.

The TIROS Arctic Drifter is somewhat unique *(Fig. ES-305)*. It has a gimbled sensor package inside this globe. The impact bag on the bottom absorbs the energy as you drop it from an aircraft, then it just rolls. This gimble seeks its equilibrium, and it ends up being always vertical so that the antenna can pop up, and you can transmit.

The next one, the Argos Data Communicator, has great potential. It's programmed for messages. It has GPS readout, and we put it on a merchant marine ship *[Fig. ES-306]*. Here it shows the plot of that ship, an hourly plot—hands-off operation. Just put it on the superstructure, forget about it. It comes on every hour; the Argos package on TIROS-N picks it up and reads it. Obviously, TIROS is not there every hour, so this can store seven to eight hours worth of data and messages if you want it to, pump it out, and then when the package picks it you can make a specific plot. Lloyd's of London would love to have something like this to track all merchant marine ships around the world.

Now let's look at the prototype communicator *(Fig. ES-307)*. Some of you may have seen the article in *National Geographic*; Will Steger used this on his trek across the Arctic. It has GPS readout, and he also files his dispatches. So the article that appeared in the *National Geographic* came via this communicator. Two of these communicators are currently being used down in the Antarctic by the chap who is trying to cross the Antarctic by himself.

In the communication applications, I want to touch briefly on two systems. A max - sats were stack-launched, and we launched those in 1990 propitiously because they were up there when Desert Storm came about. And the Marines used this extensively in support of the 2nd Marine Air Wing. They used it for logistics, administration, personnel—that kind of traffic that wasn't operational. In fact, it was so effective that the intelligence community found out about it and took it over, and the Marines had to find a backup system to get the information back. The co-orbital multiple satellite launch was in 1991, it was Micro-sat's. Seven of them were launched; unfortunately, the launch vehicle did not put them in the right orbit, so instead of living for three years, they lived for six months. But they did demonstrate the communications in an orbital plane,

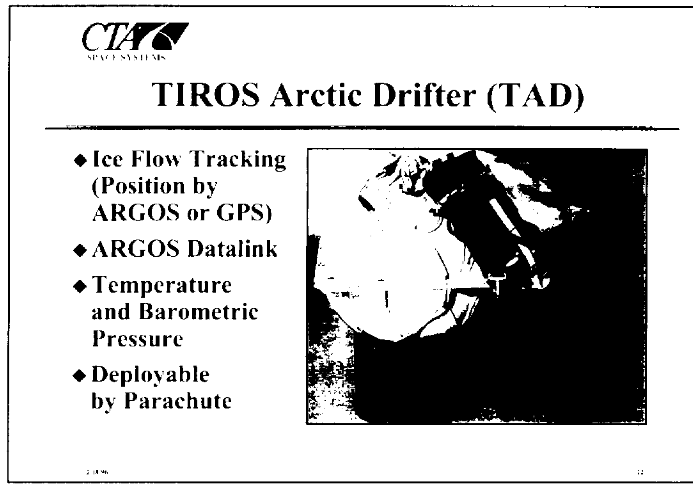


Fig. ES-305

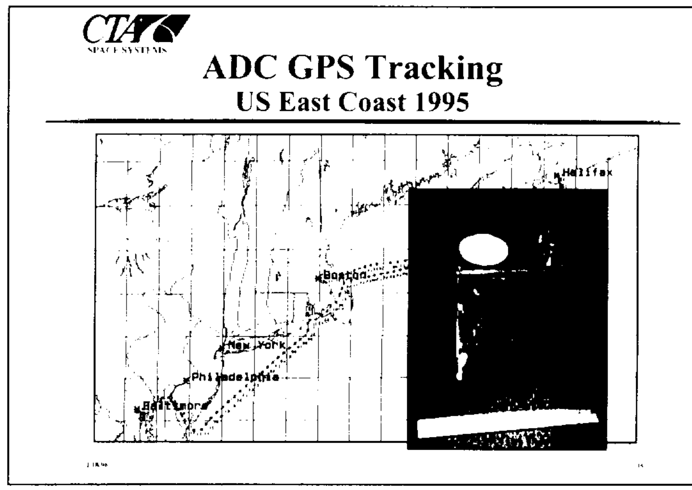


Fig. ES-306

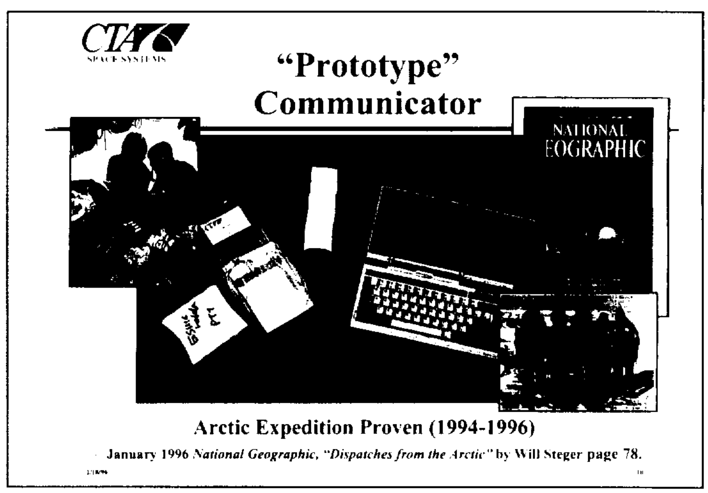


Fig. ES-307

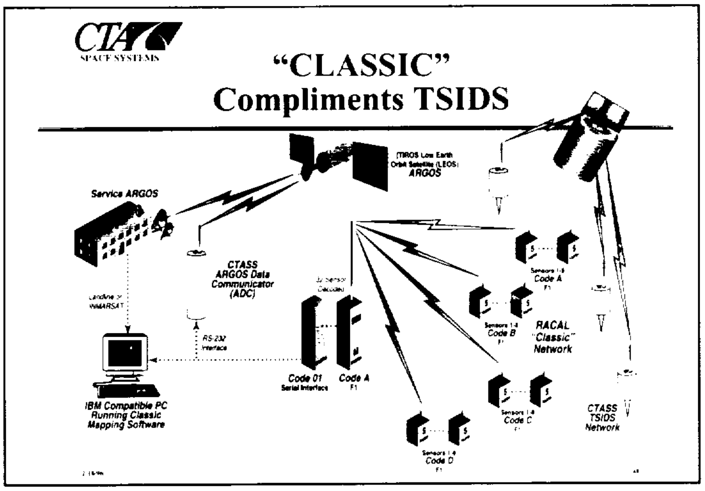


Fig. ES-308

from one footprint of the satellite, continuous footprint all the way around in that co-orbital plane. It's an application that we see being used by the ORB-COMMS, the Teledesic, etc.

With respect to navigation applications, I'll talk about Racal, which was the forerunner of our utilization of GPS in the control loop for attitude control of satellites *(Fig. ES-308)*. Racal was launched three years ago. It's up there performing very well. Racal was used to evaluate and test GPS attitude determination capability. Subsequently, we have refined it, and Rex 2, which was launched last month, actually has GPS in the control loop for the satellite. The Clark satellite will also have GPS as a attitude control. I think what's most interesting about this symposium is that at next year's conference we're going to see the proof of the pudding. Now a lot of the things that we're talking about today, in anticipation of, we're going to have actual commercial remote sensing experience. Earth Watch will be launched in late summer. Clark and Lewis will be both launched in late summer. LEO communications and ORBCOMM and others will be up there and operating. We'll have trackers on users that are moving, like semitrailers, tanks, etc., that are going to be able to give battlefield awareness capabilities, and navigation applications are going to be broadly used in a wide variety of satellite systems and controls. As Dick Vitale would say, "Wait until next year, baby." Thank you.

Mr. Thompson: Hi. I'm Dave Thompson, the president of Spectrum Astro. I'm from Phoenix, Arizona. Our company is also a developer of high performance small satellites. We historically have primarily been involved in satellites developed for ballistic missile research, ballistic missile defense research for deep space planetary exploration, and for technology demonstration and validation. The thing that I'm going to talk about today is specific application for space-based user-to-satellite communications.

As our company has been looking for diversification opportunities, one of the things that I became very interested in was this market for spacecraft-to-user voice operations. And I have been very fortunate having spent most of my time here in the United States, to have made four around-the-world trips in the past six months, visiting 15 or 20 countries three or four times. So I have sort of had a massive dose of foreign exposure here for the past six months, and I find that it has been very interesting, because I know a lot of us who are based here in the U.S. and are involved in the U.S. space industry, haven't had the opportunity or don't have the need to go overseas and see some of these opportunities. What I'm here to tell you is there are tremendous opportunities for overseas export of our technologies, not only space-based but ground based as well. I want to talk a little bit about that today.

In my very interesting trips, I found in almost every developing country I visited, on five different continents, a booming economy. I can't tell you how surprised I was to find that every road was clogged with vehicle traffic, every hotel was jammed to the rafters, every airline seat was packed a month in advance. If you have the impression that some of these Second and Third World countries don't have an appetite for your type of technology, you need to shake up your international marketing department and have them go over and talk to these people, because it's a very broad market over there. And the interesting thing is that a lot of these markets are just opening for the first time to U.S. exports, because a lot of these people have had closed markets for investment. So I think there is a tremendous opportunity for our U.S.-based companies to do this.

At the same time, space is only one element of the solution, and I happened to be in India three or four times and met with some of the senior telecommunications officials in India. One of the most interesting statistics that I heard while I was there is that there are 565,000 villages in India with no telephone service. First of all, I couldn't believe there were 565,000 villages in India, but I suppose when you have a land mass that large and a number of small villages you can come up with those kinds of statistics. The other thing that was interesting to me was that one of our foreign partners is a prominent attorney in India. He was telling me a story that it took him seven years to get his first telephone line, took him four years to get the second line, and he applied for the third line two years ago and it took two years. So this fellow has three lines. Now I think most of us who have had the experience of building a home here in the United States recently—typically you're putting four to six telephone lines in that house, and if it takes the telephone company more than a week to get the phone lines in, you're on the phone screaming at them saying, "Where's my phone lines?" So it gives you some idea of the disparity in telephone service. The other statistic I ran across was that half of the world's population is not connected and it has never made a telephone call. So if you can imagine how often we use a telephone, imagine what the market must be, once these people get telephones in their hands.

Now I have compiled some statistics which I am going to show you today. These come from a number of sources. They come from Spectrum Astro's in-house research. They come from a company called Pyramid Research, which is a funded research company located in the Boston area. It comes from Federal Communications Commission and Securities Exchange Commission filings that are on public record, and it comes from a public report by the MITRE Corporation.

It is just a top statistic in the developing world, excluding the Americas and Western Europe, by the year 2000 we expect a shortage of 350 million telephone lines worldwide *[Fig. ES-401]*. This is a traditional, voice telephone line, basic telephone service, 350 million telephone line shortage. Now let's take a look at main-line penetration in some of these areas *[Fig. ES-402]*. A main line is one circuit from the central office to the subscriber, meaning it could go to a house where there would be one subscriber family or it could go to a business where there would be several hundred users. In the world in 1988, we had 463 million telephone numbers you could dial. I didn't know this. This is pretty interesting stuff. You'd have to have a pretty big phone book to call all these guys, but by the year 1993, I think we had 612 million or 613 million. So it gives you an idea of the number of lines out there and the number of lines that are being installed by our World Telecommunications Administration in the 140-some countries which Pyramid Research monitors.

You can also see the disparity between the developing countries and the industrialized countries. We have an average of 51 phone lines in the industrialized seven nations and an average of four phone lines per 100 in the developing countries. And some of these countries have very low telephone penetration rates, as you would expect. I just picked a few examples which are shown there. Some of them are less than one telephone line per 100 people *[Fig. ES-403]*. Here it is shown graphically and you can see the graphic display of the industrialized seven nations again, which are all above 40 lines per 100 in direct telephone line penetration, main-line penetration, and then tapering back very rapidly as we move into places like Africa and Southeast Asia. And I have some more detailed statistics which I am going to show you *[Fig. ES-404]*. Basically, this is tabular data. On the left-hand side of the vertical line you can see the telephone penetration as of 1993, and on the right-hand side projected for the year 2000. And this happens to be the chart for northern and sub-Saharan Africa. You can see in the third column over there the numbers. The

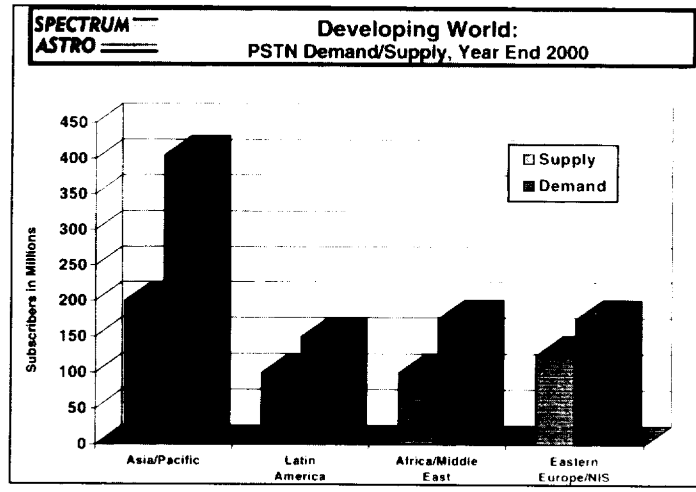


Fig. ES-401

SPECTRUM ASTRO

Main Line Penetration

"Main Line" - 1 Circuit from Central Office to Subscriber

	1988	1990	1993
World Total Main Lines (000)	463,879	511.220	613,809
Developing Countries (000)	132,360	155,647	206 754
Developed Countries (000)	331,519	355.573	407,055

Average 51 Phone Lines per 100 People - Industrialized Countries
Average 4 Phone Lines per 100 People - Developing Countries

1993 Main Line Penetration Per 100 Population (Examples)

Brazil : 2.68 India : 0.88

Sri Lanka : 1.03 Indonesia : 0.90

Fig. ES-402

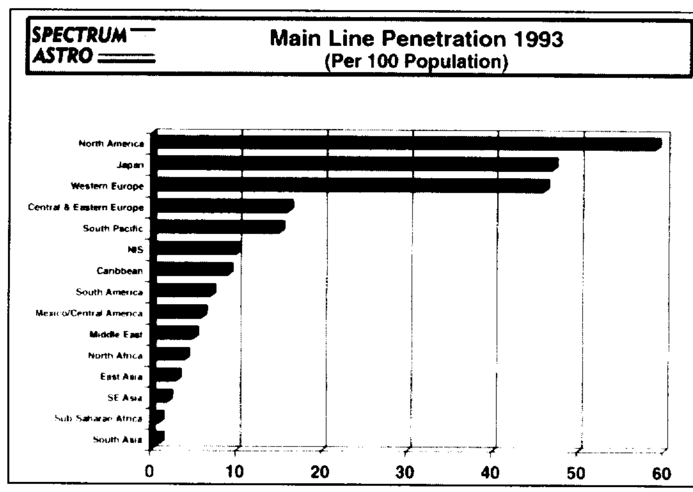


Fig. ES-403

United States' number here is more than 60 lines per 100 people. I don't think there's anybody up there that's much above 10, except for maybe South Africa. And some of these countries are down as low as one and fractions, such as Ethiopia and Cameroon.

And here is another chart *[Fig. ES-405]*. It is the same type of data. Again, current data is in 1993

SPECTRUM ASTRO — **Main Line Penetration for Select Countries : 1993 and 2000**

North Africa	1993 Main Lines (000)	Population (000)	Main Lines Per 100 Population	2000 Main Lines (000)	Population (000)	Main Lines Per 100 Population
Algeria	1,048	27,143	3.86	1,796	32,904	5.46
Egypt	[illegible]	55,926	4.50	6,161	64,210	9.60
Libya	[illegible]	4,900	5.22	460	6,500	7.08
Morocco	[illegible]	[illegible]	[illegible]	2,254	31,559	7.14
Tunisia	[illegible]	[illegible]	4.50	841	9,924	8.48
Sub-Saharan Africa						
Botswana	[illegible]	1,400	[illegible]	118	1,822	6.47
Cameroon	[illegible]	12,200	.47	102	16,701	.61
Ethiopia	148	54,800	.27	260	66,364	.39
Gabon	[illegible]	1,200	2.17	45	1,612	2.78
Gambia	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ghana	[illegible]	15,800	[illegible]	[illegible]	[illegible]	.45
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Qatar	111	499	22.24	174	[illegible]	[illegible]
Saudi Arabia	1,723	15,859	10.86	3,237	[illegible]	15.84
Syria	533	13,000	4.10	756	[illegible]	[illegible]
Turkey	12,668	59,227	[illegible]	23,446	[illegible]	[illegible]
UAE	610	1,700	35.88	1,311	[illegible]	67.22
Yemen	157	13,000	1.21	295	[illegible]	1.77

Fig. ES-404

SPECTRUM ASTRO — **Main Line Penetration for Select Countries : 1993 and 2000**

Asia-Pacific	1993 Main Lines (000)	Population (000)	Main Lines Per 100 Population	2000 Main Lines (000)	Population (000)	Main Lines Per 100 Population
Australia	[illegible]	[illegible]	48.35	[illegible]	[illegible]	[illegible]
Fiji	54	5,051	1.06	[illegible]	[illegible]	[illegible]
New Zealand	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Papua New Guinea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
South Asia						
Bangladesh	[illegible]	[illegible]	.24	[illegible]	[illegible]	[illegible]
India	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Myanmar	[illegible]	44,177	[illegible]	[illegible]	[illegible]	[illegible]
Pakistan	[illegible]	[illegible]	1.41	[illegible]	[illegible]	[illegible]
Sri Lanka	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Southeast Asia						
Brunei	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cambodia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Indonesia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Malaysia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Philippines	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Singapore	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Thailand	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vietnam	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
East Asia						
China	[illegible]	[illegible]	1.41	[illegible]	[illegible]	[illegible]
Hong Kong	[illegible]	[illegible]	[illegible]	4.45	[illegible]	[illegible]
Korea	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Taiwan	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Regional Average	74,604	2,989,386	2.5	188,123	3,332,263	5.65

Fig. ES-405

and future data in the year 2000, showing Asia-Pacific and Southeast Asia. Indonesia, the fourth most populous country in the world, has more than 190 million people. I know most of us have probably never been there. I have been there two or three times in the last six months. There are more than 7,000 islands in the Indonesian archipelago. About 5,000 of those islands have no telephone service. So this is a perfect application for a space-based telecommunications system, because you can imagine the ground infrastructure cost associated with trying to wire a place like that.

Now let's take a look at the mobile voice communications market *[Fig. ES-406]*. These are your traditional cellular-to-cellular towers of worldwide cellular subscribers. And you can see, in 1993 we had 31 million people with traditional cellphones, and by 1999 we're estimating 123 million will be using these. Now bear in mind a lot of these people may already have another type of phone—but the biggest growth element that we're seeing here is coming in the developing world. Why is that? Because it's easier to go into a village or town and put in a central tower and hook up a few thousand users, or a few towers and a couple of thousand users, rather than having to wire the whole

SPECTRUM ASTRO — **Mobile Voice Communications Market**

Worldwide Cellular Subscribers (Sources: Motorola, Pyramid Research) :
1993 - 31 Million
1994 - 47 Million
1999 (Est) - 123 Million

USA Cellular :
1984 - 1 Million
1994 - 19.3 Million

Western Europe Cellular :
1993 - 9 Million
1996 - 12 Million
2000 (Est) - 20 Million

Developing World :
1993 - 5.5 Million
2000 (Est) - 33 Million

Estimated Developing World Mobile Satellite System (MSS) Market : (Source : Pyramid)

	2000	2003	2006	2010
Low Estimate (Mil) :	2.05	4.5	8.21	16.13
High Estimate (Mil) :	4.06	10.3	20.06	34.94

Fig. ES-406

town. We're seeing this happen across big areas of Europe and are now starting to move into Asia and Africa. Pyramid Research looked at these numbers and said, "OK, if these are the numbers for worldwide traditional cellular subscribers, (let me describe what that subscriber is; that subscriber is spending about $50 a month on his telephone, about $600 a year) what would be the base for a world space-based mobile satellite system, if we had such a thing?" *[Fig. ES-407]* And bear in mind there is no such thing that does that today. There are several systems, which I am going to briefly touch on here in a minute, which will do that. You can see that there is a low estimate to a high estimate, with somewhere between 2 and 4 million subscribers in the year 2000, and somewhere between 16 million and 34 million subscribers by the year 2010. Now keep in mind this is thinking of a 50-cents-a-minute, $600-a-year subscriber. Imagine lowering the cost to a few cents per minute to a few dollars per month. Then you have a vastly expanded market.

I want to make one clarifying comment when we talk about user-to-satellite space communications systems. A lot of our communications systems today use satellites, but of course we go through our local phone company to the switching office. We go up over a big dish, to something like IntelSat. The message comes down to another big dish, and goes to our local phone company *[Fig. ES-408]*. This next generation of systems will allow the handset to talk directly to the satellite. Basically you'll be carrying around a little satellite Earth station in your pocket and you'll be talking directly to the satellite. Now this also has different versions—it will go in automobiles and mobile vehicles, it will go in telephone booths, which will be a so-called fixed-site. OK, that comes back then to the ground station and into the public switched telephone network, or the PSTN here. Then it can go to your home or back out to a cellular tower to your traditional cellular user. What we're looking at here is a growth from zero subscribers today—none of these systems is operational—to somewhere between 16 million and 34

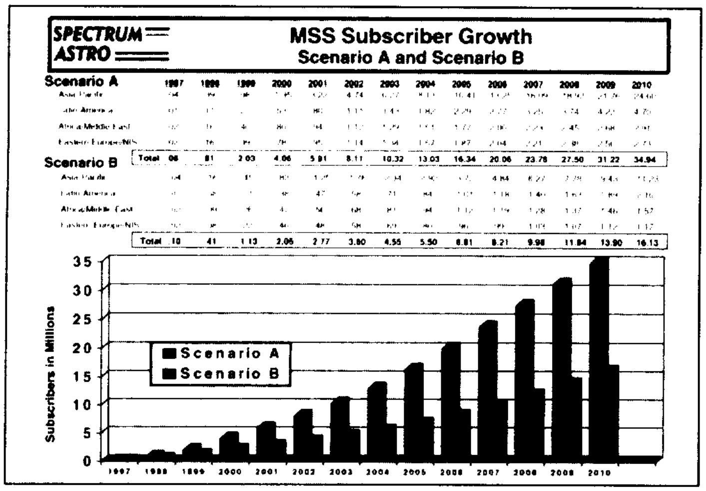


Fig. ES-407

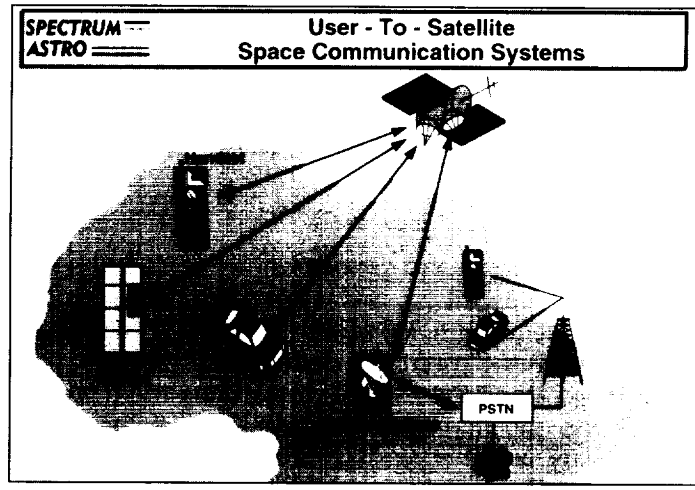


Fig. ES-408

million subscribers in about 15 years. And the revenue, I don't have the revenue chart here, but something like $11 billion a year to $22 billion a year in revenue is going to be generated from systems like this.

Now there are five systems—actually there are more than five—that have been proposed and are currently before the FCC and International Telecommunications Union *[Fig. ES-409]*. These happen to be the so-called "Big LEOS" or satellites that are in low-Earth orbit. They are called Big LEOS because their frequency is above 1 gigahertz. The little LEOS are below 1 gigahertz. There are five Big LEOS that have been proposed and are currently standing before the FCC. Three have been licensed, but basically they come in all kinds of varieties, anywhere from 16 to 66 satellites. The FCC has set very strict standards on the technical operation of these systems. One thing I wanted to call to your attention is the third column over. How many users are these systems going to address? You can see—and I want to caution about the use of these numbers because these numbers are very difficult to extract and they're dependent upon many factors in the analysis of the system—but if you don't lock onto the specific number, what you can see is these systems are going to handle a few hundred thousand users and maybe a million users simultaneously—a million simultaneous circuits. What I drew from this, if there are 30 million people currently on waiting lists around the world for telephones and there are 350 million lines short in the year 2000, my analysis says that every one of these systems is going to sell out as soon as it's launched, because these systems are going to be in demand. There are several geosynchronous systems that have also been proposed. Each one of those geosynchronous satellites is projected to handle between 12,000 and 16,000 users. These satellites do not provide millions of simultaneous circuits. A lot of people in this industry have made fun of the Teledesic people. I have nothing to do with Teledesic, but I can tell you from this research that Teledesic is going to be a

SPECTRUM ASTRO — SPACE-BASED CELLULAR SYSTEMS "BIG LEO" COMPARISON

System Name	# of Operating Satellites	Orbit Planes/ Altitudes	Simultaneous Users
ELLIPSO	16	3 Planes (2) 520 x 7846 km (1) 8068 x 8068 km	142,000 Source: Analysis
GLOBALSTAR	48	1400 km	115,000 Source: MITRE/Globalstar
IRIDIUM	66	780 km	172,000 Source: MITRE/Motorola
ODYSSEY	12	3 Planes 10,000 km	27,600 Source: MITRE/TRW
CCI	46	2,000 km	47,000 Source: FCC Filing

Fig. ES-409

big hit. Because it's going to provide about 2 million simultaneous circuits and it is going to service maybe 30 million users with that. Now you go back to that number—350 million line shortage—the whole situation is cost driven. So I think Teledesic and those guys like all these guys are going to be very successful.

In conclusion, the analysis says that there is a tremendous need worldwide for basic communication services, not only space-based but ground-based as well. We're not talking about the enhanced services that are currently in use in the United States. We're talking about basic voice. When we add the enhanced services, we're going to see a greatly increased demand above that. And many types of affordable technology are available to address this. Several of the system solutions which I have talked about here today have been proposed and there are some others which I haven't had time to address. I think the predicted demand is going to absorb the entire supply. Also, I think the opening of these markets and the reduced interference by the exporting country—with free markets and the ability to export the technologies we have here in the United States—it is going to be a tremendous opportunity for our companies here in the states and for the user countries that we have represented here today. That concludes my remarks. Thank you.

Q&A

Mr. Gibson: Ladies and gentlemen, we've had about 25 questions passed up, and we're very grateful for you having sent them. What we've done is to divide them between the members of the panel, and I'm going to go along the row this way asking them to answer one question or to combine them, if it works out that way, and then we'll work until the 25 minutes are expired. For those of you who get your questions answered in the 25 minutes, I hope you'll be appreciative, and for those who don't, I hope you'll be forgiving. Can we make a start then? To give Bill Ramsey time to come up, let us take two that are on launchers. Two people have asked whether the presentations that we've had mean that we should be going for small launch systems for small satellites, but I don't really think it's something that we can talk about in this particular session, unless anybody's got another feeling. I think we're all sitting on the edge of our chairs on this one, so we're going to safer ground and ask John MacDonald.

Dr. MacDonald: Thanks, Roy. All of the questions that Roy handed me have to do with pricing, in one way or another. I'll read you one or two of them, and then try to answer them in a sort of collective fashion. The first one says, "You mention the relationship between price and value and you used the example, the oil company client. How do you adjust the price to the required value for different potential markets as the only feasible way of flat price per scene?" That was one question. The other question that's kind of related is, "What criterion would you use to balance the need for free public access to remote sensing data and the need for providers to charge for access to that data?"

Another one says, "Does the scientific user get hardware and software for cost of manufacturing?" No they don't. Why would they get data for cost of manufacturing? I think one person here talked about criteria. I wouldn't get into criteria at all, but I'd get into mechanisms. Create a market. A market is a mechanism which determines price value balances. Now in the remote sensing business, we are used to thinking about scenes as the unit of data. The real unit of data is the pixel. It's quite feasible today to sell data by the pixel. And I would suggest that one way around this problem of pricing and so on is to sell data by the pixel. And you can start giving quantity discounts for pixels, which means sub-scenes, scenes, and super scenes, all that sort of thing. The whole point about all of this is, let's not think about criterion, let's not think about government setting rules or something, but rather let's try to do the things that allow the creation of a market mechanism for this type of stuff. I just want to make one point about the person who asked about the scientific user getting the hardware and software, the cost of manufacturing. This is a point of view I tried to put across in various committees both here in the United States and Canada for years, and got nowhere because most of the committees were dominated by the scientific community. I finally gave up and came up with the idea that I put forward in my presentation. I do recall, though, that when I was a professor many, many years ago and could classify myself, I guess, as a scientist, I did get books for free. I did get hardware and software at what was termed an educational discount, and if you look at the price lists of RSI or EOSAT, or SPOT Image, you will find certain types of data available at quite low prices that are quite suitable for the scientific community. I can't speak for EOSAT, Dave certainly can, but I can for RSI since I'm involved with them, that's RADARSAT International by the way. RADARSAT International does give data away to scientists who are doing bonafide research for very low prices and sometimes for free, because it's in their commercial interest to do so.

Mr. Gibson: Thank you. Murray Felsher?

Dr. Felsher: One question reads, "Given the vast amount of remote sensing data that is and will be available, is there any national or international effort to categorize that data?" I'm assuming that the question meant not only categorize but catalogue data as well. To my knowledge there is no international effort to categorize or catalogue the vast amount of data that's available, especially as it applies to remote sensing inter-commercialization. However, I happen to have with me here a pertinent Statement of Work. About four or five months ago, this consultant went over to NASA and said very much what this question asked, except he said, "How come there's no attempt to categorize or catalogue the data, or is there an attempt? Do you people at NASA know what you've got, that the commercial remote sensing industry could use?" And they went around and I'm sure there may be one or two NASA folk here, and they came back and told me, "No. We don't know what we have." So I wrote a proposal and beginning May 1, 1996, there will be a study undertaken on the "compilation of existing software and data sets related to remote sensing applications currently residing within and outside of NASA and the presentation of a plan designed to distribute this inventory to interested parties within and outside of NASA." We're going to work very hard to make a first crack at getting this kind of information. It's incredible to some that with all the data that is available in the research community, in NOAA and in NASA, that no one has ever tried to put this together and show how we could use these data in the commercial arena. Hopefully we're starting along that road right now. Unless I'm mistaken, no attempt has been made to do this before.

Mr. Gibson: Thank you very much, Murray. Dave Edwards?

Mr. Edwards: I've got two questions here having to do with receiving imagery, either real time or at least through a subscription service through the Internet. I'll address those two first. In essence, asking: When will that sort of service be available? That sort of service we're developing now to be available this summer. I'm unaware of other data sources, at least from a satellite imagery point of view, because of the bandwidth that's needed and how large those files are for scenes being available at this point in time. And for us we're starting with the WiFS data since with the low resolution, the file sizes are manageable so we actually use the internet connection. And pretty much with a PC that's at least a 386. Anything above that will help you. The reality is they'll all be in standard formats of GIF, TIFF, BMP types of formats, so you can plug and play with them as long as you've got that general image processing type software, you can be able to get that delivered. When would I expect LANDSAT, SPOT, IRS full scene data available? That's part of this question. I still think we're a couple years away from that. We don't have the bandwidth. The technology is out there, here and there, but from the standpoint of us commercially getting it all consolidated and integrated at a cheap enough price so it could be worth the subscription and delivery, it's going to be a little longer way off. That's where I think we are with electronic delivery.

Mr. Gibson: Bill?

Vice Adm. Ramsey: The question is, "What is the power level and channel capacity of Endo-Star, and what is the cost of the user receivers?" Endo-Star direct broadcast satellite at geo-synchronous orbit is 1,800 watts on orbit. There are eight transmitters, five of which are active at any one time. Generally each transmitter puts out 24 megabits per second data rate, and the power level is around 50 dBW. The cost of the user equipment will come down to about $300 per unit. DirecTV is somewhat of a model that you could refer to now. DirecTV started, as I think most of you know, about $700 and already you can get it at WalMart and Sam's for $495.

Mr. Gibson: You better take another one, Bill. That was too easy.

Vice Adm. Ramsey: Will GPS attitude controls replace or simply augment current attitude determination sensors? It is a goal at CTA, Inc. to develop enough confidence and engineering reliability that you can eventually replace attitude control systems with the GPS attitude control system. There's significant cost savings involved that you can do that. However, having said that, I think it's doubtful that critical satellites that need redundancy will ever give up the more conventional attitude control systems.

Mr. Gibson: Thank you very much. Dave?

It's incredible to some that with all the data that is available in the research community, in NOAA and in NASA, that no one has ever tried to put this together and show how we could use these data in the commercial arena.

Mr. Thompson: I have four questions also. First one—the question says, "The survey data show that the largest growth of phone lines will be in undeveloped countries. Phones or lines will cost approximately $10 - $50 per month. This is the total income of most persons in undeveloped countries. Do you believe a person wants a phone instead of food for his family?" Now generally when I'm hungry I will eat before I use the phone, but I don't know about these guys. Obviously, I think this reflects a misunderstanding of what some of these markets are. First of all, take India, for example. India has almost 1 billion people, something like 900 million people, and in fact 700 million of those people may not be able to afford a phone service like this. But there are 200 million people in that country alone, who you would call the so-called middle class of India, who could afford this service. I think you will find that across a lot of these developing nations that they have a very rapidly developing, maybe we would consider it a lower middle class, but a middle class that can afford some of these types of services. The other thing you should keep in mind is that in the case of villages where the income level is low, one might install a phone booth. A number of these providers have talked about satellite phone booths, which might service 500 or 1,000 users. So you could amortize the cost of installing the phone booth over many more users and therefore lower the cost of use of the booth. Then it gets down of course to the cost of calls per minute, and you get into things like differential nighttime pricing, weekends, holidays, that kind of thing. There certainly will be some people who will not be a candidate for this type of service, but I think the market is large enough and statistics will bear this out, they'll be supported by the emerging middle class there and these phone booth type operations.

Mr. Gibson: Thank you very much, Dave. We've been asked, "How are the security interests of governmental agencies being addressed with this push to output as much information to the civilian sector as possible?" I don't think that, certainly in Europe, this has been a problem. Once the people in the civil agencies and the defense agencies agree that they're going to work together, there's enough imagination between them to draw the frontier in a way which doesn't impinge on security. I'm particularly impressed with what the French have done, whereby even some of the control of the actual development program has been done by the civilian space agency. I really don't think that this is a show stopper. I don't know if anybody would care to comment. I'm not saying that security isn't important, on the contrary, I'm saying it's so important that it will be looked after, but much more difficult as a show stopper is internal resistance.

There are, as we all know, at least three organizations here in the United States that plan to launch various types of Earth observation satellites and appear on a commercial basis and charge for the data and thereby hopefully support the cost of the whole thing.

Dr. Felsher: No matter what happens, this country has historically been far advanced technologically in Earth sensing for national security purposes, and that will never change, and that can never change. The release recently of Corona and Aurora early imagery happened with a lot of people saying, "It's got to happen," and a lot of other people saying, "It shouldn't happen, but we'll go no further than this." My own feeling is that we live in a more dangerous world than we did when there was an "evil empire." We must always maintain a technological edge in remote sensing for national security. That's got to stay the way it is. I know a lot of people may disagree with that. Maybe some on the panel here, but I'll be happy to discuss it.

Mr. Gibson: John, you're back on.

Dr. MacDonald: I've got one here that says, "What criterion do you suggest for determination of when remote sensing data should cease to be publicly supported and available and be privatized, for example, weather information?" You've got to look at this as a sort of multi-step process. First of all, it's beginning to happen already. There are, as we all know, at least three organizations here in the United States that plan to launch various types of Earth observation satellites and appear on a commercial basis and charge for the data and thereby hopefully support the cost of the whole thing. Something else is also happening, if I could have the first overhead. It was one of the ones I showed you before. If you look at the system from the spacecraft on through to distribution, if you look at what EOSAT does, and it's exactly the same now as what SPOT Image does, exactly the same as what RSI does. From the spacecraft down to the archive is basically government supported. From there on is a private enterprise function. If you create the market at the left end here, and it gets back to this mechanism of creating market, as you begin to egress people's real needs for information, as the volume increases, you can afford to move the private sector backwards through the chain. The mechanisms are already happening in all of remote sensing all over the world, either through private initiatives that companies are taking, or the kind of mechanism I'm showing here. As EOSAT, RSI and SPOT Image have all shown, you can operate that part of the system as quite a viable, profitable business today. It works just fine, and has been so for about five or six years. There's a role that government can play in this. There's another aspect to all this. If you could put up the second overhead, which is the one I didn't show you, it's two ways of government involvement in the business. The top one shows the space agency doing most of the funding. This is all government activity now in remote sensing. The space agency doing most of the funding of both the ground segment and the space segment. The user agencies like the USGS, and so on and so forth, not really supporting the system, getting the information, the data, paying a nominal price for it, and the guy with the red face up there is the taxpayer. The taxpayer of course in government is the ultimate source of all money. If you look at the bottom, it's the same diagram, except now the user agencies are funding the system. The space agency provides a little bit of funding for technical support, and so on. If you think about it for a moment, that's the way DoD operates. It's also the way NOAA operates. But none of the other user agencies does. The weather system, for whatever reason, has always been a so-called public good or a public service. The defense system, of course, has to be. When you get into those bottom three boxes, the space segment, the ground segment and the user agency, particularly with the ground segment, in the NOAA case and of course in the DoD case, NOAA is also the performer in both of those boxes on the right hand side. But there's no reason that they have to be. Those services could be purchased by NOAA if they so chose to do, and I would suggest that as things evolve, we try to go to the bottom mechanism for government use and gradually move toward private sector performance of certainly the Earth segment box, and that's in effect what's happening now in most cases, and ultimately in the space segment box. It's a mechanism, not a criterion.

Mr. Gibson: Thank you. Murray?

Dr. Felsher: How will NARSIA "balance" CEOS? I think that's a very perceptive question. What it pre-supposes is that there is a balance required. CEOS, you remember, being the Committee on Earth Observation Satellites that's essentially an international body of representatives from the space-faring agencies. The key word here is government agencies, and indeed there is no, zero, zip representation from the private sector whatsoever. Dr. Silvestrini, who talked this morning, said that there has been some impact. That's not the word, Arturo, but it's close to it. A door has been opened. But my feeling is that there is some balance required. There is a necessity for providing true private sector input other than the lip service that we've been getting from CEOS in the past, and this may be a bit harsh, as to their considerations about what satellites will be built by the governments of the world. Historically of course, there was no reason to have the private sector there since in the past all of the Earth remote sensing satellites have been government satellites, and as a matter of fact, as we speak, it's still the same. Our expectation in the next several years is that it will change, and there has to be some means for providing input into CEOS' considerations and into their programs and priorities, and we look for NARSIA to be doing just that.

Mr. Gibson: Thank you, Murray. David?

Mr. Edwards: Last question I have here has to do with the price ranges for different scenes and how long does it take to get product to user? Typically the time it takes for somebody to get a scene is within the week they order it, unless there are special circumstances or something that requires some support service. But typically that's starting to become the industry standard in terms of actual measured performance. Sometimes it's a lot quicker than that. When there's an emergency, typically a disaster, a lot of suppliers, including ourselves, have been known to put out a lot of products within the same day the orders come in. There's a lot of excess capacity from the standpoint of production in the industry. Nobody runs more than two shifts for a five-day work week in the industry, so there's at least excess capacity for one more shift, and I'm well aware of that. At EOSAT sometimes we don't even run two shifts. Throughput's not a problem. I'll just give you one price since I was talking about IRS-1C. If you want to see a IRS-1C scene of Tucson, pick up your free coffee mug out in the hallway there for that data. For our 23 x 23(km) scene, $900, and for 70 x 70(km) you're looking at $2,500. Additional pricing you can get at our booth. Please visit our booth. We have a lot of imagery on display. That's about where it is.

Mr. Gibson: Thank you. Bill?

Vice Adm. Ramsey: The question is, "Which, if any, remote sensing systems can provide data in the GPS coordinant system or WGS-84 and at what level of accuracy can it be obtained?" *EarthWatch,* when they come on-line, will be providing data that is within the GPS coordinate system, and I believe everybody eventually will, with the processing advances being made. I think that all of the remote sensors up there will eventually use GPS coordinates and the accuracy level will probably, again because of the processing advances, be within the criteria of the GPS error probability bands of 15 meter (spherical).

Mr. Gibson: Thank you very much. David, last question.

There is a necessity for providing true private sector input other than the lip service that we've been getting from CEOS in the past, and this may be a bit harsh, as to their considerations about what satellites will be built by the governments of the world.

Mr. Thompson: I have a question here that says, "Will wireless local loop (fixed cellular service) represent a tough competitive threat to space-based PCS or space-based personal communications systems in terms of pricing?" First of all, I want to tell you I'm not an expert on wireless local loop. I know enough about it to be dangerous. But I do know that we have to be very careful in the definitions of what we're talking about here, because you hear a lot of these terms that get thrown around, and for example, wireless local loop is not necessarily fixed cellular. There are wireless local loops that operate at other frequencies than our GSM, or other existing cellular services that are out there. I think, and I only know of one space-based PCS system, if you're familiar with PCS, PCS is the new trend toward smaller and smaller cells in the fixed based cellular service which will allow more capacity for users, mostly in cities. Let me say that I think there will be a tremendous demand for wireless local loops in these developing countries, unrelated to space, because the biggest expense of installing phone systems is the local loop. That's running the cable down the street and into each house. There are some companies that had these wireless local loops that basically give you a little radio telephone that sits in your house and goes to the central office to help cut the cost of that wiring, and I think there'll be a tremendous market for that. That doesn't necessarily have to compete with the space-based cellular systems or other types of services, because that's basic local service. It turns out that these can actually work in very good concert with the space-based systems by having a wireless local loop, I described this phone booth earlier, which is sort of the central node in the village. You can have a wireless local loop that's connected to the phone booth and then allowed shared access to that uplink that would allow a village to have international access through that space-based service. I think the bottom line is, it's a very bizarre marketplace right now. There are a lot of new services coming on-line, and you must be very careful in making analyses of these markets because the markets are rapidly changing, and the services that are being offered are combining a wide number of different sources from the existing terrestrial suppliers, from the space-based guys like we've talked about here, and from other services like VHF and UHF services in the region and Irridium and things like that.

There are a lot of new services coming on-line, and you must be very careful in making analyses of these markets because the markets are rapidly changing.

My suggestion to the members of the audience would be make sure you do a very careful financial analysis before you get involved in these things because there are a lot of potholes that you can step into. My analysis of some of the things that have been done in this particular area is that they haven't necessarily been done with a lot of forethought. People jumped in here and said, "Here's my service," not knowing that right around the corner is coming a whole new brand of services from existing providers and things of that nature. So there's going to be a lot of market turmoil and we're only seeing the first generation of these systems, so it probably won't settle out until we see the second generation, about the year 2005 or 2010, which is when Teledesic and guys like that are coming along. It will be interesting to see what happens.

Mr. Gibson: Thank you. A final word of wisdom from Dave Edwards.

Mr. Edwards: I wanted to do a bit of followup on some of the questions that came to John. He had to field them all for the most part in terms of both pricing and market. I think it's real critical to emphasize his point about the mechanism being the market—in creating the market. We have to get away from the paradigms and emotions of worrying about prices, prices-per-scenes and the paradigms associated with if government contributes towards a satellite system, if our data should be free. In the absence of that, there'll be continued fragmentation. If there's a continued fragmentation, you don't create the market. The market is the only mechanism which you can be sure is going to generate consistent funding no matter what the transition time is, and how we come about getting those funds back towards paying for the data, that is again application driven and not a techno-push. That is so absolutely critical. If you look at the sleeping giant in terms of remote sensing being the Indians, they basically said there was a lot of wisdom in the worldwide remote sensing community, western technology, western utilization, but they keep fighting about the politics of it and the pricing of it. The Indians just started to do it. If you look at their history now, they continue to just advance the satellites and a continual sweep of sensors that there's a consensus by people needed for utilization of managing Earth resources, and they're just doing it, and they're just building it. In the meantime, we can continue to fight in the West, and we don't have any contribution at all except the one-sy, two-sy programs that may be good for the life of that one satellite. But you don't create a market and you don't bring this together.

Mr. Gibson: This is all the time that we've got for our questions. We apologize very sincerely for those that we've not been able to tackle, but out of respect for the next session, we really must draw it to a close. With thanks to all those who've been on the panel. And thanks too for the technical help that we've had. Please don't go away because the next session starts straight away. There will not be another coffee break, you've already had it. Thank you very much.

Faster, Better, Cheaper

Master Moderator: **Steven P. Scott**
Program Development Manager
Rockwell Space System Division

Session Chair: **The Honorable Hans Mark, Ph.D.**
Chair Professor
Dept. of Aerospace Engineering and Engineering Mechanics
The University of Texas at Austin
Former Deputy Administrator, NASA, and Secretary of the Air Force

Speakers: **Peter Wilhelm**
Director
Naval Center for Space Technology, U.S. Naval Research Laboratory

Dr. Edward Stone
Director
Jet Propulsion Laboratory

Mr. Scott: Our final session for today is on applying the faster, better, cheaper methodology to space systems. Leading the discussion is the Honorable Hans Mark, professor of aerospace engineering and engineering mechanics at the University of Texas at Austin. Prior to that he was both the undersecretary and secretary of the Air Force, as well as deputy administrator of NASA. Ladies and gentlemen, please welcome Dr. Hans Mark.

Dr. Mark: Exploratory missions to the giants of the sol ar system, Jupiter and Saturn, were the subject of inte nse study by the scientists and executives of our planetary exploration program in the mid-1960s. It was recognized very quickly that the outer planets would have to be explored by spacecraft rather different from those used in the case of Venus and Mars. First, the spacecraft would have to travel much farther than those used for the inner planets. The nearest outer planet, Jupiter, at its closest approach to the Earth, is more than 400 million miles away, in contrast to Mars which comes to within 50 million miles. A trip to Jupiter is therefore much longer than anything attempted in the case of the inner planets, and the spacecraft would have to be designed to last longer. A second important point is that in going to the outer planets it is necessary to move away from the sun. All of the spacecraft used to explore the inner planets obtained their electrical power from the sun. Solar panels were attached to the spacecraft or solar cells were actually mounted on the spacecraft body in order to produce electrical power. This could not be done with spacecraft designed to go to the outer planets. These would have to rely on nuclear thermal electric generators in order to provide the necessary electric power. These power supplies use the energy liberated during the radioactive decay of Plutonium-238. They have proven to be very effective and reliable and have been built to deliver up to 400 watts of electrical power. Finally, the long distances require a much more capable communication system than those used by the spacecraft discussed so far. Thus, all the spacecraft that were ultimately designed to go to the outer planets are dominated in appearance by the presence of a large dish-shaped high gain antenna.

One of the early ideas that emerged from the planning sessions of the 1960s was to use the gravitational fields of the planets, which were the targets of flybys, to alter the trajectory of the spacecraft so that it could reach the next planet. This principle was applied in the case of the voyage of Mariner 10 to Venus and Mercury, where the gravitational field of Venus was used to divert the spacecraft to Mercury. A much more ambitious mission was conceived for the outer planets. It was found that during the 1970s the large outer planets would be in a favorable position for a voyage that would use gravity assist methods in such a way that all of the large outer planets could be visited. Initially, this mission was called the Grand Tour, and had the voyage been started in the early 1970s, the "Grand Tour" could have included Pluto, which is the outermost known planet of our Solar System. (Pluto is not a large planet, being smaller than the Earth. It is probably a rocky planet whose origin is unknown.) As things turned out, this was not to be, but the idea was important and almost every mission to the outer planets has used gravity assist methods to achieve its objectives.

The considerations of a Grand Tour with a very sophisticated spacecraft to measure all the properties of interest resulted in the conceptual design of some very expensive spacecraft, and people were concerned whether the spacecraft would survive the trip. There were very real hazards that had to be overcome in journeys to the outer planets. One was the asteroid belt which lies between Mars and Jupiter. This is a region of space containing hundreds of thousands of small rocky fragments orbiting the sun, ranging in size from a few miles in diameter to objects of microscopic dimensions. The asteroid belt probably resulted from the breakup of a planet that originally occupied this space in the solar system. Collisions with the debris could destroy a spacecraft on the way to Jupiter and it was important to determine whether this would happen with an inexpensive spacecraft, rather than a complex and sophisticated one that would be used for the Grand Tour.

Another hazard was the very strong magnetic field that we knew surrounds the planet Jupiter. It was very likely that energetic charged particles were trapped in this field just as they are in Earth's magnetic field. Therefore, when the spacecraft approaches Jupiter, it would be subjected to very high levels of radiation that might very well damage it. Since there was no way of knowing the intensity of the radiation fields around Jupiter, this had to be placed in the category of an unknown hazard. Once again, a precursor mission with an inexpensive spacecraft would be important.

In order to deal with these problems, it was decided to send a relatively inexpensive precursor spacecraft to Jupiter in order to provide the necessary design data for the spacecraft that would eventually execute the Grand Tour. These spacecraft became Pioneers 10 and 11. The precursor mission to Jupiter was given the go-ahead by NASA Headquarters in February 1969. Eventually, this would develop into the Pioneer Jupiter-Saturn project. The NASA-Ames Research Center was selected to manage the Pioneer Jupiter-Saturn Program. The center had already managed the development of the very successful plasma probes, Pioneers 6 through 9, which were orbiting the sun and collecting important measurements on the structure of the solar wind. At the time, I was serving as the director of the NASA Ames Research Center and I have to confess that I, along with everyone else at Ames, was elated when we were given the firm go-ahead to plan for two new Pioneer missions, which would be the precursors to the Grand Tour. We were given a very stringent budget limit for the performance of this mission. Specifically, the entire program consisting of the two spacecraft with all the systems on board should come in for a run-out development cost of less than $100 million, in 1970 dollars. (Compare this to the $1 billion program cost for the Viking Project, which was carried on at about the same time.) The TRW organization was selected to develop and construct the Pioneer Jupiter-Saturn spacecraft. The Ames Research Center had developed a strong relationship with TRW through their work on earlier Pioneer spacecraft, and so this was a logical step. I was heavily involved in the planning for the Pioneer program, and, later on, in the execution. When faced with cost constraints of the kind I have mentioned, we had to adopt a strategy which would permit us to control costs and at the same time do something useful scientifically.

In order to make certain that we could meet these very stringent requirements, we adopted some very clear management principles that we would adhere to under any and all circumstances:

• There would be simple and clearly defined mission objectives.

• There would be a small management team at NASA-Ames, not more than 20 people.

• Broad delegation of authority would be given to the prime contractor.

• Project managers would be carefully chosen: Charles F. Hall managed the program at Ames and Bernard J. O'Brien would do the same job at TRW. Both were first class people.

• Existing technology would be used wherever possible in the spacecraft development process. Engineering constraints would be imposed on the spacecraft design that would prevent escalation of requirements.

The last point turned out to every much the most important. Normally in a spacecraft program of this kind, the scientific requirements dominate, and therefore the costs escalate if the requirements are such that they can command support from the political authorities. In the case of Pioneer Jupiter-Saturn (which later became Pioneer 10 and 11), we could not let the cost escalate beyond $100 million without risking program cancellation. What we decided to do, therefore, was to place two arbitrary constraints on the spacecraft that would guarantee low costs. One of these constraints was that we would not provide a three-axis stabilized spacecraft platform, stabilizing a spacecraft with the appropriate control rockets to a high degree of accuracy is expensive. We therefore elected to use spin stabilization, which is achieved by rotating the spacecraft around an axis with a large moment of inertia. In the case of the Pioneer Jupiter-Saturn spacecraft, the spin axis was in the plane of the ecliptic, which permitted pointing the communication antenna always toward the Earth. The large moment of inertia which leads to a stable spinning system was provided by the heavy nuclear thermal electric power supplies mounted on long beams about 15 feet away from the axis of the spacecraft. This method of controlling the motion of the spacecraft is inexpensive, but there is a price to be paid: It is impossible to obtain really good high resolution photographs of the target planet.

The second engineering constraint that we placed on the spacecraft was that we would not store any data on board the spacecraft. All data obtained would be transmitted back to Earth on a bitstream not to exceed 1,024 bits per second in real time. We recognized that high capacity data storage equipment and high data rate transmission systems would be extremely expensive. Once again there was a price to

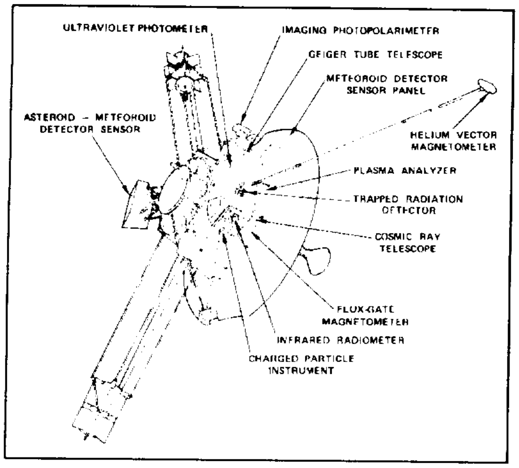


Fig. FB-101

be paid for placing this constraint on the spacecraft. Low data rates meant again that high resolution pictures could not be obtained. Also it would not be possible to secure high resolution data of the plasma stream and other phenomena to be investigated. The scientists who were to build the experimental packages mounted on the Pioneer spacecraft were given these constraints and were asked to live within them. While this situation was obviously not ideal from their point of view, most of them agreed that the constraints made sense. They reasoned that in a scientific investigation of this kind it was as important to be first on the scene than it was to get the very best data.

A line drawing of the Pioneer 10 spacecraft showing the location of the experiment packages is shown here *[Fig. FB-101]*. Its sister ship Pioneer 11 was essentially identical to Pioneer 10. This figure shows the Pioneer spacecraft as built by TRW Systems Group *[Fig. FB-102]*. Because of the engineering constraints that were placed on the design of the spacecraft before the scientific experiments were developed, we were able to control the cost of the program. And we did indeed successfully complete the development and construction phases for a runout cost of less than $100 million. Pioneer 10 and 11 were small spacecraft weighing about 550 pounds. The communications system uses approximately 100 watts of electrical power. The rest of the systems on the spacecraft were simple and rugged in design (see reference 1). Existing technology was used wherever possible. Advanced technology components and systems would be employed only when absolutely necessary. The fact is advanced technology is both expensive and risky. Therefore, we felt it would be prudent to introduce advanced technology in an incremental manner. The principle of carefully calculated risk governed us in the design of the Pioneer Jupiter-Saturn spacecraft.

The project management lessons to be drawn from this experience are that controlling escalating requirements—be they scientific in a program of this kind or military in projects related to the national security through some externally imposed engineering constraint—is absolutely essential for cost control.

The mission planning for the two spacecraft

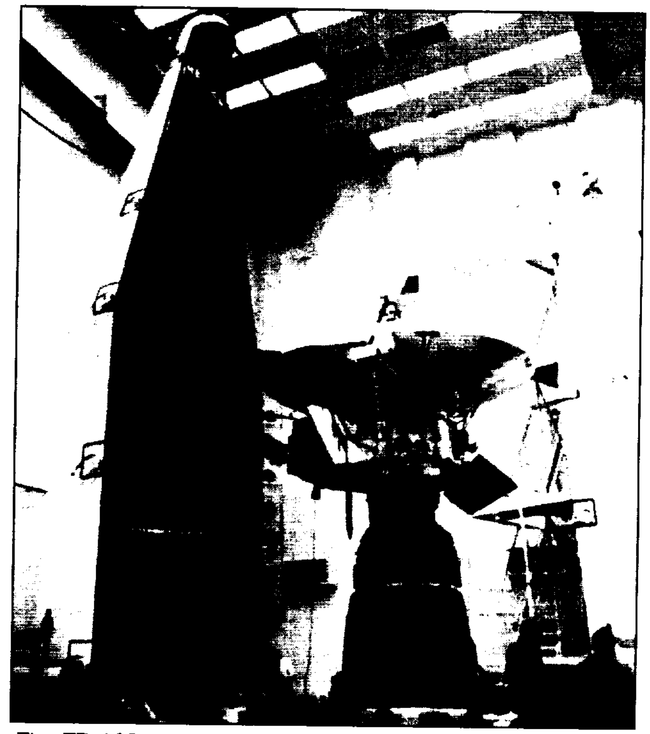


Fig. FB-102

called for two very bold maneuvers. Pioneer 10 would fly by the planet Jupiter in such a way that it would be accelerated. In that process, Pioneer 10 would pick up enough energy to become the first man-made object to leave the solar system. Pioneer 11, on the other hand, would fly by Jupiter with a trajectory so that five years later it would be able to fly past the planet Saturn and become the first spacecraft to explore that beautiful planet with its rings and large satellite Titan (see reference 2). It is amusing for me to remember that our arch-rivals at the time at the Jet Propulsion lab vigorously opposed this mission plan. While they recognized the necessity of a precursor mission to their much more expensive Grand Tour, that they would execute, they did not want the precursors to become the first spacecraft to leave the solar system or the first one to fly past Saturn. I remember that there was some very heavy politicking at NASA headquarters before we were able to gain approval for this mission plan. (The engineering model of Pioneer 10 is now exhibited in the "Hall of Firsts" at the Smithsonian National Air and Space Museum in Washington—because the real article was, indeed, the first man-made object to leave the solar system. It shares the room with the Wright brothers' plane, the Spirit of St. Louis, and John Glenn's Mercury capsule).

The "Grand Tour," as envisaged in the 1960s, was eventually carried out, but in a more limit manner with the Voyager I and II spacecraft. These were sophisticated stable platforms weighing almost 2000 pounds. The Voyager project was managed by the Jet Propulsion Laboratory and was highly successful. A wealth of very important scientific information was

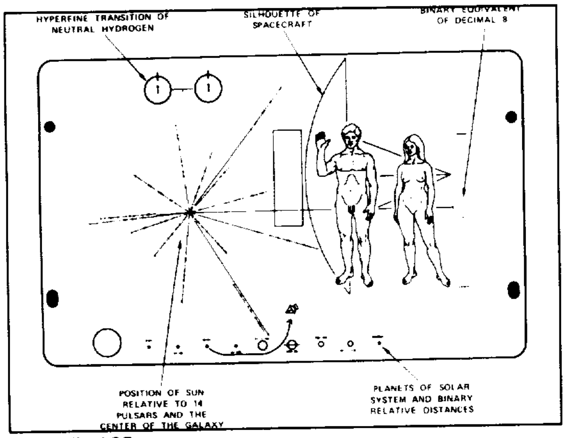


Fig. FB-103

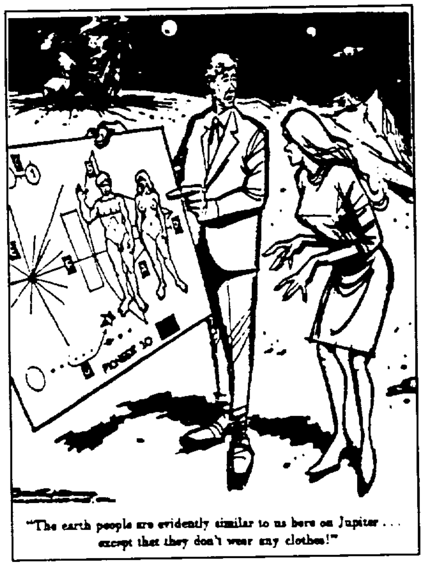


Fig. FB-104

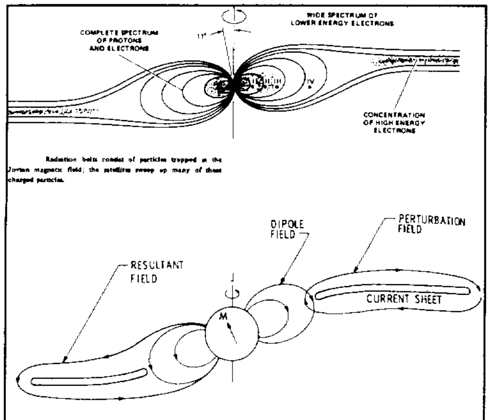
collected. Voyager II flew past the four large outer planets—Jupiter, Saturn, Uranus and Neptune—and returned excellent pictures from all of them. (The Voyager program development cost was about $600 million in then-year dollars.)

There is another amusing incident which I need to recount relating to Pioneer 10. I have already mentioned the fact that Pioneer 10 would become the first man-made object to leave the solar system, About three months before the scheduled launch of Pioneer 10 on March 3, 1972, I received a telephone call form my old friend, Carl Sagan, whom I first met when he was a post doctoral fellow at the University of California in Berkeley in 1960 or 1961 (Carl was not yet as famous as he is today because the Cosmos television series was still some years in the future). Carl asked me whether I realized that Pioneer 10 would be the first man-made object to leave the solar system. I said, "of course," and then added some words to the effect of "so what?" Carl, with a trace of exasperation in his voice, replied that this was a most important event and that we should put a message on the spacecraft in case someone finds it. By 1972 we had begun to speculate in the problem of how one might look for extraterrestrial life, and Carl—his imagination always being somewhat ahead of the rest of us—asked me to consider what would happen if somebody out there found our spacecraft. He pointed out that it would be good if we could put a message on Pioneer 10 which would at least provide the finder some information on where the spacecraft came from and who built it. I had to agree that Carl had a point, and so the idea of placing an appropriate plaque on

Fig. FB-105

the Pioneer 10 spacecraft was born. The plaque itself was designed by Carl's wife, Linda, and my job was to take that design and to get some of them manufactured so that we could put one of them on the spacecraft. I remember going to a small engraving shop in Mountain View, Calif., to have Linda's design etched on some brass plates, (one of which would finally have the distinction of flying on Pioneer 10.) The plaque is shown here and the instructions for deciphering it are in the caption *[Fig. FB-103]*. (Some of my friends continued to insist that absolutely no one, no matter how smart, could decipher what Linda and Carl Sagan put on that plaque. The Los Angeles Times had a somewhat different viewpoint. Shortly after the plaque design became public, the editorial cartoonist pointed out that the finders would wonder whether all people on Earth walked around without any clothes *[Fig. FB-104]*!)

Pioneer 10 was successfully launched on March 3, 1972, just over three years after the project was approved. It flew by Jupiter on Dec. 4, 1973, and is now on its way out of the solar system. Pioneer 11 was successfully launched on April 6, 1973, and it reached Jupiter on Dec. 3, 1974. Pioneer 11 then went on to achieve the first close encounter with the planet Saturn on Sept. 1, 1979. It was the first spacecraft to send back to Earth pictures of the planet Saturn and of its absolutely spectacular rings taken from a point close to the planet (see reference 3). The Pioneers returned a number of important scientific results about Jupiter, Saturn, and about the nature of the interplanetary medium. They also achieved the objective of being the precursor missions to more sophisticated and expensive spacecraft. It was discovered by Pioneer 10 that the asteroid belt does not present a real danger. In fact, there was no noticeable increase in the number of meteorite hits on the spacecraft as it passed through the asteroid belt. Pioneer 10



Radiation belts consist of particles trapped in the Jovian magnetic field; the satellites sweep up many of these charged particles.

Model of the Jovian current system. This model, which is based on the Pioneer observations, shows the tilted dipole M and Jupiter's rotation axis J. The two components of the magnetospheric field associated with the dipole and the thin current sheet are shown in the right-hand side.

Fig. FB-106

was also the first spacecraft to measure the magnetic field and the radiation intensity around the planet Jupiter. Once again, it was discovered that, with an appropriately designed trajectory, a spacecraft could safely approach the planet (see reference 4). Pioneer 10 obtained the first good pictures of Jupiter. A sample is shown here *[Fig. FB-105]*. The spacecraft also made the first survey of the magnetic field of Jupiter and the trapped charged particle distributions. A schematic diagram is shown here *[Fig. FB-106]*. Pioneer 11 was the first spacecraft to take close up pictures of Saturn and its ring system. A sample is shown here *[Fig. FB-107]*.

Pioneer 10 is now on its way out of the solar system. In 1990, the spacecraft passed beyond the orbit of Pluto. At the present time, Pioneer 10 is more than four billion miles away from the Earth. What is most remarkable about this little 550-pound spacecraft is that we are still receiving signals from it. The power now available to transmit these signals is a little bit less than 50 watts, or what you might get from a weak electric light bulb, and yet the signals can still be heard. It is really a remarkable technical achievement. Pioneer 10 will hopefully still be within earshot when it actually passes the boundary of the solar system. This boundary has been defined as the point where the solar wind no longer exerts any pressure. It is expected that a plasma discontinuity will be observed at that point. This will be the last piece of scientific information we receive from Pioneer 10. Hopefully, we will receive it soon, since it is now 23 years after the spacecraft was launched. Once the spacecraft passes that plasma discontinuity, it will be the first man-made object to truly arrive in interplanetary space.

The example of the Pioneer Jupiter-Saturn program is encouraging. The program was executed according to the principles that we evolved 25 years ago to assure "better, cheaper, faster" space vehicle developments. One question that is most important is to consider whether it is possible to apply the same principles now. The fact is that we were able to enforce our constraints only because the Pioneer program was indeed a precursor to something much more elaborate. The scientists working with us were therefore willing to accept the management discipline that we

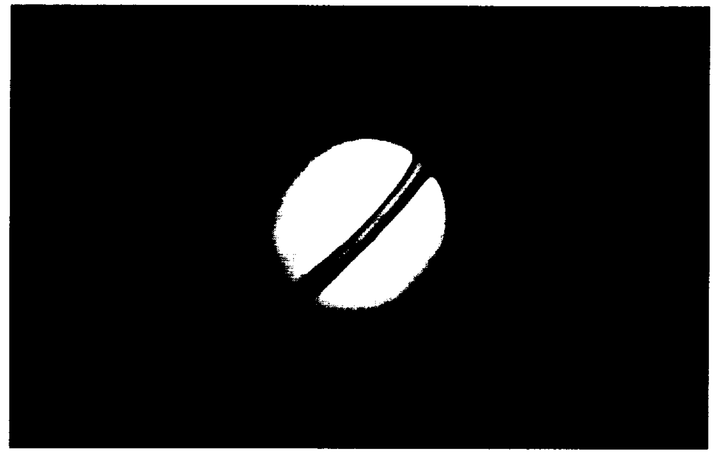


Fig. FB-107

imposed. It is not at all clear that we could have imposed our constraints and our discipline had we not been able to look forward to the Voyager program. It is important to make this point here to hedge the conclusion that the prescription I have outlined here for doing things "better, cheaper, faster" will work today.

Speaker's note: References for the preceeding presentation by Dr. Mark.

1. Charles F. Hall, Hans Mark and John H. Wolfe, "The Journey to Jupiter." *Endeavor*, Vol. 35, No. 124, pp 9-14, January 1976.

2. "Pioneer: First to Jupiter, Saturn, and Beyond," Richard O. Fimmel, James A. Van Allen and Eric Burgess, (NASA SP-446, 1980, Washington, D.C.).

3. "Pioneer Saturn," *Journal of Geophysical Research*, Vol., 85, No. All, November 1, 1980.

4. "Jupiter: Studies of the Interior, Atmosphere, Magnetosphere and Satellites," Thomas Gehrels, Editor, The University of Arizona Press, (Tucson) 1976.

Dr. Mark: I'd like to now introduce our speakers. I want to apologize just a little bit, we have decided to reverse the order, because as they appear on the program it wasn't quite as logical. I'm going to ask Pete Wilhelm to be our first speaker. Peter G. Wilhelm is the director of the center for Naval Space Technology at the U.S. Naval Research Laboratory, which is one of the nation's really distinguished technology development institutions. It is unique in the sense that it is the only institution within the Department of Defense that can actually build and develop space satellites, and when I was sitting in the Pentagon some 15 years ago I made use of that capability liberally as you will remember and that is still there. Mr. Wilhelm has been recognized by a number of awards. He holds the

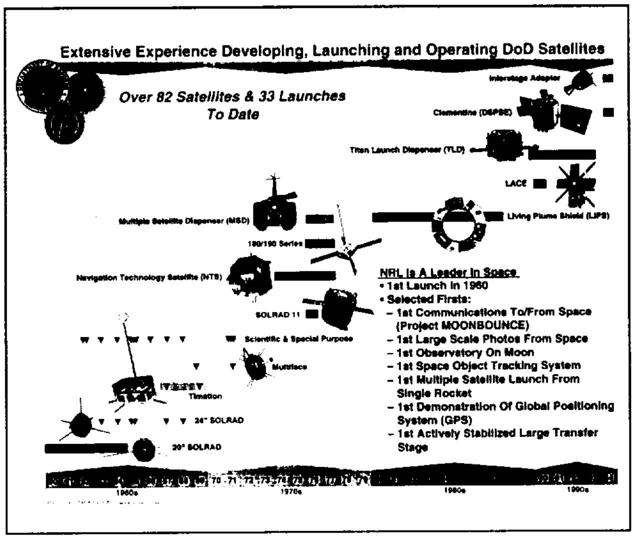


Fig. FB-201

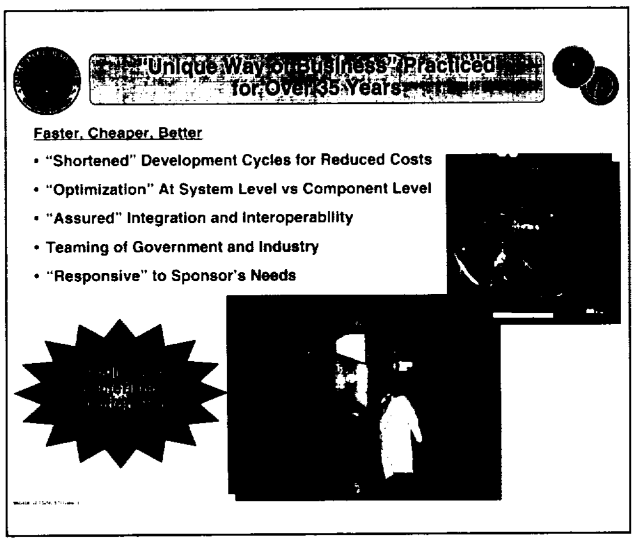


Fig. FB-202

Distinguished Civil Civilian Service Medal of the U.S. Navy, he's a fellow of the Institute for Aeronautics & Astronautics. Mr. Wilhelm is a graduate of Purdue University. And it is a great pleasure to introduce Pete Wilhelm, whose last and most important achievement really recently was the flight of the Clementine spacecraft, which is our current example of what this panel is about. So Pete, please, the podium is yours.

Mr. Wilhelm: I was asked to write an abstract and in that abstract I said I would describe the history of the space program at NRL. As you can tell by this viewgraph it is a very, very long history *[Fig. FB-201]*. Fortunately for you I don't have the time to give you the unabridged version. So what I will do is select three particular spacecraft because I think they make the points that I will try to make in my brief talk. One of those satellites will be the navigational technology one. The second will be a satellite called LACE and, finally, Clementine.

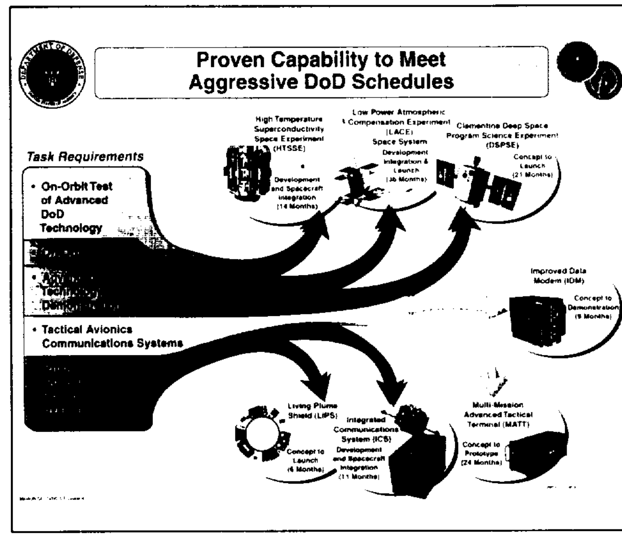


Fig. FB-203

Now, "faster, better, cheaper" has become a recent slogan, but the point I would like to make is that it's something that we have practiced at NRL for the past 35 years *[Fig. FB-202]*. It is inherent to our culture, if you will. As Dr. Mark mentioned on the Pioneer, we follow some of the same general ground rules. We try to establish a small project team, empower those people, use people with a wide variety of experience levels, from very senior people to junior level engineers and then challenge those people with aggressive peer review processes and support them with a robust test program. We have found that is the formula for success. Without a robust test program you don't catch the problems. The other thing is that if you can work faster, it is almost always going to be cheaper, but it is only with the skill level and experience of your best people that you can actually make it better. That is a very important point, I think.

Lest you think that the satellites, the three satellites I've talked about, are the only things we've ever done rapidly, this chart gives you a couple of more *[Fig. FB-203]*. We've done some small high temperature superconducting space experiments in 14 months. These four things on the bottom were all tactical terminals and tactical communication links that were done in a very short period. The one that holds our current record is one we call LIPS, which was done in six months.

The other thing that's important in trying to work rapidly is to have access to all of the necessary facilities, test facilities, both space and ground *[Fig. FB-204]*. We have those at NRL. In fact the ones for space testing are all under one roof. And you see pictures of the major facilities there on the left. Recently those facilities at the NRL main campus have been linked together with our ground station, using fiber optic ATM links. That gives us the capability, for our people at the ground station who are going to have

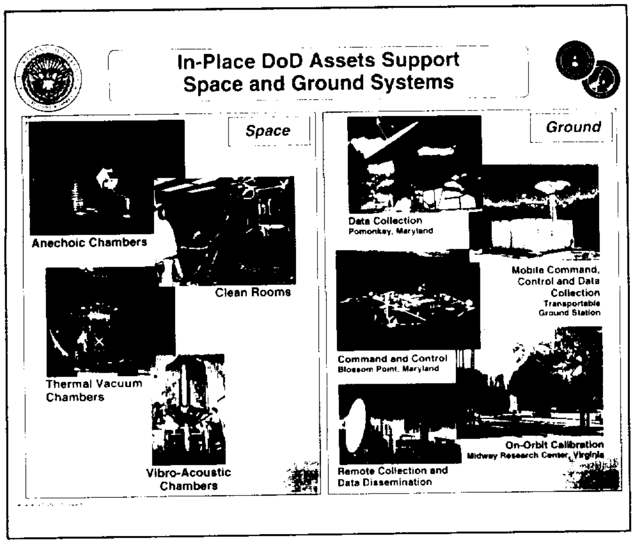


Fig. FB-204

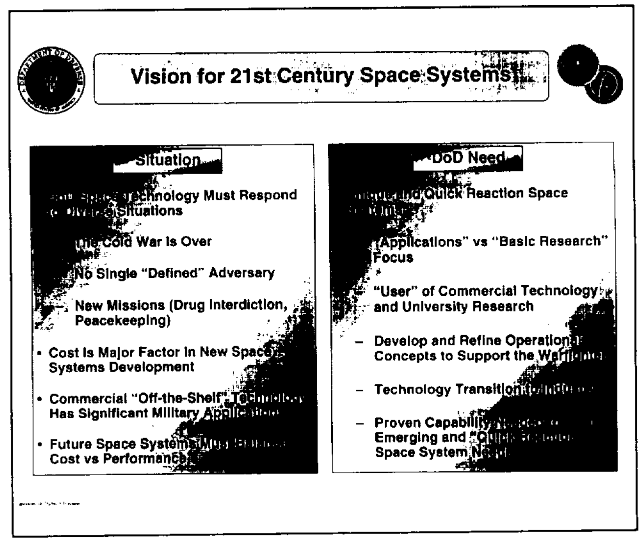


Fig. FB-205

to control the satellite when it goes into orbit, and can now actually interact with the spacecraft prior to launch, and we have found that to be a very effective tool. And, on the right, this shows a number of our ground stations, both fixed and mobile ground stations.

I talked a little bit now about the past, but before I go any further I think we have to stop and look at what the future holds *[Fig. FB-205]*. You don't want to drive too far down the road while only looking in your rear view mirror. I think we see a pretty different situation, at least within the Department of Defense. As probably has been said a number of times, the Cold War is over. We no longer have a single enemy to worry about. In fact, in just the last couple of days we heard the North Koreans are starting to cause trouble on the demilitarized zone. Secretary Perry announced that we've caught Moammar Ghadafi with poison gas facilities being built in Libya. We've got peacekeeping missions in Bosnia. So it's really a very different world than it has been in the more recent past. Cost has more than ever become a major factor in what DoD will be able to do. I think the one thing that we can pretty well count on, though, is that DoD is going to have to be even faster on its feet, even more agile than it has been in the past.

Now, I would like to get to those three particular satellite programs that I talked about. The first one is our navigation program *[Fig. FB-206]*. You'll see a number of satellites listed there: Timation I, II and III. In effect, those satellites were what we today call advanced technology demonstrators. They proved out and developed the three fundamental capabilities upon which GPS is founded: the stable clocks, the improved accuracy that you get from "passive one way ranging," and then the use of high altitude and high inclination orbits to give you global coverage. Those are the three fundamental things that GPS relies on. After those programs had been completed, we are now up to 1977,

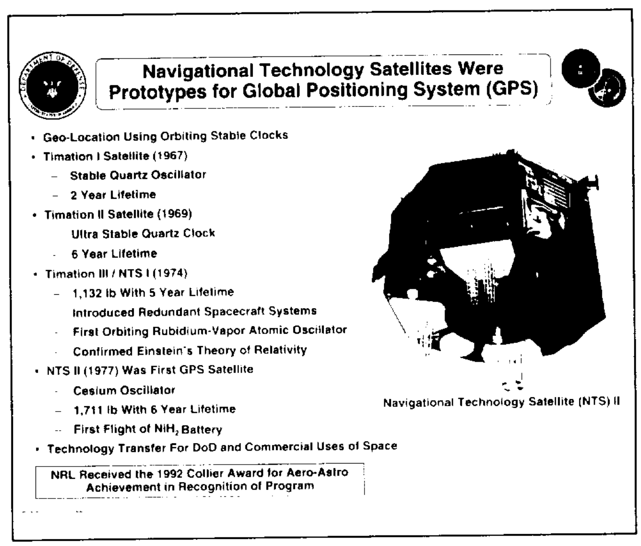


Fig. FB-206

and we were ready to put up the first prototype GPS satellite. This was also done under a Joint Program Office. And I don't know if it was the first Joint Program Office, but it was certainly the most successful.

In 1992, NRL, along with the Air Force's SAMSO organization, The Aerospace Corporation and Rockwell International, shared in the very prestigious Collier Award. I think as you look at the elements of this program, the advanced technology demonstrator, transitioning the technology to the industry, developing what has now become a major commercial off-the-shelf capability, there is a huge market place for GPS data products for this country. And it all came about because the Navy, the Air Force, and industry were able to cooperate as they never have before. And I think the results stand for themselves. I know in my career that there is no single thing that I was ever involved in that gave me more personal satisfaction than to have played a role in this GPS program.

The second satellite I would like to talk about is called LACE (low-powered atmospheric compensa-

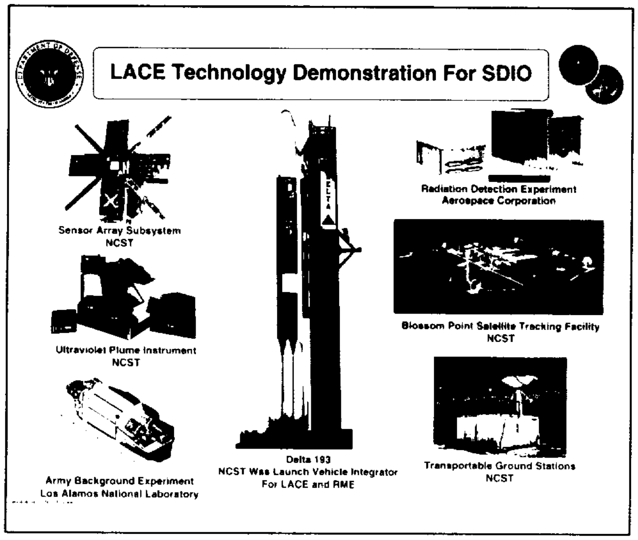


Fig. FB-207

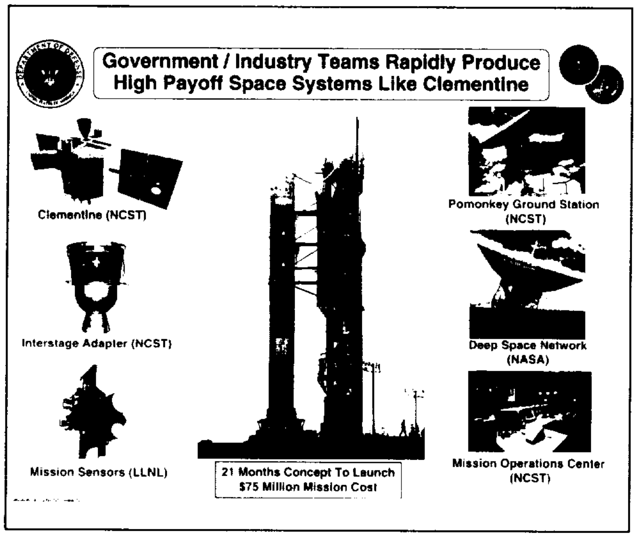


Fig. FB-208

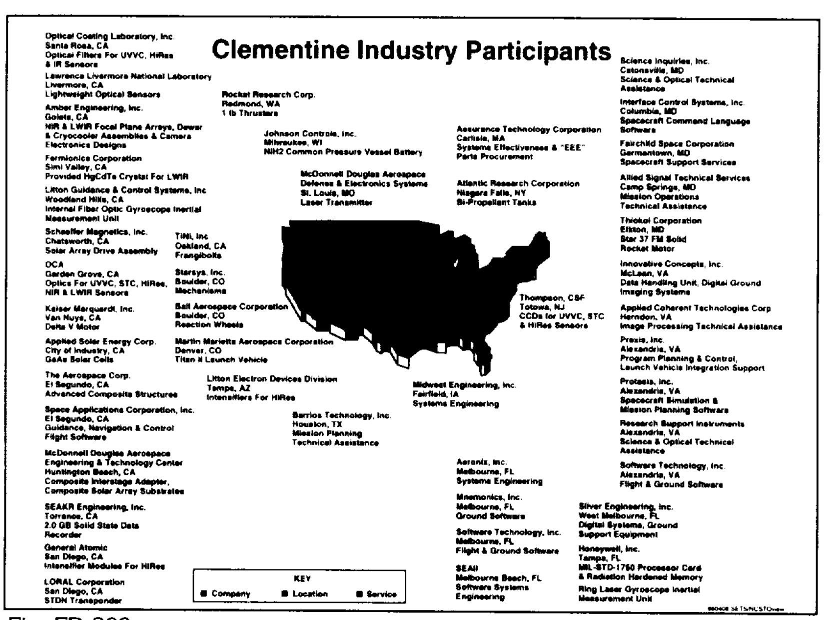


Fig. FB-209

tion experiment) *[Fig. FB-207]*. It was the first satellite that was done by us for the SDIO. It was a very successful program, also. The main thing with this program is that the sponsor was continuously changing the requirements. We had to always be adapting to new situations. I think it's one of the fundamental advantages of an in-house capability. When the sponsor—government sponsor—says he wants to change the scope, if you're in-house you can react to that very quickly. You don't have to renegotiate a contract or anything. Things like the UVPI instrument from Loral were added 18 months before launch. SDIO decided they wanted to launch another satellite with us and they changed the launch vehicle and we wound up using a Delta. There were a number of things that were very unique about that program. The thing that I think was probably most beneficial to us is we were given an award by SDIO for the best program of the year, but, more importantly, we had gotten their confidence in our ability.

The next satellite that I'll talk about was awarded to us because of the LACE satellite and that's Clementine *[Fig. FB-208]*. This viewgraph shows some of the main elements of the Clementine program: the spacecraft itself, the inner stage adapter, the sensors or the cameras which were provided by Lawrence Livermore National Labs, one of our NRL ground stations, a 100 foot dish that was used in conjunction with JPL NASA Deep Space network to take the data from Clementine as it was going around the moon, and then our mission control station, which some of you may have heard of, referred to as the Bat Cave, a very low cost operation. So the total Clementine satellite was done in 21 months for $75 million.

Now this chart depicts one of the other important characteristics of this program and that was that it involved a very large team from the industry *[Fig. FB-209]*. There were 45 companies and they were selected by us because we felt they had the best technology that was available in the U.S. industry at the time. The next thing is the question of the funding and how that funding was divvied up. In spite of the fact that Clementine, for the most part, received a lot of good publicity, there was early criticism that we were taking work away from industry—and I think this chart shows that that's kind of a "bum wrap" *[Fig. FB-210]*.

The small NRL team consumed only 16 percent of the total pie. The other 84 percent was consumed by industry. But the point is, that 84 percent would have never occurred if it hadn't been for the enabling capability that the Lab brought to this program. Now I have to apologize, this is a very busy chart, and I'll leave it up here while I try to explain some other things

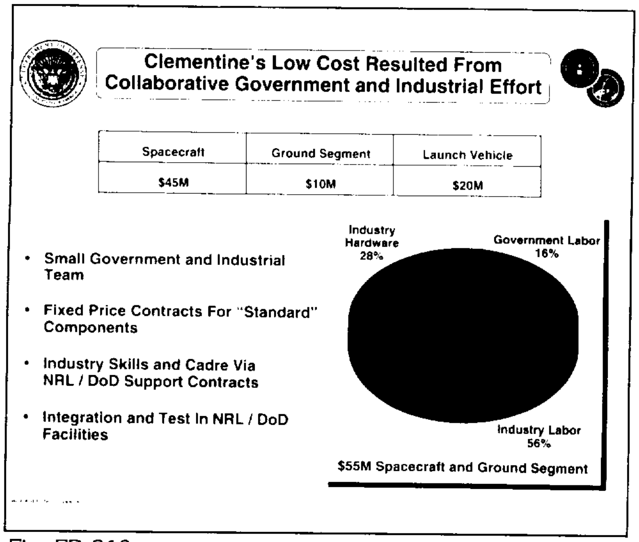


Fig. FB-210

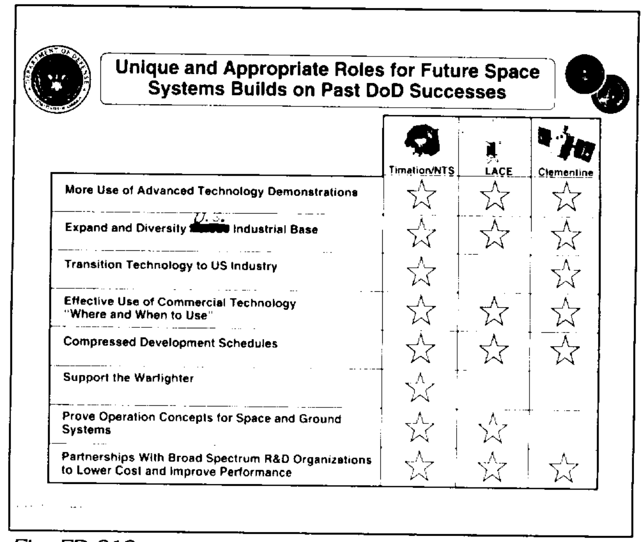


Fig. FB-212

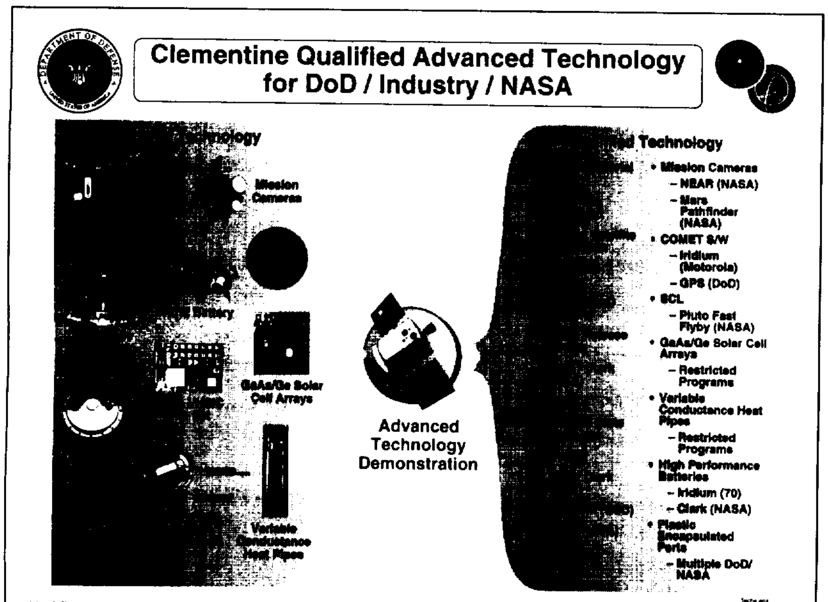


Fig. FB-211

about the Clementine program that aren't on the chart [*Fig. FB-211*]. And that is, the reason Clementine probably received so much favorable publicity was because it was the first U.S. mission to return to the moon in 25 years. It did completely map the surface of the moon. Probably the most significant thing that happened to the Clementine program, in my estimation, was that it made the front page of the Weekly Reader. Last night here the stage was full of a bunch of young children that I'm sure all read the Weekly Reader and they all know about Clementine. This chart points out the motivation of the Ballistic Missile Defense Organization and it was to qualify and transition all of those technologies, and that has been done very successfully. All of the scientific data that got the good publicity was serendipity, really. That was not the purpose of the mission from the DoD standpoint. This is all hardware here, it's hard to show a picture of software, but there are a couple of software transitions that occurred. Our Comet software has been adopted by Motorola for the Iridium project and by the GPS program office. Also we had developed a satellite control language which is ideal for automated spacecraft operations, and JPL is going to use that on its Pluto fast-flyby mission. So I think the transition of the technology was very successful.

Now I'd like to go back and make that bridge between what worked well in the past and what I think is going to be needed in the future. The rows on the left are the things that I think are going to be important in our future [*Fig. FB-212*]. The vertical columns are what we have been able to do in the past and I think you see a very good match there. I think the one thing I would highly recommend to our seniors is that we make more effective use of what we call advanced technology demonstrators to reduce the risk of some of these major space programs.

The other thing is that we will continue to try to achieve compressed schedules because time is money, and there is no better way to do it cheaper than to do it fast. And maybe the last one is, I see the need to have more and more partnerships in the future to reach out to a broader spectrum of our community, because nobody seems to have enough money to do these things on their own.

And there is one last viewgraph that I have. Bob Davis, who is the Deputy Undersecretary of Defense for Space, was kind enough to accept our invitation to give us his views on what the future issues in space would be. He took that opportunity to challenge us to put down, in print, a vision statement: What is it you guys want to do in the future? And then to try to promulgate that throughout the aerospace community and debate it. And this is the first time it has really been shown in public. I can't think of a bet-

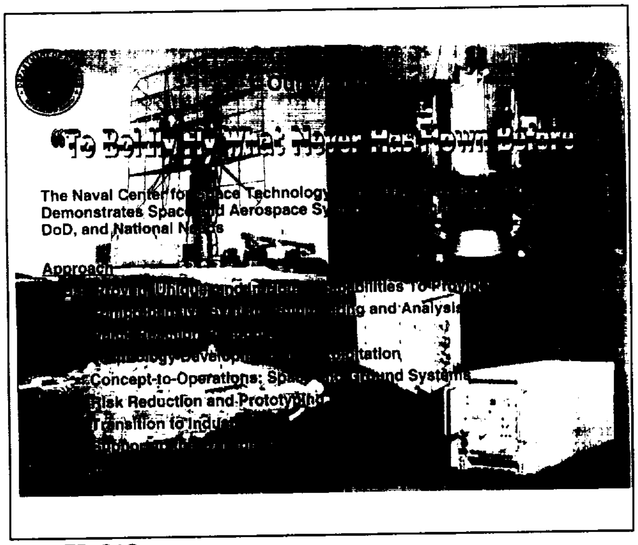


Fig. FB-213

ter place to do it than at this conference. I won't read the whole thing, but the simple statement that you can carry away with you is that we would like "to boldly fly what never has flown before" *[Fig. FB-213]*.

In summary then, I have tried to show what we think has worked well in the past, why it worked well, and what parts of it will have applications in the future.

Thank you.

Dr. Mark: It's a great pleasure for me now to introduce our next speaker, who is a very old friend of many, many, many years' standing. He is the current director of the Jet Propulsion Laboratory of California Institute of Technology, which also doubles as a NASA center. When I was serving as a NASA center director that dual role always gave me a little bit of trouble. But it is a very effective organization.

Ed Stone was appointed to that job in 1988 and has been the director since then. He also serves as a professor of physics at the California Institute of Technology, and I believe he's also the vice president to the institute. So, he has a least three jobs, all of which are eight-hour-a-day jobs, right? So he doesn't sleep very much.

Ed has been—is known really and famous for being—the principal scientist on most of our out-of-planet exploration spacecraft. If there is anyone who is responsible for what has now become called the "Golden Age of Planetary Exploration," it's Ed Stone. I remember working with him in those years, and it was always a pleasure to watch him operate and how he did business. He is a graduate of the University of Chicago, from which he received his Ph.D., and is a member of the National Academy of Sciences, a fellow of the AIAA, and lots of other nice things. So with that, let me ask Ed Stone to come to the podium.

Dr. Stone: Thank you, Hans. It is certainly my pleasure to be back this year and to talk about quicker, better, cheaper and how that really fits well with what I call the next phase of planetary exploration. NASA's role is to do what hasn't been done before and to expand the frontiers of this new realm of human activity—space—and not to do what others can do. In the past we've done that in many ways, but certainly one of the ways was the exploration of the planets with flybys and orbiters.

All of the planets, except Pluto have been explored by using technology to build increasingly complex and capable spacecraft. And, as Hans Mark said, it was this promise of increasing capability for each succeeding mission that allowed one to constrain missions like Pioneer 10 and 11. The approach resulted in the development of digital communications, digital imaging, and computer-controlled spacecraft, which in turn led to autonomous spacecraft.

All of these technologies led to increased spacecraft capability and complexity. Voyager was the spacecraft of the '80s, and in the '90s, it's the Galileo spacecraft. The first decade of the next century will be the Cassini spacecraft, developed jointly with the European and Italian space agencies, that characterizes this particular development path of doing what has not been done before. Those missions have done and will do very comprehensive surveys.

The next phase of exploration really requires much more frequent access to space, which means much lower costs. We need to get closer to things; we need to get 100 kilometers from objects rather than 10,000 kilometers. We need to get down into atmospheres. We need to get down onto surfaces. We need to actually bore beneath the surfaces, and we need to bring things back from the surfaces. That's the challenge of the next phase of exploration, and that has to be done in an affordable way so that we can do it frequently, not just once every two decades, as was the case for the Mars program until a few years ago.

We were at Mars in '76 with Viking and we were going back in '93 with Mars Observer. We now have a Mars program through which we'll be going back every 26 months, with two missions every time. You can't do that if every mission costs $1 billion. You can do that only if the missions are much, much

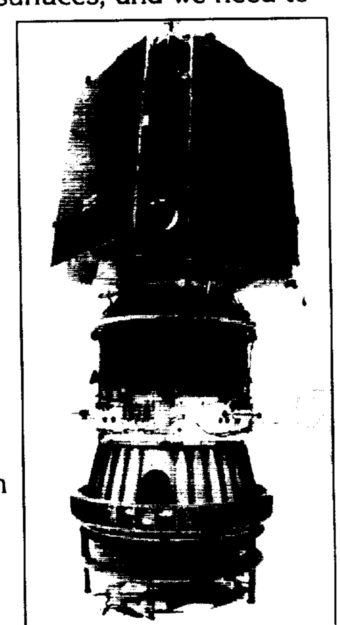


Fig. FB-301

Fig. FB-302

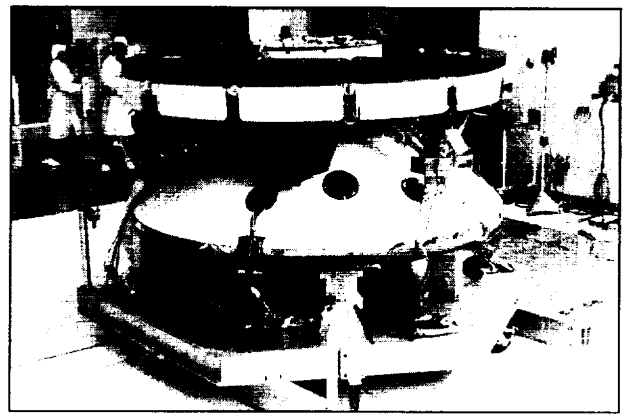


Fig. FB-303

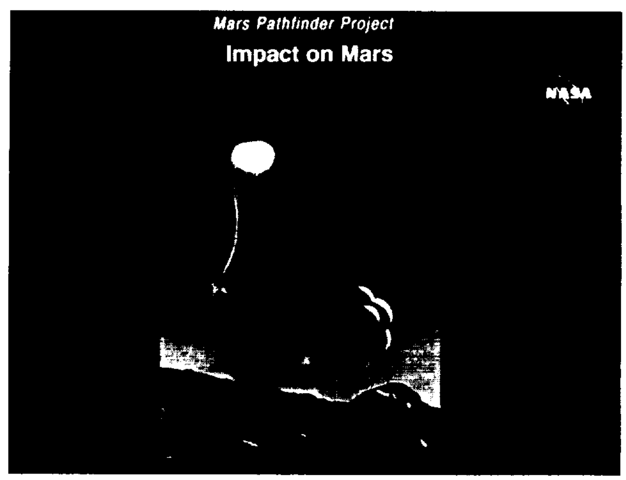


Fig. FB-304

less costly and much more focused. You have to replace the promise of the larger, more complex mission, which made possible the constraints on Pioneer, with the promise that there will be additional small missions to be able to cover the other science that you can't do on this current small mission.

The Clementine spacecraft showed that you can build a modern spacecraft with the same mass as Pioneer, at a lower cost in constant dollars by using advanced technology to do things that could not have been done with 1970s technology. Applying advanced technology is an important factor in achieving quicker, better and cheaper missions.

NASA now has three kinds of programs I want to briefly discuss. One is the Discovery program, in which each mission is constrained to cost no more than $150 million in fiscal year '92 dollars and take no more than three years to develop. The second is the Mars Surveyor program, which now is intended to take us back to Mars every time there is a chance at funding level of about $100 million dollars a year. The third is the New Millennium program, which in many ways is to do for the planetary program, what Clementine was doing for the military program, that is, to serve as technology test beds so that the small missions will be able to rely upon new technology coming out of the New Millennium program.

The first Discovery spacecraft, launched in February is the Near Earth Asteroid Rendezvous (NEAR) spacecraft built by the Applied Physics Laboratory in 27 months at a cost in FY '92 dollars of $112 million *[Fig. FB-301]*. NEAR planned to orbit the asteroid Eros at a distance of about 50 kilometers radius *[Fig. FB-302]*. The object itself is 40 kilometers long. So this is going to be a very complex orbit, as you might imagine. It certainly will provide a precise measurement of the mass of the object, because of the orbital dynamics, and of course, knowing the size, we'll know its density, and whether it's a composite with a density of 2 to 3, or has been melted and has a density on the order of five.

NEAR has a number of very sophisticated instruments, for example, imaging at a resolution of several meters and infrared spectroscopy at the 300-meter level. It will arrive at Eros January '99 and return very strikingly new data during that time period. A very good example of quicker, better, cheaper.

The next Discovery mission is the Mars Pathfinder mission. The last time we were at Mars was 1976 when there were two Viking orbiters and two landers. If we were to redo that mission today, just the same as it was but price it in today's dollars, it would cost $3.5 billion. That's the reason we haven't done it again. Mars Pathfinder will demonstrate a much lower cost way of landing on Mars *[Fig. FB-303]*. The cruise stage is the circular structure above the cone-shaped entry body, will land on July 4, 1997. Launched this December, it directly enters into the atmosphere of Mars with an aeroshell deploying a parachute, and finally airbags to absorb the final energy as it descends to the surface *[Fig. FB-304]*.

Mars Pathfinder carries a small rover called Sojourner *[Fig. FB-305]*. The 12-kilogram rover runs on eight watts of electrical power on the average, and has an alpha, proton x-ray spectrometer, which can be placed against a rock to measure it's composition. It has stereo-imaging so it can look at rock structure. We're landing Sojourner in a place were rocks have

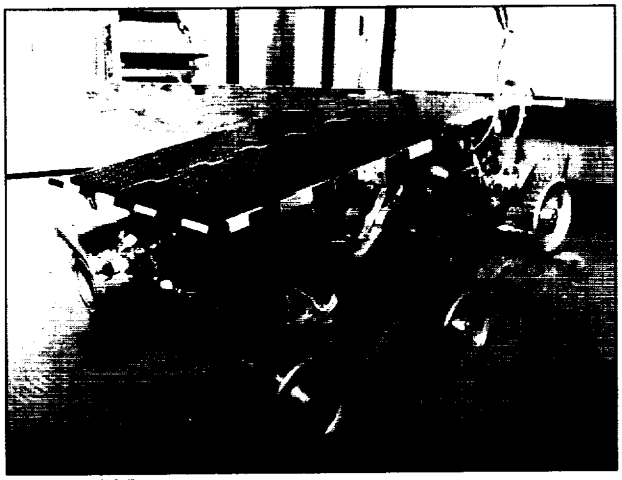


Fig. FB-305

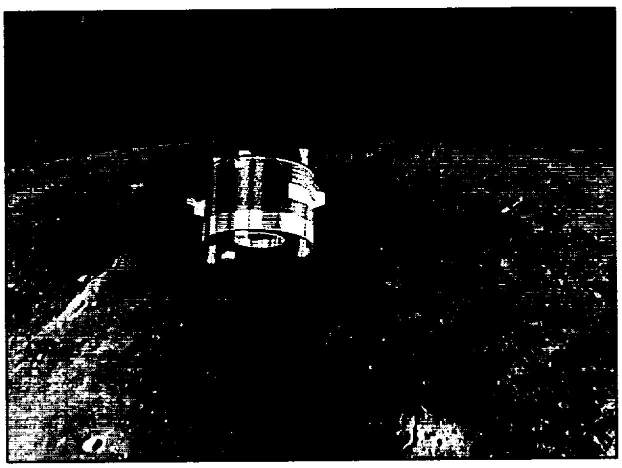


Fig. FB-306

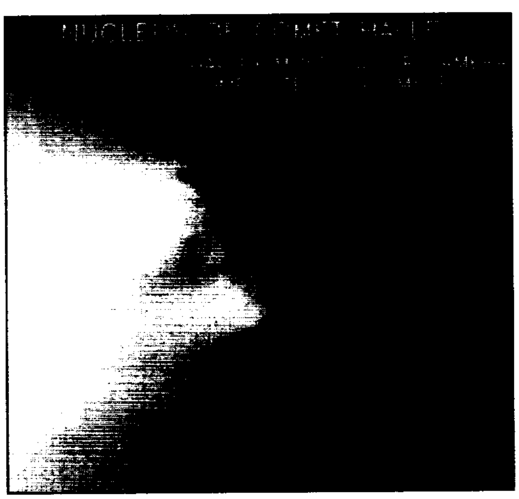


Fig. FB-307

been carried from a wide region on Mars by the floods 3.5 billion years ago, down to the region where they're accessible. The cost of Sojourner is $25 million and the landing system is about $175 million. That's the quicker, better, cheaper.

The next Discovery will be the Lunar Prospector that is being developed by Lockheed Martin, with Allen Binder as the principal investigator *[Fig. FB-306]*. It's a 280-kilogram spacecraft, $51 million (FY '92 dollars). It will have a 100-kilometer altitude orbit and supplement and complement the data that came from Clementine by using gamma rays and

Fig. FB-308

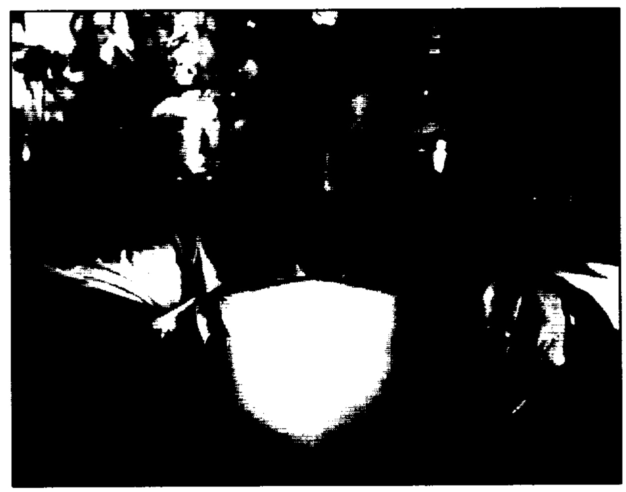


Fig. FB-309

X-rays to determine the composition of the lunar surface, and tracking the spacecraft will provide information on distributions.

The next Stardust spacecraft will visit a comet. The ESA Giotto spacecraft flew by comet Halley in 1986 and discovered that it was ejecting a lot of material so fine that it is not visible *[Fig. FB-307]*. These particles were mainly carbon, hydrogen, oxygen, and nitrogen, the building blocks of organic material. And, of course, the questions are "What is this material? Is it organic? Is it part of the material out of which the solar system formed? What role did this organic material possibly play in the origin of life here on Earth?"

To answer these questions, we need to return a comet sample to Earth. Stardust is a discovery mission that will extend blocks of aerogel into the comet as it flies within 100 kilometers of the nucleus of the comet *[Fig. FB-308]*. The aerogel will capture the dust particles as they impact at five kilometers per second. The aerogel will be retracted into a canister that will then be returned to Earth for analysis in the year Aerogel is a silicate material that is 99 percent empty by volume, so it will not destroy the fine dust particles as they're captured *[Fig. FB-309]*. So, here is a sample return mission that fits into the Discovery class, costing less than $150 million to develop in FY '92 dollars.

So that is the Discovery program, and the intent is that there will continue to be opportunities. These programs are led by principal investigator teams that include industry with support by the Jet Propulsion Laboratory. For Example, Stardust will be developed by Lockheed Martin Astronautics, with the Ames Research Center involved in the heat shield that is being developed for the return capsule.

Another example of quicker, better, cheaper is the Mars Surveyor program. The first Mars Surveyor spacecraft is being built by Lockheed Martin Astronautics *[Fig. FB-310]*. This will carry six of the eight instruments that were on the Mars Observer, will be launched in November of this year, and will go into orbit around Mars in September of '97. A circular polar orbit will provide a complete high-resolution map of Mars as well as some very localized ultrahigh-resolution so we can begin to look for some of the more interesting regions on the surface where we might want to send future landers and probes. The MGS spacecraft mass is about 600-kilograms, about half the mass of the Mars Observer, so it can be launched on a Delta launch vehicle rather than on a Titan III. Much lower launch costs come along with much smaller spacecraft.

In 1998, there will be another orbiter and lander. The lander, built by Lockheed Martin, will land in the polar region next to the polar icecap. It will have a camera and a scoop so we can look at the layered terrain, which is presumably the result of the annual deposition of ice and dust, and we'll be able to do a residual gas analysis of the material that is collected. Again this fits within the $100 million a year budget for the Mars Surveyor Program.

Advanced technology is clearly the key to making all of this happen *[Fig. FB-311]*. The early Discovery and Mars programs have benefitted from the Cassini project which has had the time and the money to develop a new space transponder that is being used by NEAR and will be used by Mars Pathfinder. The hemispherical resonating gyro, which Cassini developed, is now on NEAR. But in the future, there will be no Cassini-class missions to fund the new technology. We need something like a Clementine program that is technology-driven and not science-driven, so that the new technology can be developed outside of the constraints of the science programs that have to fit within their budget and their schedules and therefore cannot use any significantly unproven technology. That's where the New Millennium program comes in.

There are four New Millennium missions under consideration *[Fig. FB-312]*: Deep Space 1, an asteroid and comet flyby launched in '98; Deep Space 2, a penetrator probe, carried on the Mars '98 mission to

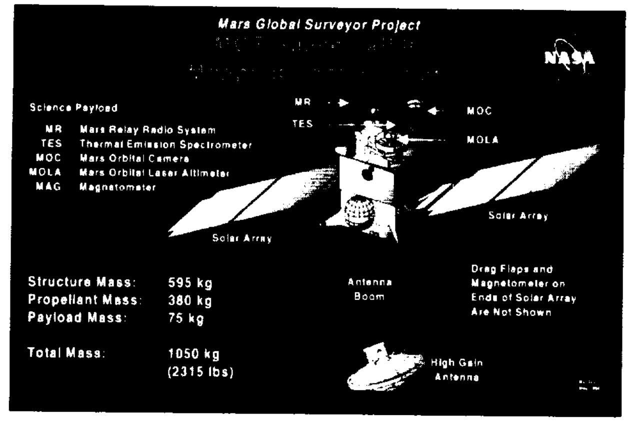


Fig. FB-310

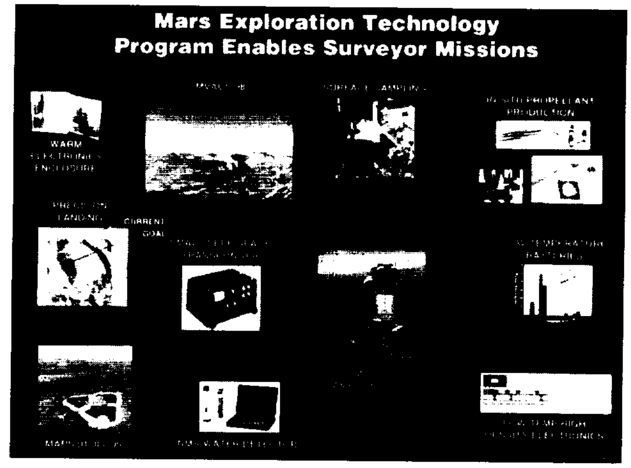


Fig. FB-311

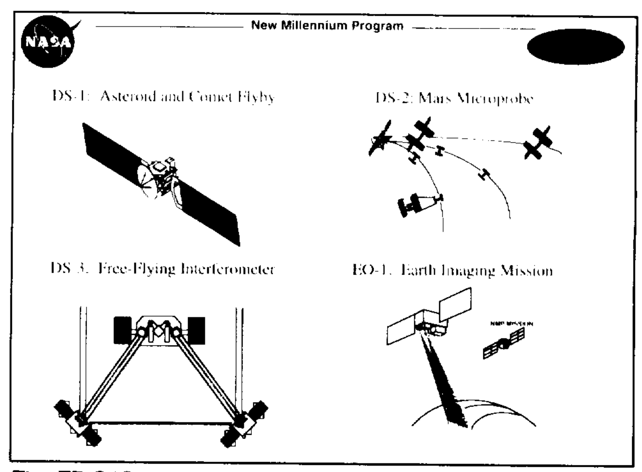


Fig. FB-312

probe the surface of Mars; Deep Space 3, which will test some of the associated technology, putting an interferometer into space so that optical and infrared telescopes, separated by kilometers, can be optically phased. Similar approaches to developing the technology will reduce the cost and size of instruments for Earth observing.

The New Millennium program brings technology from throughout the nation. There are integrated product development teams in six ares: communications, autonomy, microelectronics, modular and multi-

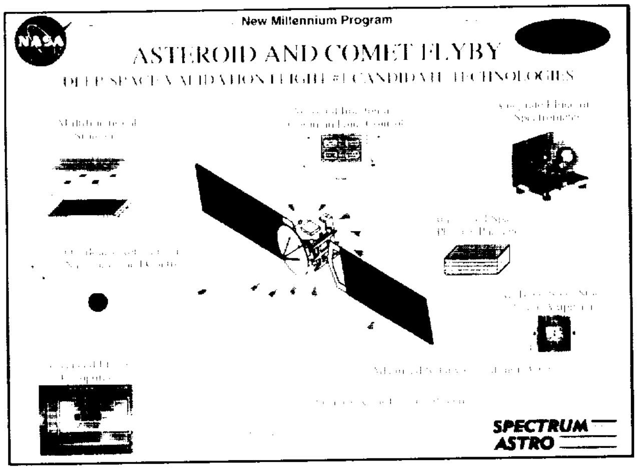


Fig. FB-313

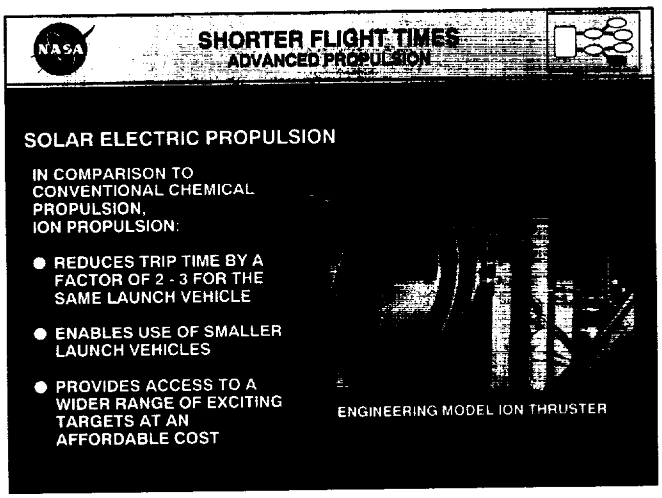


Fig. FB-314

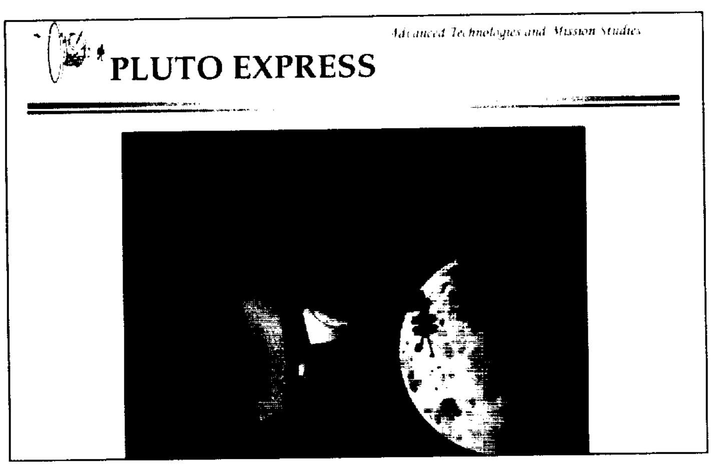


Fig. FB-315

functional systems, in situ instruments, and microelectro-mechanical systems, and instrument technology and architecture. There are 44 organizations involved, including industry, other NASA laboratories, and federal laboratories, such as the Phillips Laboratory. Lincoln Labs and Sandia are part of this team because this is a national effort to press the technology to reduce the cost and size of future space systems.

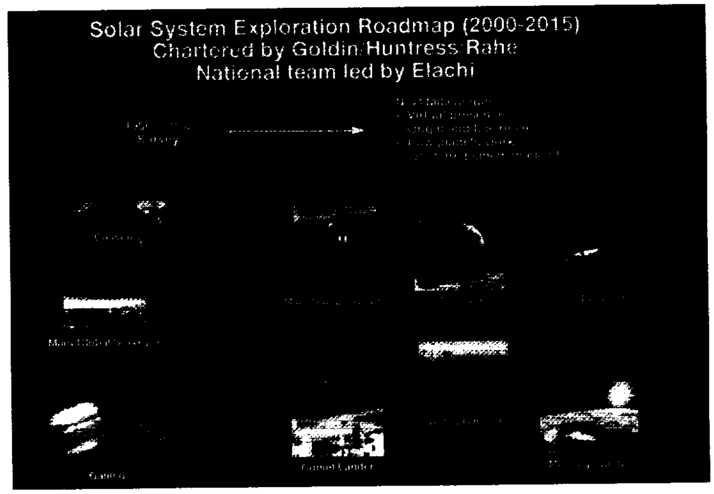


Fig. FB-316

The Deep Space 1 will demonstrate a number of technologies: a flight computer that weighs 98 grams and a multifunctional structure, which is more than structure, and others indicated in the figure *[Fig. FB-313]*. Deep Space 1 will be launched in '98, has a scientific objective to fly by comet Wild 2. One particularly fascinating technology demonstration is the ion thruster *[Fig. FB-314]*. After having talked about it and talked about it for decades, this mission will use an ion thruster to move about the solar system. Langley Research Center has led the development, working with TRW, the Hughes Electron Dynamics Division, and Spectrum Astro. This particular thruster has a thrust—a small thrust—of 30 to 90 mN, but a continuous thrust for the 8,000 hours lifetime for this thruster produces a V of 10 kilometers per second. It will change the way we fly within the solar system. By the way, the New Millennium program is funded at about $50 million a year.

All of this will make possible a mission to Pluto, the only planet that has not yet been visited. The Pluto Express spacecraft is a 100-kilogram spacecraft, not a 1,000-kilogram spacecraft, which is designed to fly by Pluto and its moon, Charon *[Fig. FB-315]*. We hope we can start development in '99, so that we can fly by Jupiter in the year 2006, arriving at Pluto in the year 2013.

With the new focus on in sit explorations, we need a new road map for exploring the solar system, and such a study is underway *[Fig. FB-316]*. It involves a 56-member development group, including 13 industry participants, other NASA centers, and other federal laboratories. Again, the idea is to gather the best ideas so that we can lay out a general road map for the next phase of solar system exploration. We can then make investments in the technology that enable in situ exploration and the return of samples of the many bodies that share the solar system with Earth.

Thank you very much.

Q&A

Dr. Mark: We have a number of questions, and some are for Pete (Wilhelm) and some for Ed (Stone). What I'll do is start myself and then go down the line. Do we have any more questions? Well let me start.

Using lessons learned from Pioneer, what changes would you make to the next generation of manned launched systems?

Right now I don't think there's going to be a next generation of manned launched systems. I don't think the current political situation will really permit the kind of investments to actually develop a new generation. Therefore the lesson to apply is, what can we do with existing manned launch systems to improve them? In this country we have the Space Shuttle. The shuttle is a good air frame, but it ought to have new avionics, it ought to have new control systems, we ought to get rid of the hydraulic actuators, and we ought to perhaps put on new liquid boosters. There's a lot to be done to improve the existing Space Shuttle. In terms of management, NASA is already doing what really needs to be done, and that is to put the operation of the Space Shuttle on contract. We should have done that a long time ago. NASA is not an operational organization. I think that this move will improve NASA and also improve the operation of the shuttle. The other manned launched vehicles around are the Russian launch vehicles. We ought to take a good look at what American technology could bring to the Russians to improve their manned launched vehicles. I really believe that right now I would recommend that we do not think about a brand new generation of launch vehicles. I just don't think it's in the cards.

Mr. Wilhelm: One question here I'll read: Clementine made a successful mapping of the moon but spun out of control on May 7, 1995, and failed to rendezvous with asteroid Geographos. What's the status of the orbit of Geographos, and will you send another space probe to attempt to map the object again?

The short answer is no. We will not send one out to Geographos. There is another mission called Clementine II, which is an asteroid encounter mission. It was a plus-up in this year's congressional budget. The verbiage says that it should be done by the same Clementine team, which specifically means Naval Research Lab, Lawrence Livermore, and Phillips Lab. The funding for that program right now is being held up, as are a number of congressional plus-ups, because of the need to pay the bills for Bosnia. Whether that money will be released shortly we can only hope. But it will be an exciting mission in that it will actually send probes out to intercept three different asteroids over a period of two years.

Dr. Stone: My question reads: Will international cooperation in satellite manufacturing create a longer acquisition process, increase cost, and reduce the threat of reduced capabilities to appease all countries involved; i.e. the major delays associated with the International Space Station?

Our experience in the planetary program has been that the international cooperation, which has occurred now for some time, has really been very good. For instance, the main engine which put Galileo into orbit around Jupiter, was provided by Germany. In the case of Casinni, there is major European contribution. The Huygens probe is an ESA development, and the main radio system and antenna are provided by the Italian Space Agency. Those cooperations have enabled those programs. We had a recent flight of a synthetic aperture radar system involving the German and Italian Space Agencies. So, international cooperation, at least in the programs I'm involved with, will grow. If there are more missions, which I hope will be the case as we reduce the cost of missions, there will be more opportunities for cooperative activity to really leverage the investment that each of the nations can make.

Dr. Mark: Let me look at this question. The panel addressed specific cases of things that have been done well, but did not mention the launch costs associated with getting into orbit. What are your opinions on improving our launch capability?

If there are more missions, which I hope will be the case as we reduce the cost of missions, there will be more opportunities for cooperative activity to really leverage the investment that each of the nations can make.

You know, I have never believed the talk of the creation of a cheap launch vehicle—17,000 miles an hour is an awful lot of kinetic energy, and it is always going to be expensive to get things into space. I don't think there is such a thing as a space truck or whatever people want to call it. Let me give you my opinion about what needs to be done to reduce launch costs, and I know this is one that perhaps may not be popular. The fact of the matter, ladies and gentleman, is that Earth is awash in launch vehicles. We have thousands of surplus military rockets that could easily be turned into launch vehicles, and in a limited way we have already done that by taking the 50-plus Titan II rockets that we had and converted them. The Russians have 300 SS-18's that we could turn into very capable launch vehicles. Now, I know that there are some folks in the launch vehicle industry who are unhappy about that thought. But if you ask me how we lower the cost of getting into space, then the answer is to use what we've got. People say, well refurbishment costs are high. I don't believe that. I believe it is cheaper to take a Titan and refurbish it than to build a new one. Martin has done that. And I think that's what I would recommend if we were really interested in reducing launch costs in the near term.

Mr. Wilhelm: There are a couple more questions relating to Clementine II. I think I've said about all I can about Clementine II right now. There is another one here, though, that makes a point about the multi-spectral imaging that Clementine was able to do of the Moon being very useful, and since warfighters can also use multi-spectral imaging, shouldn't we take some credit for supporting the warfighter? I'm always willing to take credit for supporting a warfighter, but I think, seriously, there are other programs that we're looking at that will use multi-spectral and hyper-spectral imaging to support the warfighter. It's pretty well established that hyper-spectral imaging is very effective at discerning camouflage and looking through camouflage, and things like that, so it can find man-made targets quite easily. That is another program, but multi-spectral imaging and hyper-spectral are very definitely some of those exciting new technologies.

If you're going to do things faster and cheaper it almost forces you to use existing hardware, and that automatically reduces rather than increases the risk.

Dr. Stone: Does "faster, better, cheaper" necessitate small, single-use, specialized payloads? Isn't this what the former Soviet Union has done since its inception which is antithetical to the traditional American programs?

I think we've discussed that. As Hans pointed out, the traditional program has been one of increasingly complex and capable systems, at the rate of once per decade. So you wanted it to do as much as you could since you have one chance a decade. With the approach of having many launches in a decade, it makes sense to have single-purpose missions, because other scientists will have an opportunity to do what they think is important within a reasonable period of time, and not wait one or two or three decades.

Dr. Mark: The near-Earth asteroid rendezvous mission, NASA's first discovery mission, was developed in 27 months for less than $120 million by John Hopkins University's Applied Physics Laboratory. The paradigm for development was point for point with your first and second slides. Haven't we just realized that we've come back to the future? Can dedication and teamwork overcome politics and budget constraints?

The answer is simple: yes. My hope is that once this thing is launched and flies it will be as successful as Pioneer 10.

Mr. Wilhelm: One more question on Clementine II, the joint program with Phillips Lab. Please comment on status of program. Congress has provided a ringing endorsement of the program—in fact a mandate that it should be done. What is your prognosis for the program? Is it going to happen, or is it falling victim to inter-service politics?

I've told you what the status is relative to the money being held up, but I can say it is not because of inter-service politics. The Naval Research Lab and Phillips Lab are absolutely in lockstep on this program. We both want to see it go, and it could be another example of the two services really operating and cooperating together very well. I certainly hope the program gets unstuck.

Dr. Stone: There are several questions here all having to do with how one can better convince Congress to fund these programs and how one can better engage the public to get public support for these kinds of programs. That is a challenge. I think certainly in my discussions in Washington it is clear that many of those who have some responsibility for the NASA program do believe that the direction of the source of things which I have described are the right direction for the space science program. It's just that we're all caught up in this environment where the discretionary part of the budget is the only place to go to balance the budget. And the NASA budget certainly seems to have been hit very hard. At least the projections for the year 2000—$11.6 billion—certainly constrains doing very much of what I've described in that time period. So it is a very serious problem. It's a problem which is tied up with much larger issues the nation's dealing with. I feel we have to make sure that decision makers, both in the administration and the Congress, understand the quest for investment. That this is for the nation, and somehow in dealing with the immediate issues of balancing the budget, some short-term decisions that are and aren't made, in fact, have a critical, long-term disabling effect on the program.

Dr. Mark: Faster and cheaper almost always imply increased risk. The question then is based on that proposition. But before I get to the question, I want to talk about the proposition a little bit, because it's not at all clear to me that it's correct. The question of risk is associated with knowledge—knowledge of your hardware, detailed knowledge of your hardware. One of the major properties, in my judgment anyway, of doing things better and faster and cheaper is in fact to use hardware that you have already flown, that has already been used. We always did that when we did both the Jupiter Pioneers and Pioneer Venus. As a matter of fact, in the case of Pioneer Venus, all we did was cut up a Hughes communication satellite and use it as it stood. So I would have to say if you use existing hardware, I don't agree with the initial proposition of this question. If you're going to do things faster and cheaper it almost forces you to use existing hardware, and that automatically reduces rather than increases the risk.

The question then is, of course, what risk mitigation management approaches have we learned to add "better" to the equation? In my travels around the industry and the NASA centers and the military labs since I have left active building and operating of spacecraft, I find that we have gotten a lot better in doing test programs. We have automated a lot of the testing. We have learned how to do many more tests in the same time. I saw that in your place, Pete, when we were doing Clementine. I went into that, as you know, in great detail. And I think we have learned a lot about how to do test programs cheaper, and I think that's the last answer to this rather interesting and complicated question.

Mr. Wilhelm: My next question is, what aspects of the NTS LACE and Clementine projects would you like to see implemented by the current aerospace industries? I think the one common denominator across all of these programs was that they were all done on relatively compressed schedules, which as we've talked about quite a bit, saves cost. And I think many in industry have demonstrated their capability to do very fast turnaround, and I think unless companies can demonstrate that capability they're not going to compete very well in the future. So that would be my advice to them.

Dr. Stone: What are the best ways to transition advanced technology, that is from the New Millennium, to the broad U.S. space industry, not just to selective program participants?

I think that the whole point of the New Millennium Program is to focus a limited resource on some key areas and to do it so that development is then in the private sector and available for incorporation in other space missions besides the planetary science missions. So I think that is the basic approach in New Millennium. In general, for technology developed at JPL, we make it known through NASA Tech Briefs, and we have a Technology Affiliates Program. If you have other suggestions, please let me know how we can be more effective in transferring the technology which is being developed to industry so it becomes part of the economy more quickly.

Dr. Mark: I have to confess I have another question where I am not sure I agree with the proposition, but let me read it to you. "NASA Headquarters could operate with streamlined management in 1969. What happened to NASA Headquarters and its centers in the 1980s and the 1990s? Does NASA have a road map for returning to streamlined management? And will the centers empower industry to perform on contracts or continue to perform developments in house?"

The question then is, of course, what risk mitigation management approaches have we learned to add "better" to the equation?

This is a good question and it is a complicated one. Whether you can execute something with a streamlined management depends really on how badly the political system wants to do it. I spent some years as the director of the National Reconnaissance Office and, as you know, the president is the chief customer organization. He badly wanted his pictures and his information so we could do things in a way that bypassed much of the political system that normally controls how federal money gets spent. The answer to the question of what happened between the 1960s and the 1990s is very simple. In the 1960s NASA was politically popular and today it's not. Whatever else you say there is a very small constituency for the kind of things we've talked about here. And if I listen, you know I get asked to testify before various congressional committees, I would have to say that with few exceptions most of the questions I get are hostile. You know, why are you spending so much money? Do we really have to do this? Why are we doing that and why are we doing this? And so I think that what is regarded as streamlined management really should be translated into political popularity. If what you're doing is something that the political leadership wants to do, then you can have streamlined management. If it is something that you are really doing kind of against the wind, which is the position we are in today, then I think you're going to have a problem.

Editor's note: Due to technical difficulties in the recording process, the rest of the question-and-answer part of this session cannot be provided.

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Global Security Interests in Space

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Session Chair: **General Joseph W. Ashy, USAF**
Commander in Chief
NORAD/U.S. Space Command
Commander
Air Force Space Command

Keynote Speaker: **The Honorable Robert Davis**
Deputy Undersecretary for Space
U.S. Department of Defense

Speakers: **Brig. General Willie B. Nance, Jr., USA**
Deputy Commander
U.S. Army Space & Strategic Defense Command

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Rear Adm. Katharine Laughton, USN
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Director, Office of Plans & Analysis
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Mr. Scott: Good morning, everybody. I'm Steven Scott, and welcome back to Day Two of the 12th National Space Symposium. Yesterday we looked across a wide spectrum of space systems and discussed the growing range of applications now and in the future, with the emphasis on commercial utility. Today we'll focus on several global security aspects of space.

And leading this morning's panel is Gen. Joseph W. Ashy. Gen. Ashy is commander in chief, North American Aerospace Defense Command, the unique binational command that includes Canada and is responsible for the air and space security of North America. He is also the commander in chief of the U.S. Space Command and commander, Air Force Space Command. In his present position, Gen. Ashy has been shaping U.S. doctrine in the use of space for national security, and can speak from experience as he guides us through today's discussion of global security space issues. Ladies and gentlemen, please welcome Gen. Joe Ashy.

Gen. Ashy: Thank you very much and good morning everyone. First, I'd like to thank Gen. Hill and Dick MacLeod and the United States Space Foundation for including us in a very productive and very vital forum. The Foundation is a wonderful organization, and we're proud to participate again this year. I'm personally proud to represent the men and women of NORAD, United States Space Command, and Air Force Space Command as the moderator of this panel and discussions this morning.

Before I introduce our distinguished guest speaker, let me tell you why his position is very important. The space community was rightly criticized in the past for not having all of the organizational elements in place to deal appropriately with policy, acquisition, and coordination issues, and so I'm proud to report to the Foundation this morning that we now have a deputy undersecretary for Space, Mr. Bob Davis, in place and functioning, I should say, very effectively. We have Maj. Gen. Bob Dickman, who is our new space architect, in place. We have a Joint Space Management Board (JSMB) that's now been authorized and is functioning, and we have a Joint Requirements Oversight Council (JROC) that's functioning and reviewing military space requirements. Specifically how our requirements fit, work and interact appropriately together. And those, altogether with our command, which has assigned missions given to us by the president through the secretary of defense and the chairman, have formed the beginnings of a very effective and very good team, I should say, teams within a team.

That is what Mr. Keyhole, Mr. Bob Davis, Maj. Gen. Bob Dickman and I testified recently before the Senate Armed Services Committee. In fact the Subcommittee on Strategic Systems, I think, sent the message back saying, "Hey, we got the message." Bob probably will talk about this a little bit in his remarks.

Not only did we get the message, we made it happen. So now, we need to move out, and I think again Mr. Davis will acknowledge that and in fact is moving out. I think all of you know him. He is a superb leader. In his new job, he deals primarily in policy and strategy, but he also gets heavily involved in acquisition and international cooperation matters as we come to grips with space related issues. Before coming to this very important leadership position, he was the senior professional staff member of the Committee on Appropriations of the U.S. House of Representatives. He is from Tulsa, Okla. A state that calls itself a state, but is really a northern county of the great republic of Texas. He went to the Massachusetts Institute of Technology (MIT), and certainly has extensive experience with our intelligence space entities and organization from the oversight perspective. Ladies and gentlemen, give a warm welcome to the Deputy Undersecretary for Space, U.S. Department of Defense, Mr. Bob Davis.

Mr. Davis: Thanks, Gen. Ashy, for that kind introduction. Let me say, it's a great pleasure for me to be with you here today and to be able to share my views with you on where I think the Department of Defense is headed in terms of space and our evolving global security interests. Actually, after eight straight months, it's a great pleasure for me to speak on any topic other than the "Office of the Deputy Undersecretary of Defense for Space and its Role in Space Management." Since the U. S. Space Foundation asked me to address something new, I have to believe that after a dozen speeches, either I've finally made my role clear or, at a minimum, the audience has already heard that speech. Either way, it's nice to have a new topic.

By the time we developed an effective strategy, the capabilities and systems that supported that strategy were also in the hands of not just our global peers, but the next lower tier nations as well.

What I'd like to do today is to paint, with a pretty broad brush, what's going on in space—where we've been and where we're headed—and how it likely affects our national and our global security interests, our strategy, and our doctrine. I think it's telling that while I've been asked to give the remarks for this session, the podium will be filled shortly by folks who make a living by formulating space doctrine and strategy and conducting space operations. That's quite a mix of responsibilities. More than anything else, this demonstrates the close interaction between the capabilities and systems on one side of the space equation and the doctrine and strategy on the other side.

About a month ago the National Security Industrial Association hosted a conference for me labeled "Space: Thinking Out of the Box." Some of the same people who were panel members there are speaking at this conference this week. I don't know how many of you were able to attend that meeting but I personally found it to be very thought-provoking and very stimulating. I learned a lot from the two days there and I want to continue that dialogue we began within the DoD, the intelligence community, and with our industry partners. I think the topic here today is linked directly to the sessions we held last month. Space is changing; how we manage space is changing; the systems are changing; and the space actors are changing. The very fact that I'm standing here—my office just celebrated its first birthday—I think those are significant indicators of the change that is actually in place. The continuing revolution in military affairs is mirrored by a revolution in military uses of space. It is changing our global security landscape. If we don't begin thinking out of the box we won't be able to recognize the revolution; we won't be able to react to it; and we definitely won't be able to stay ahead of it, and it will happen without us. What does that mean?

Let me explain by beginning with an unsupported assertion which is also my personal opinion. My assertion is this: Space power today is at a turning point comparable to where air power was near the end of World War II. Why do I say that?

In 1903 the Wright Brothers made their first historic flight over the beaches at Kitty Hawk. Over the next 30 years we worked on developing aircraft and air power. We conducted tests, set records, demonstrated new capabilities, fielded new technologies. We used the airplane during World War I as a platform for observation and some force application. We engaged in counter air. The Billy Mitchells and Guilio Douhets developed early strategy and doctrine. Some of those strategies were right, some of them were ultimately wrong. It wasn't really until World War II, though, over 30 years from that first flight, that we really began to integrate air power into our overall strategy. That integration was hastened because we were forced into it; the Navy because it had lost most of its battleships, and the Army Air Corps because it was the only means of attacking the continent. Even after the war, the proper role of air power was not properly assessed. We had to learn some new lessons in Korea and again in Vietnam, as well as improve some technologies. We especially had to learn how the doctrine was affected by the existence of an air-capable adversary. We really hadn't completely integrated air power's role until we developed the Air Land Battle concept in the '70s. By the time we developed an effective strategy, the capabilities and systems that supported that strategy were also in the hands of not just our global peers, but the next lower tier nations as well.

Compare that history to space and where we are today. In the late 1950s, the U.S. headed into space. Over the next 30 years we worked on developing space craft and space power; we conducted tests, set records, demonstrated new capabilities, fielded new technologies. We used space systems during the Cold War mostly as a platform for observation and force enhancement. Both Department of Defense and the national intelligence community have developed some strategy and some doctrine for how we should use space. Some of it is probably right; some of it may ultimately prove wrong. It wasn't really until the Gulf War, though, over 30 years from the first flight, that we really began to integrate space power into our overall strategy. That integration was hastened because we were forced into it. We had to deal with threats like SCUD missiles that we hadn't adequately planned for. And we had to operate in an area in the desert where the type of terrain and lack of communications infrastructure forced us to rely on space-based systems like communications, positioning, and reconnaissance. But even after that war, the proper role of space power is probably not fully appreciated. We will most likely learn some lessons in new conflicts, in future conflicts. And we'll continue to improve technologies. We have yet to learn how the doctrine will be affected by the existence of a space-capable adversary. And that's something for us to think about. The problem is, I don't know that we've got the time. I'd hate for somebody to be standing here in 35 years—I guess at my age I'd actually be happy just to be able to stand here in 35 years under my own power—but I'd hate for someone to be standing here telling you that by the time we developed an effective strategy the capabilities and systems that supported that strategy were in the hands of not just our global peers, but the rest of the world as well. The rest of the world was watching our first space war; they will not mark time until the next one. In a nutshell, that's the problem that we all face, and the one I think we need to address today.

The revolution in military space will have profound impact on the global security interests of the United States. We, as space warriors and space policy managers, need to recognize that fact and prepare for it. It's a two-sided challenge: First, how do we continue down the path we've just set out on and truly integrate space into warfighting doctrine and terrestrial operations?; and second, how do we prepare for the time in the not too distant future when we face adversaries that use space nearly as well as we do?

Integration of Space Into Warfighting Operations

Before I begin, let me acknowledge that it's Gen. Ashy's job, not mine, to truly integrate space into our warfighting doctrine—but I do get a vote. I think there are some interesting possibilities that we need to consider. I'm told that about a year before the Gulf War there was an argument as to whether or not we should use DSP to give tactical warning for a SCUD-like missile attack. Obviously, we decided to do it. When we were forced to make it work, we did. Through efforts like TENCAP, and through the hard work of a lot of talented people over the years, we've managed to take space capabilities designed for one purpose and use them for another. On the one hand, that's a monument to initiative and ingenuity. On the other, it's a failure on some of our parts to adequately incorporate space operations and doctrine into our thinking.

I look at studies all the time about what we'll be able to do in and from space in the future, whether from the Defense Science Board, private industry, or New World Vista reports from the Air Force, and although we all recognize that new systems are right around the corner, we haven't been sufficiently aggressive in applying these capabilities to new doctrine and new strategies. Those capabilities that were fielded only in our imagination a decade ago will be into the hands of our operators a decade from now. What are we going to do with them?

And we had to operate in an area in the desert where the type of terrain and lack of communications infrastructure forced us to rely on space-based systems like communications, positioning, and reconnaissance.

What's the effect on the battle if the commander can view the actions of his individual troops a hemisphere away in Clancy-esque fashion a la "Patriot Games?" We all remember how President Carter was patched through to Desert One during the aborted Iran hostage rescue. What would it have meant if he could have seen the action unfolding in real time, or, using a hand-held personal communications system, spoken directly to the commander? How would the plan have changed if we could have landed without the aid of deployed landing systems or the need to even see the ground? These things will be possible within the decade. Have we prepared for their impact? I'm not sure we really have.

This past summer we in the Pentagon spent considerable time and energy building a consensus for a new Global Broadcast Service, or GBS. We got the program approved and we carved out nearly a half billion dollars worth of funding with more to follow. We're already building the system. And yet, even today, when I ask what we intend to do with 24 mega bits per second of data, what echelon it should go to, and what information should be sent, I don't get a consistent answer. Using the combination of space assets, UAV, Global Positioning, and the Global Broadcast, we could theoretically select a target, launch a Tomahawk from well over the horizon, guide it to the target, see it impact, and then re-engage that target or move on to the next one all in the matter of minutes. It's somewhat easy to see how this kind of capability can change our tactics; it's tougher to envision how we change our doctrine and our strategic thinking. Now don't take any of this to mean that I'm unhappy with the Global Broadcast decision. On the contrary, I think it's great. Using capabilities like hand-held mobile communications, and smart weapons, we have gained an unprecedented capability to synchronize the battlespace. And yet I feel like the guy standing in his garage after inventing Velcro saying, "This is great! Now what do I do with it?"

The problem isn't in figuring out how to use the systems we're fielding; it's deciding which direction to head. If we don't understand the doctrinal impacts of the systems we deploy, we can't appreciate where we should be investing our dollars. What would it mean to the warfighter in the future if we could fly a reusable launch vehicle that gave him unprecedented access to space? Air Mobility Command knew the doctrinal implications of access to the battlefield and so designed a C-17. How would an RLV affect our use of space? Could it tip the balance in usage from force enhancement to force application? How will small satellites affect the operational tempo? What new terrestrial capabilities should we be planning, given the new space capabilities we intend to build? If I can't answer these questions—if the warfighter can't answer these questions—then we as a department can't plan the systems that will give us the most leverage not just for the next generation, but the generations to follow.

The problem isn't in figuring out how to use the systems we're fielding; it's deciding which direction to head. If we don't understand the doctrinal impacts of the systems we deploy, we can't appreciate where we should be investing our dollars.

We faced the same problem after World War II. The Air Force drew the lesson from the war that it was the age of the strategic bomber. SAC was king and tactical air was shortchanged. We didn't understand how air power should best be integrated into warfighting doctrine. That left us woefully unprepared for Korea and Vietnam, where tactical bombing, not strategic bombing, ultimately was the key. Our first space war may not be the model for future wars. We need to do the thinking if we hope to build the right mix of capabilities.

Gen. Dickman, who will be up here on stage, is the space architect. He is wrestling with these issues right now in his Military Satellite Communication Architecture study. Previous studies looked at the existing systems and put together an architecture that merely replaced them. We've got to do better. We need to understand how communication satellite usage will change as we move into the next century. We need to understand how these new communication systems affect the way terrestrial systems work and change our tactics or our systems to take best advantage of these new space opportunities. We're working on a National Security Space Master Plan to lay out the broad view of this structure and the Space Architect is working the individual system questions. But without a clear strategic view, our plans will consistently aim behind our possibilities. We must plan carefully for the integration of space into our warfighting operations.

As I've outlined, integration of space into warfighting is our first challenge. It's important, but in the final analysis, if we fail to do it properly the worst we risk is an inefficient use of resources for an extended period. The second challenge, the one that is in my mind more threatening, is preparing for the time when the adversaries we face will be able to use space to their advantage the way we use it for ours. That day may be arriving sooner than we had previously imagined. There are two factors that are hastening the arrival of that day: the commercialization of space and the rapidly growing international expertise in non-commercial space systems.

We don't need to look much further than this room to understand the commercialization of space. Nowhere is that commercialization more evident than in the satellite communications arena. We all know the names—Irridium, Globalstar, Odyssey, ICO, Teledesic, Spaceway, and my apologies to any of you whose systems I didn't mention—the list is becoming endless. During the next 10 years, there will be more space communications platforms and more space communications capacity launched than in the entire history of satellite communications. In 10 years, through the commercial market I'll be able to buy Direct Broadcast, worldwide point to point hand held communications, private VSAT networks, space borne wide area computer nets, and processed switched bandwidth capacity at near EHF frequencies—all from the privacy of my own home, or from the local terrorist training camp.

In the next 10 years there'll be imagery available down to 1-meter resolution or better as a commercial product. Within 10 years there will be access to GPS worldwide with the same degree of accuracy—or better—now reserved for authorized military users. Imagine, if you will, the scenario of any individual in the most remote corner of the world able to order and download a GPS benchmarked image of any target in near real-time from a deployed computer terminal hooked into the Global Information Infrastructure via direct satellite connections. What if that individual also has access to a GPS guided weapon, say a Cessna with GPS autopilot loaded with conventional explosives? What could he do? What should we be doing to counter that?

Today, only the U.S. has the capacity to field-processed, crosslinked communication satellites. The rest of the world will soon be able to get access to that technology from the commercial marketplace. The same is true for highly accurate GPS using soon to be available wide area augmentation systems. But in the not too distant future these products will also be available from non-U.S. sources. Through industrial partnering and outright purchases, the desert will be in the hands of both our allies and our foes in the near future. We can forestall this process—through export controls, licensing restrictions, and international cooperative developments which give us some say in how our technology is used—but we have no hope of halting it. We're in the mode of buying ourselves time.

And it's time we must not squander. The challenge for the U.S., the policy manager, and the warfighter, is to develop the mix of national space policy and operational space doctrine that will allow us to operate the new space order as effectively as we did in the old. We need to develop the systems that can counter the hostile use of space, and tactics that render that use ineffective. We need to do this while at the same time preserving and improving our ability to operate in that medium. That's not an insignificant task. And we need to do it soon. I don't know when it will occur, but I guarantee in the near future this threat will emerge. It's only a matter of time.

What I do know is, we will not arrive at the answer to either of these questions—how should we best use space and how should we prevent it from being used against us?—unless we open our perspective. We do not have the resources to develop space systems the way we have in the past, nor to wait until those systems are developed to create the doctrinal changes that make them useful. We need to relook at our entire approach to space system support and space systems operations to make sure we are poised to take advantage of the opportunities afforded us by changing technology and not to be hampered by the way things worked into the past. If this means breaking down the walls between intelligence and DoD space systems, then those walls must fall. If that means moving to reusable launch vehicles or contractor-run launch operations, then that's the direction we'll head. If it means relying to an ever greater extent on commercial communication systems tailored to our needs, then we need to put in place the policies to make it possible. We need to find the core competencies in space, determine how they affect the doctrine, and then put in place the policies which move us in that direction.

My organization's already begun this process, as has Gen. Ashy's. But it's a task we must all embrace. I'm not certain the answers I'm coming up with today will be the ones that get us to the goal tomorrow. But lack of the correct answer certainly will not prevent us from asking the right questions. Thinking out of the box is not a solitary task. It is a group exercise in which we all must participate. In 1945, when Arthur C. Clark envisioned a geostationary satellite through which earthbound communication occurred, he was definitely out of the box. Then the box expanded again 25 years ago when someone envisioned a signal from space that would eventually allow pinpoint navigation. The box continued to expand. We can stay ahead of it only by looking into the future, questioning our strategy and our doctrine, and planning for space offense and space defense. Or we can remain anchored to our current ways of doing business and be swallowed as the limits of the box overwhelm us. If we let that happen, then we haven't done our jobs.

I have a quotation from retired Adm. Bill Owens, the former vice chairman of the Joint Chiefs of Staff, taped to the computer screen at my desk in the office. I probably read it a dozen times a day. It says, "Today, the real risk lies in hesitating, and the real payoff will go to the bold, the innovative, and the inventive." I believe his statement is true not only for those of you here today who will almost certainly be called upon to fight real wars, but it is also true for those of us who must fight the bureaucratic wars necessary to change the way we do business to provide better space support to the warfighter.

We need to relook at our entire approach to space system support and space systems operations to make sure we are poised to take advantage of the opportunities afforded us by changing technology and not to be hampered by the way things worked into the past.

To those of you in the audience today who may still be entirely too comfortable with the way DoD and the intelligence community have conducted our space business in the past, I say, "Watch out." This is a time of change. It is our intention to make change a way of life for those involved in national security space activities. For those who do not want to be "bold," "innovative," and "inventive," as Adm. Owens said, then I leave you with the admonition that you will not be part of our space future. To those of you who are already committed to change and helping to lead the way, I say, "Thank you." You are now and will continue to be

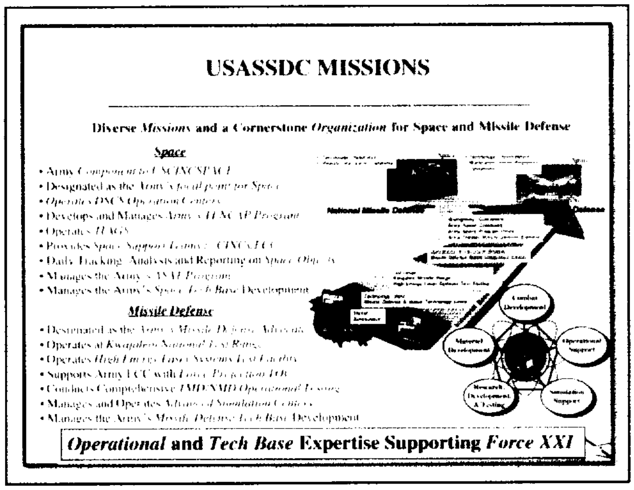


Fig. GS-101

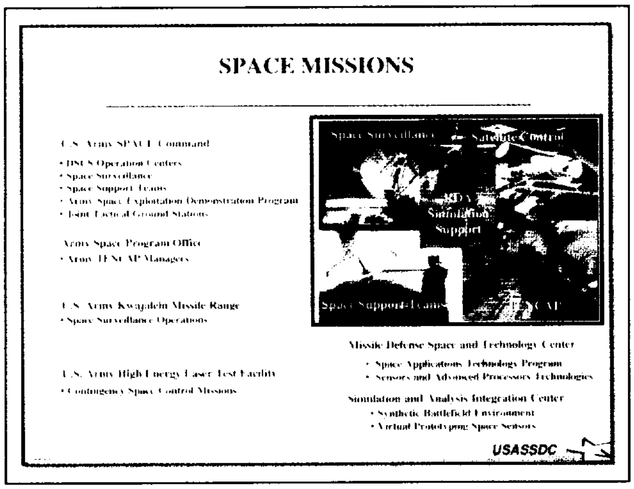


Fig. GS-102

a critical part of ensuring the success of our national security mission in the 21st century.

In conclusion, Gen. Ashy, I appreciate all of the help you have given me and my office as we were getting started. I look forward to continuing the close relationship that you and I and our staffs have established in order to improve space support to the warfighter.

Thank you for permitting me to share my thoughts here today.

Gen. Ashy: Thank you, Bob, for getting us on the right course. Just a recap of what we're going to do this morning in terms of our agenda. I'm going to briefly introduce our other panel members, in the order that you see them at the table, then we'll take a break, I'll come back and make a few remarks as the moderator to get things going. Our panel members will all come on stage. If you will write out your questions for the panel, we have a system set up to distribute them here to Col. Gary Dahlen. If you'll write your questions out, we'll have people pick them up. Gary will be sitting up here to help me put them in some sort of order so we can address your questions.

I'd like to now introduce our distinguished panel members. The first is Brig. Gen. Bill Nance, who is representing Lt. Gen. Jay Garner here this morning. Jay, as you know, commands U.S. Army Space and Strategic Defense Command and is dual hatted as the commander of Army Space Command. Bill is the deputy commanding general. We regret that Jay couldn't be with us this morning, and he sends his best to everyone. Bill certainly is a very capable representative, and we're honored to have him. Bill has a distinguished career; I won't go into all the details. He has extensive operational experience, coupled with an extensive background in the acquisition business. Before he comes up here, let me briefly explain how he fits into the panel.

As you all know, NORAD has three regions. One in Canada, commanded by a Canadian officer, one in Alaska, and one in the continental United States. To go along with that organization, since the commander, yours truly, is dual-hatted, U.S. Space Command has three component commands. One is the Army Space Command, which I just described to you, commanded by Bill and Jay Garner. They have a forward headquarters out here in Colorado Springs, and I tell you they do an absolutely fantastic job supporting warfighters and operating some space systems like DSCS, the defense satellite communications system.

We have Rear Adm. Kathy Laughton here with us this morning who I will later introduce. She is the component commander for Naval Space Command, reporting to me as USCINCSPACE. And Air Force Space Command, delegated to 14th Air Force. Maj. Gen. David Vesely is the Air Force component to U.S. Space Command.

Before these three speakers speak, I wanted you to know how they fit into the organization here. They are all three very key members, and they are the ones in fact that make things happen as Bob Davis described with regard to executing our military missions, given to us by the president through the Unified Command Plan (UCP). Without further ado, help me welcome Bill Nance.

Brig. Gen. Nance: Thank you, sir, and thank you for the opportunity to be here this morning. I have about five view graphs and the purpose of those view graphs is to share with you what the mission of the Space and Strategic Command is, how we support Gen. Ashy and the other war-fighting CINCs, and also to talk briefly about the Army Space Exploration and Demonstration Program and what we're doing with that to bring space capability and technology to the war-fighting CINCs.

The Space and Strategic Defense Command is the Army's focal point for space and strategic defense matters *[Fig. GS-101]*. And in that role, we have two primary responsibilities. First, we're responsible for the exploitation of space and strategic assets and to get that capability into the hands of our soldiers and our war-fighting CINCs so that they can do their jobs. Secondly, we're also responsible for the technology base activity to support the development of space-based technologies and systems and missile defense technologies and systems.

We have six commands within Space and Strategic Defense Command, and I'll spend some time focusing on the Army Space Command (ARSPACE), but I will also tell you how the roles of each of the other commands' play in our mission *[Fig. GS-102]*. The Army Space Command Office is located in Fairfax, Va. They manage the Army's TENCAP program. They have, over the course of time, developed and fielded 60 systems and deployed those to 26 sites worldwide to bring the information we get from our national capabilities to our warfighters.

The Kwajalein Missile Range located in the Pacific certainly has the responsibility to support missile testing, but is also responsible for supporting operational activities in support of Gen. Ashy in space surveillance operations. They spend about 128 hours per week on their systems doing deep-space tracking operations. Additionally, they support NASA in tracking Space Shuttle launch and activities.

The High Energy Laser Systems Test Facility (HELSTF) located at White Sands Missile Range, New Mexico, has a testbed capability and is available to DoD agencies for them to bring their laser systems to the test bed facility for experimentation, testing, and exploitation.

In Huntsville, Ala., we have a Missile Defense and Space Technology Center. Their primary activity is to focus on the technology-based activities that support space technologies and missile defense technologies. In Huntsville, we also have the Missile Defense Battle Integration Center. The center has a modeling simulation capability that can be used in a synthetic battlefield environment for analysis and provide opportunities to look at the utility of space assets and missile defense assets.

The Army Space Command, as Gen. Ashy said, is the Army's component support of him and the U.S. Space Command, and provides space capabilities to our war-fighting CINCs *[Fig. GS-103]*. They are headquartered in Colorado Springs. They have civilians and soldiers deployed around the world who are providing that capability. A couple of their missions are shown here. They operate the worldwide defense satellite communications systems [DSCS]. The soldiers belong to the First Satellite Communications Battalion. They, in conjunction with the Navy, operate the Joint Tactical Ground Stations [JTGS]. We currently have two stations deployed, one in Europe and one in Southeast Asia. The ARSPACE is the parent command for the

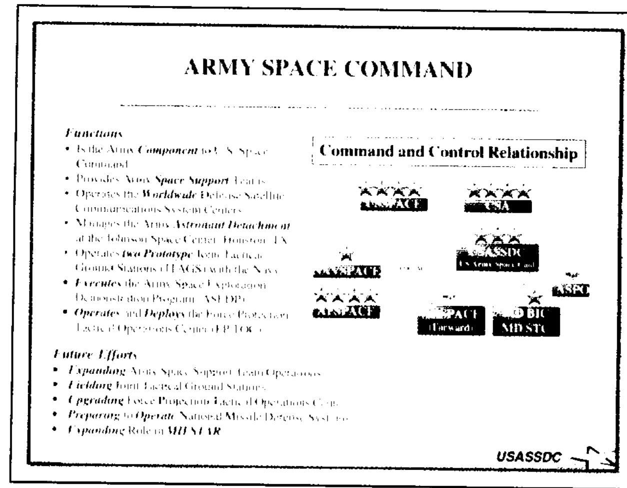


Fig. GS-103

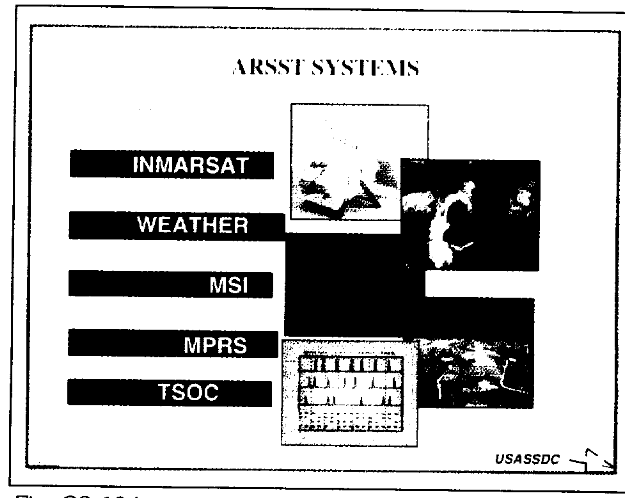


Fig. GS-104

Army's astronaut detachment. Those astronauts are located at Johnson Space Center in Houston, Texas.

A capability that they have is that they are "green ramp" available, that is, ready to deploy whenever required to wherever required as shown in this chart in Army Support Teams *[Fig. GS-104]*. Those teams have the equipment and the trained people to go wherever they need to go to provide this capability. The INMARSAT system provides small receivers and transmitters so that we can leverage commercial satellite capabilities for communications with our satellites. We use multi spectral imaging so that we can get up to date mapping and terrain data to our decision makers in theater and we can also take a multi-spectral image, load it into a computer, get a three dimensional picture and, in effect, produce a movie capability so that you can do mission planning and rehearsals. If you need to fly an air mission, you can develop a movie that will allow you to fly that; If you're doing convoy route planning, then you can use that capability to look at the terrain that the convoy will operate over.

The capability that ARSPACE provides has

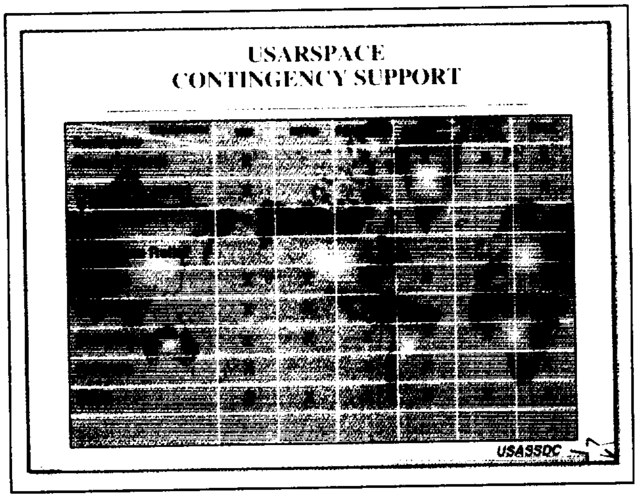


Fig. GS-105

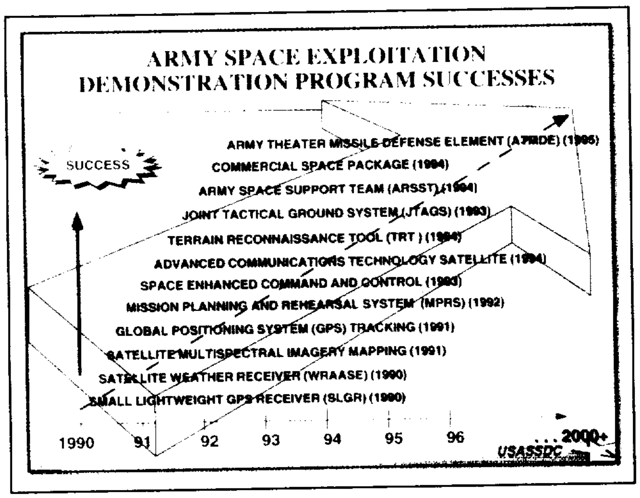


Fig. GS-106

been in existence for awhile. It has supported the Army and the war-fighting CINCs in the various missions *[Fig. GS-105]*. From Desert Storm, Somalia, Rwanda, and Haiti, our soldiers are doing a great job of supporting those requirements.

One of the programs that we currently have that is doing a great job identifying space technology and performing rapid prototyping to bring that capability to military application, is the Army Space Exploitation and Demonstration program *[Fig. GS-106]*. This chart shows some of the success this program has had from 1990 through present day. If you look in 1990, just prior to Desert Storm, there were a couple of programs that were being demonstrated—the small lightweight GPS receiver and the satellite weather receivers. The units involved in the demonstration of those programs requested those capabilities be deployed with them. We continue to operate that program on an annual basis. The structure by which we operate that is through the *Commerce Business Daily*. We seek good ideas from industry and academia about space technologies that we can use for military application. When those ideas are provided, a panel of experts review them; and we then select technologies to provide funding for demonstration and rapid prototyping. In summary, I would say that the Army's Space Command, Space and Strategic Space Command, and the Army serve as members of the joint team to ensure that space technologies and capabilities are available and provided to our warfighters. Thank you very much.

Gen. Ashy: Before I introduce our next speaker, let me just say I recently visited Jay Garner at his headquarters in Washington, D.C., and I'm really proud of our Army Space Command and all they do for us, as Bill alluded to and we'll hear about later. They are heavily involved in the business of preparing us for a ballistic missile defense system in North America, our National Missile Defense System, and I'm sure we'll have some questions on that, and we can discuss that later.

Our next panel member and speaker is no stranger to this forum. It's Bob Dickman. His new title is architect, and I don't know what that means. He's explained it several times. So has Bob Davis. He'll get up here and tell you what it means again, but I hope you all will ask him some questions about that.

Seriously, what it means to me, after we've got a policy and a strategy and we've got a military requirement properly articulated, he is the guy. He and his people put this thing together so that we can build the house. We can build the capability. He's got extensive experience in the space business and certainly the acquisition business. I'm proud of him because he's an operational commander of a space launch wing out at Patrick, Cape Canaveral. He did a great job. I can personally attest to that because he was in Air Force Space Command when he did it. We're really proud to have him and his office stood up, and we're proud of what he's doing and most specifically what he's about to do. Help me welcome back Bob Dickman.

Maj. Gen. Dickman: It is a pleasure to be back. I have a lot of trouble holding a job, but the constant in my life seems to be that I get to come back to the Foundation every year, so it's probably worth it.

We stood up in October last year. Our charter, as Bob Davis explained, is to provide space mission and system architectures. If you will, we are a line organization under Dr. Kaminsky, but at the same time we provide an awful lot of technical support to Mr. Davis' office and to other parts of the community that want to look at very detailed, specific things about the space business. We are not in the acquisition business. We support Bob Davis in that, as well as the service acquisition executives. We are not in the requirements business. Gen. Ashy is our requirer; the Joint Requirements Oversights Council is our validator of the requirements.

In the best of all worlds we would have both a space master plan and a complete set of packaged and well-vectored requirements in place before we started any architectural work *[Fig. GS-201]*. That is not the case, as you are all well aware, and so we are in fact trying to nibble that elephant a bite at a time. Looking across the top part of that matrix for the various mission areas: communications, remote sensing, and the others as well and on the side to whomever is a space provider for this capability. It is becoming more and more clear, certainly to the component commanders for Gen. Ashy, that it is not military space programs themselves that will provide the capability that our warfighters will use but those that come out of DoD-driven programs, the intelligence community, the civil programs as well, and to a larger and larger extent, commercial sector.

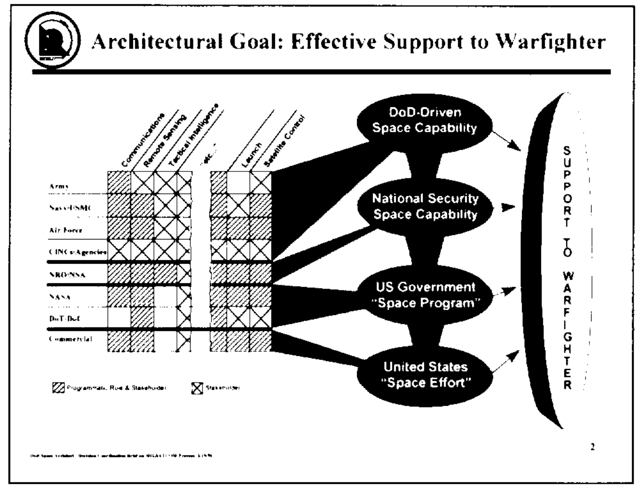


Fig. GS-201

We are about six months into our first architecture *[Fig. GS-202]*. The first was military satellite communications. As Bob mentioned, a lot of fallout from last year's effort led us to take that on first. Second is space control, that is how we protect our own systems, how to deny space capabilities from someone else, or keep a third party from interfering in what we want to do. The third, which we're just kicking off, is satellite operations. How do we "care and feed" a satellite in orbit? Our commitment is to deliver an architecture nine months from start and start a new architecture about every three months, so we have MILSATCOM about two-thirds of the way through its process, space control about a third of the way through, and satellite operations just beginning.

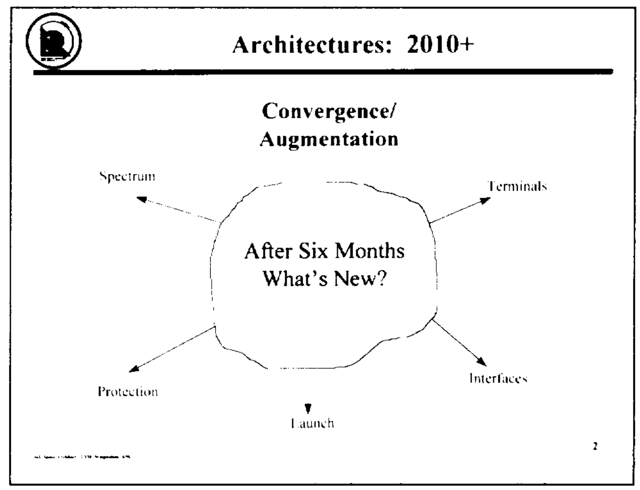


Fig. GS-202

In the six months that we've been working on MILSATCOM, we've gotten some vectors, and what I'd like to do is spend a couple of minutes explaining what those are taking us toward in a couple of the areas and then we can leave the rest for the Q & A session or however you'd like to pursue them if you're interested. As we do any architecture, our first step in general is to go out to industry and find out what the technology will bear, go to the services and try to understand the doctrines, work with Gen. Ashy's folks to put in place a capstone requirements document that gets above the level of the detailed databases of requirements and actually can give us a vector against which to move space systems, and finally to deal with the actual customers themselves. Not the warfighters—that's Gen. Ashy's role—but the troops that are out operating satellite communications terminals, what's important to them. From that we've got a number of trends, not at all firm. The Joint Space Management Board will pick an architecture from a number of alternatives, and in fact some things are going to happen and some things aren't going to happen based on those decisions.

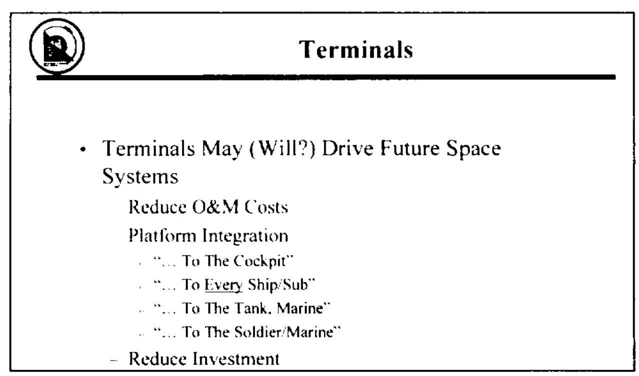


Fig. GS-203

The area I'll talk about first is terminals *[Fig. GS-203]*. It is one that is absolutely fascinating to us. I would assert to you that terminals "will," but—because there is still uncertainty—I'll say "may," actually drive future space missions. In the past, our space capabilities have probably been driven more by the technology that we could put on orbit. However, there's a number of factors that are driving the ground side of that. The first is simply the reduction of O & M costs. We are putting 900 soldiers, sailors, and airmen through a 34-week course at Fort Gordon every year to produce just satellite communications terminal operators. That's about 500 man-years per year training people who will

Interfaces

- All SATCOM Must Be Part Of DISN/DTI!
- End Equipment Must Be GCCS!
- Presume Everything Will Be Secure!
- Time/Location "Tag" All Traffic?

Fig. GS-204

leave the military on average within something like six years of completing that training. We're spending hundreds of millions of dollars on maintenance costs alone. If we expect space systems to be ubiquitous, across the warfare spectrum down to the combatant level, we simply have to change that paradigm of the level of training required and the maintenance we need to do for our operations.

Taking that same step of the ubiquity of space to the space terminals themselves, without exception looking at service doctrines and the plans of the warfighters, the requirements that we get from USCINCSPACE, everyone tells us that the products will have to be delivered to the end customer, not the command centers, not the echelon above corps, not the Joint Forces Air Component Commander, but the airplane, the tank, the armored personnel carrier, the soldier, the marine. If we're going to do that, we have to have a fundamentally different way of building terminals. We have to have a fundamentally different way of looking at the data we're going to provide. Hundreds of megabytes to a wristwatch terminal simply won't work. And yet the doctrine is pointing us in that direction. Warfighters are building their plans assuming that information is going to be available. We've got to change how we look at the satellite and how we look at the terminals as well. You can buy a terminal. Many of you have, for your house, for under $500, and it allows you to tune hundreds of channels. That is a satellite terminal. It is a highly sophisticated piece of equipment. We may spend 10 times that for our satellite communications terminals. We may spend 100 times that for our satellite communications terminals. But we shouldn't spend 1,000 times that or 10,000 times that, and that's what we're spending today. We've got to change that initial investment cost as well.

The final vector that I'd point out is interfaces, and I apologize; it's a little bit of alphabet soup, but I hope it's one that's familiar to a lot of the audience— the Defense Information System Network and the Defense Information Infrastructure *[Fig. GS-204]*. It is simply an assertion by us that all satellite communications, everything we do, every bit we pass has to be part of the larger DISN architecture, so it is absolutely transparent to the warfighter whether or not satellite communications is in that communications media. It may go "fiber." It may go twisted pair. It may go satellite. It has to be independent to the end customer. Taking that one step forward, we have to move away from dedicated terminals. A Milstar terminal that can't do anything else is almost useless to that person who has to carry it out with him. It's got to be GCCS, the Global Command and Control System compatible.

We are assuming that everything we do will be encrypted. Whether that actually turns out to be the case or not I don't know. But from everything that we're hearing from information warfare says we simply cannot afford not to make that presumption. So the systems we buy, the systems we lease, have got to be secure. And I would also assert we will time-tag and location-tag every bit of traffic that comes out of a space system sometime in the not too distant future. So that warfighters and our data bases will not only include what it is, what the intelligence is, but when the data was collected, where it was collected— and so we have a three-dimensional view of the entire battlespace that is always current and always logged. A lot of visions of where we're going. I look forward to talking to you about them in more detail in the future. Thank you.

Gen. Ashy: Our Naval Space Command, as I mentioned, is commanded by Adm. Kathy Laughton. It's been a great experience for me being teamed up with her. She and her people do a great service for Naval services and Naval warfighters out there. I just visited her headquarters at Dahlgren, Virginia—and it's not the first time—but it renewed my view that they're doing a great job. They are a vital and superb component to U.S. Space Command. Kathy in her own right is a superb leader, as she has proven time and time again in a superb career of service to the nation and the U.S. Navy and the Naval services. As you all I think know, her background is primarily in the communications business. Ladies and gentlemen, would you help me welcome Kathy Laughton.

Rear Adm. Laughton: I want to start by thanking the United States Space Foundation for inviting me, and a special thanks to Gen. Ashy for hosting this distinguished panel.

The subject of Global Security Interests in Space is a fascinating one for Naval forces. In many ways it represents the challenge faced by our maritime forces for centuries as they projected force around the globe *[Fig. GS-301]*. As this viewgraph clearly illustrates, we are certainly global in deployment today.

As Gen. Ashy said, space is a very powerful tool to be used by those forces in harm's way. We need to be innovative and proactive in our use of space in providing all appropriate tools. The Navy has been leading the way for many years in this arena. The need

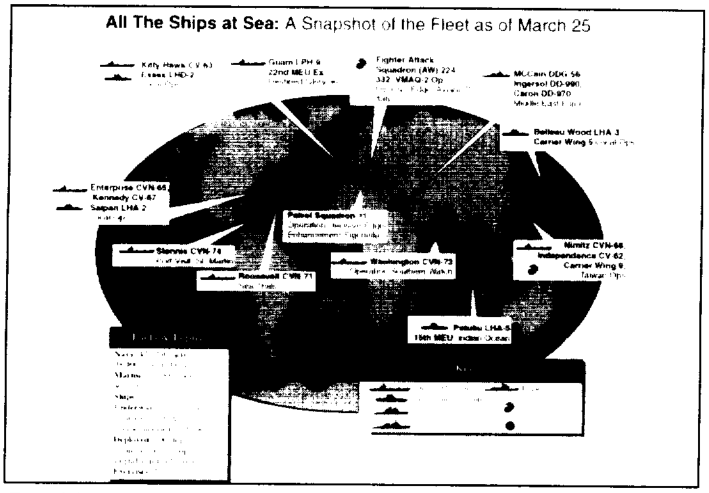


Fig. GS-301

remains, the complexities involved in meeting that need grow daily. We are now faced with a complex mixture of civil, commercial, and military space capabilities on a global scale. The capabilities available to us are only partially exploited. We need to squeeze every ounce of capability out of space-based resources that we can. The growth in space dependence and the related security considerations can be illustrated by looking at the loss of space capabilities. We are used to thinking in terms of air, ground, and maritime forces. The loss of any one of these in a conflict would radically change the strategic picture. I would encourage all of you to look at space in that same strategic way.

If Desert Storm is used as a baseline for this examination, the results are remarkable. Ninety percent of theater communications relied on satellites. Particularly in this area, there was a rich mixture of civil, commercial and military satellites, some owned by other nations or as part of an international consortium. Could we communicate without satellites? Yes, but not at the level required to fight the war as well as we did.

Without space-based navigation, our forces would have been forced to maneuver and fight in a featureless terrain with inaccurate maps and charts. Lack of this capability would have affected gunfire support, strike planning, mine hunting, and the use of precision weapons—all of this using a GPS system that is become more commercial by the day. Could we have done our job without GPS? Yes, but at a cost.

Gen. Ashy's DSP early warning system was the heart and soul of the SCUD alerting network. Would the Patriot batteries still have been able to counter the incoming missiles? Possibly.

The air campaign in particular was highly sensitive to the weather conditions. Without the military and civil weather satellites, the highly accurate timely forecasting required would have been impossible.

No space support means limited ELINT/SIGINT from national sensors, including the unique wide area images from commercial LANDSAT and SPOT systems. Imagine relying solely on organic sensors for critical intelligence information.

I want to congratulate each of you in this room today. Your collective efforts made sure that the resources were available to Gen. Norman Schwartzkopf. Now we need to look at the challenges that lie ahead of us. There are a lot of questions being faced by the members of this panel as we look to the future:

- What is the mix of civil, commercial, and mil itary space assets?
- How can we be assured of the ability to use those assets in time of conflict?
- Will the "civilianizing" of space, as seen in GPS, impact our edge in using those precious resources?
- Are we capitalizing on all possible capabilities for the benefit of the warfighter?

The capabilities available to us are only partially exploited. We need to squeeze every ounce of capability out of space-based resources that we can.

These questions address our security interests in space and represent a huge challenge to us today. Thank you.

Gen. Ashy: As I mentioned earlier we have three components in U.S. Space Command, and representing the Air Force component this morning is Dave Vesely, who commands 14th Air Force headquartered at Vandenberg Air Force Base. Dave has extensive operational experience throughout the world as a fighter pilot. He has been in the intelligence business before, and before taking this job he was the commander of the Space Warfare Center out here at Falcon Air Force Base. He is certainly not new to this community. He is a very key member and a component to the U.S. Space Command. Would you help me welcome him back?

Maj. Gen. Vesely: Thank you, Gen. Ashy. I am also from the state of Michigan, which is far enough north and cold enough that it is not claimed by either the republic of Texas or the state of Oklahoma. That does give me some relief.

It is great to be here to discuss some perspectives on global security interests in space. What I'd like to do is take a few moments to familiarize you with how 14th Air Force is adapting to that changing world and a quick review of how we did the business in the past. As we all know, we were entrenched in a Cold War for many, many years, with the Soviet Union. Space in those days was postured to ensure that we had global access for the important surveillance warning, communications, and other things necessary for the global conflict against the Soviets. We had strategic sensors and a strategic command and control system which was modeled after the Cold War paradigm that we all knew so well. Those systems basically met the needs of the day, but the space systems themselves were not able to respond very well to a changing environment. Among other problems, the command and control system that we had was very cumbersome and stilted. It was not designed for war fighting, much less the full range of military operations that we were going to face after that Cold War ended.

That became very evident when Iraq invaded Kuwait and we became embroiled in Desert Shield and Desert Storm. But what that conflict did do was highlight the immense potential for space systems to contribute to military operations. We also learned how far we had to come in order to take full advantage of space forces, and our previous speakers have alluded to that. We had changes necessary in organization, in doctrine, in our systems, in our operational concepts—and we are pursuing virtually all of those.

Now this change may seem trivial, but it has really been pretty extraordinary. We are now organized to carry out the basic military tenet of centralized control and decentralized execution.

Specifically, command and control is very, very cumbersome. At the time of Desert Storm it was very poorly structured to be very responsive to that warfighter. So among the changes we've had to make to the force structure is the organizational change that Gen. Ashy had alluded to—an organizational change designed to be able to control and exploit space systems for the good of the military operator. Now as Gen. Ashy explained, the U.S. Space Command now executes space forces through its component commanders, much like in other geographic CINCs. Gen. Garner executes Army space forces, and Adm. Laughton executes the Naval space forces. As the Air Force component commander, 14th Air Force has the responsibility to command, control, and execute Air Force space resources. Now how do I do that? Well, it cannot be done by some central authority who does not have the responsibility for those forces. So I had to develop an operational center in order to do that: commanding, controlling, and executing. We are doing that.

What I would like to briefly review with you is, what does that operation center do? It is very much like an air operation center that an Air Force component to a fighting CINC would have. It does four basic functions. First it is a fusion center to provide the status of space forces, because I need to know what my forces look like and how they are postured. That is not an uncomplicated process, when you are looking at 131 units in 36 locations in 15 time zones around the nation. Much of that was previously done, by the way, in Cheyenne Mountain. The second function is a global information center in order to provide me an understanding of the environment that the commander I am supporting is facing. Whether it is in the intelligence order of battle or the weather system that he is facing or, in fact, the space environment that we almost face. The third is it has to be linked to a warfighter or a supported commander. I do that through Air Force space support teams, because I have to know what that commander is trying to do to win his war or how he is going to pursue his objectives. What is his game plan? How can I support what he wants to achieve? And finally it's a decision and execution center to best configure and execute the space forces in support of that commander or in the direction that Gen. Ashy has given me as a CINC space.

I have an interim space operations center today. We started in December with a STU-3 and a fax. It's getting far, far better and it's in 24-hour operation. This summer we will have a new facility with a robust crew, and we will be full up and running to do those four functions. How well is it working? Gen. Ashy asked me the same thing. He didn't trust my answer so he sent the Air Force Space Command Inspector General to give me an Operational Readiness Inspection and, oh, by the way, give the ORI to my subordinate wings at the same time. The ORI validated and the IG validated that in fact we were doing it pretty well, and we are certainly going to do better as we get our new systems and get full up and running. Now this change may seem trivial, but it has really been pretty extraordinary. We are now organized to carry out the basic military tenet of centralized control and decentralized execution.

So, in summary, I would like to report proudly that 14th Air Force is leaning forward, always trying to improve how we're going to control and exploit space in support of CINC space and theater commanders worldwide. I am looking forward to the discussion a little bit later on. Thank you.

Gen. Ashy: Our last speaker and panel member, certainly not least, represents an organization that's absolutely vital to national security. I'm talking about the National Reconnaissance Organization (NRO). Representing the NRO today is a distinguished member, Jeff Grant. It's great to have him back, and we appreciate his being here to represent the NRO. Jeff's got extensive experience in that organization and in the intelligence business, and he is extraordinarily well-qualified to represent the organization and address us here today. Help me welcome him back.

Mr. Grant: Good morning. On behalf of Keith Hall and approximately 3,000 men and women in the National Reconnaissance Office, I want to thank you for inviting me to address you today. It's a rare opportunity for the NRO to come to forums like this, but I think more often we're getting the call.

I wanted to talk a little bit about our past in addressing the theme of today's conference, "Global Security Interests in Space." I wanted to give it from the perspective of the NRO and the intelligence community. I wanted to briefly go over our mission statement because I think many people don't truly understand that. I'll quote, "We're to ensure that the United States has the technology and the space assets needed to acquire intelligence worldwide. The mission is accomplished through research, development, acquisition, and operation of the nation's intelligence satellites."

Very simply, we see that as a worldwide responsibility, and cradle-to-grave responsibility. It's an organization that has over three decades of history. We were born during the Cold War, and our focus during those three decades was the Cold War. I'd like to sort of reflect on how we did. The counterpart of the director of the NRO, Lt. Gen. Palchuk spoke at a conference last May in Washington, and he said, "I am proud of my service and of yours. We both labored during the Cold War to keep our leaders informed. Every time our leaders feared the worst, our evidence showed the intentions of the other side were not so dire. I know that we both helped the Cold War from becoming a hot one." But those days are behind us. I think the speakers earlier have all reflected on the number of changes we've gone through, and so we're getting new direction and new focus.

The National Security Strategy document that was recently signed out challenges us to continue our collection activities and to make them broader. To that end, the organization and its mission are declassified. Many of you may have been present in May of last year when we had the Corona program declassification, a large public celebration at the National Air and Space Museum. The result of that is that the many men and women who put together a remarkable program have for the first time been given the public recognition they so richly deserved. In addition, millions of feet of film have been declassified and are being archived and will be available on the Internet.

Speaking of the Internet, the NRO has a web site now. It went operational within the last month, and we get thousands of hits a week now from many people who are interested in just what we're doing. We've received many compliments on the information contained in there, because we do believe the days of being a Cold War agency are behind us.

We've been through a number of organizational reviews, and we continue to be under organization reviews. After an extensive one in the early 1990s, we went through a major reorganization. The result of that was to create a position called the deputy director for military support. That position is currently headed by Gen. Dave Baker, and as we've created an operational support organization and have representation in the unified commands, so we actually have NRO personnel on site. We've changed our organization to align by functional responsibilities, not parent organizations. The legacy of programs A, B, and C, the NRO consisting of the CIA, the Air Force, and Navy are behind us. Now if you go to our web site you'll see that we're organized by "INT" (referring to the "INTS," i.e., HUMINT, SEGINT, etc.).

"We're to ensure that the United States has the technology and the space assets needed to acquire intelligence worldwide. The mission is accomplished through research, development, acquisition, and operation of the nation's intelligence satellites."

Just as we've changed organizationally, our missions and customers have grown and changed substantially. I think our systems have successfully responded in recent years to the diversity of the global threats we face, the rogue states that we face, and the broad variety of intelligence issues that are challenging us. As we have done that, we have not lost our focus. Our focus is clearly support to military operations and to the military. You'll see NRO systems providing key intelligence for indications & warning (INW), for mapping, charting & geodesy (MCNG), supporting preparation of the battlefield, precision strike, bomb damage assessment, and while we're doing all of those things in areas such as Bosnia, you will find us supporting key diplomatic efforts in areas of the Middle East, the Balkans, and Korea. You'll also see us monitoring the proliferation of weapons of mass destruction, monitoring the trafficking of narcotics, supporting the activities against international terrorism, economic intelligence gathering, and more recently, environmental and humanitarian support with the systems that we build and operate.

The National Security Strategy challenges us to focus our collection and our activities where open sources are inadequate (e.g. newspapers, periodicals, TV news reports, etc.), *and* we must consider changes in our intelligence-gathering techniques because of things like the Internet and CNN. We're challenged to have intelligence continuously available, not a rare brief sample product. And so we have committed to produce and operate systems that are timely and responsive to our customer base. We are allowing many more of our intelligence products (because of the change in classification of the products) to be disseminated across the world at a higher reliability level than ever before.

I took a recent trip to the CAOC in Vincenza, Italy, where the IFOR forces were operating out of, and it was just remarkable for me to see over a dozen nations routinely using the products of NRO systems in support of the IFOR mission. The technologies that have allowed the better dissemination of the data have clearly allowed us to support a broad range of customers, and not those just in the Washington area, as we have done over the decades.

In looking to the future, I see the challenge as maintaining our technical edge. Indeed we spy from space, and in order to spy from space, you have to be capable of doing things that people do not credit you with doing. And so our capabilities in space reconnaissance in the future must continue to improve, and we must maintain the edge. Our challenges are doing this in a declining budget environment, and when there is a broad range of competing interests for other intelligence collection and processing exploitation. Just as defense and commercial communications coexist, I believe so shall the systems that the NRO builds and operates and the other commercially licensed space-imaging companies. Thank you very much for your time, and I look forward to your questions.

The technologies that have allowed the better dissemination of the data have clearly allowed us to support a broad range of customers, and not those just in the Washington area, as we have done over the decades.

Gen. Ashy: Ladies and gentlemen, before we begin the Q&A session, I would give you my perspective from a U.S. Space Command view. These remarks build on what the panel members have already said, and will help you frame your questions setting the stage for our discussions to follow. Talking to Gary Dahlen, who was sitting over there, he's already got a number of questions, and that's really good. We look forward to those discussions.

I'd like to frame my remarks by referring to our missions, which I think is the key to our discussions with regard to this panel on national security. As Mr. Davis said, we need to look at these missions constantly. But assuming that we've got the missions down, and I think we're pretty close, certainly in today's world, then we need to allow the military requirements to flow from the missions and their objectives for accomplishment. No capability can exist without a military requirement first. I promised Mr. Davis and Maj. Gen. Dickman, when we all got together as this newly formed team, that we would do our absolute dead-level best to articulate properly from our missions what those military capabilities and requirements should be. After Mr. Davis and his office look at the strategies and policies that go along with the missions, then we can give it to the architect. After the architecture is planned, then the acquisition community can work with our support partners in the commercial sector and in the industry, to field a better, faster, smoother, and cheaper capability that is responsive to the warfighter and our national security perspective.

I'll talk a little more about that later, but first let me go through the missions. We have given them a lot of thought, we constantly do. One of the first missions that we need to address from the U.S. Space Command perspective is to support NORAD, and, as I mentioned earlier, the commander is dual-hatted.

The common command and control node is Cheyenne Mountain. We do this support primarily from the space surveillance business. As you know, we track over 8,000 objects very accurately with a worldwide capability, which Dave Vesely described earlier. The algorithms from observing objects go into a huge computer in Cheyenne Mountain so that we know exactly where space objects are. It's very important, if you're going to do space control, to ensure the capabilities of your own systems and deny the other side. You've got to start with space surveillance. We also, with space-borne systems and land-borne systems, perform the mission of attack warning and assessment. That's been a long enduring mission of NORAD.

And by the way, while I'm on NORAD, I'm pleased to report to the forum that the secretary of state and the minister of foreign affairs of both nations (U.S. and Canada) just signed the eighth renewal of the agreement between two special nations. So we're good to go for five more years in NORAD.

So attack warning and assessment on North America remains a very vital function. Of course we can't do that mission without the support of our components in U.S. Space Command.

Turning to our specific Unified Command Plan missions first, let me describe them for you, and then I'll give you a short update. This will help in our discussion later, with regard to what are we doing about them, as Mr. Davis alluded to in his remarks.

The first one is titled "Space Forces Support." Space Forces Support is the business of placing objects in space and then operating them. It's the logistics and the administrative activities of those functions. As you know, and we're going to hear from Mr. Goldin later on, the president has signed a policy that's been in force for some time that delegates the reusable business to our colleagues in NASA and expendable function to the Department of Defense. That's been delegated to the Air Force, and Dave Vesely in his role as the commander of 14th Air Force now performs those functions from the East and West coasts, specifically Patrick and Vandenberg Air Force bases, with expendable vehicles.

That does not mean that we don't have overarching interests in reusables and expendables between the two entities, we certainly do. What it does, though, is designate who's in charge or who's in the lead for the expendable and reusable functions. Then once the satellite is placed into orbit we use the Air Force Satellite Control Network (AFSCN), a worldwide network to operate those systems. One of the key control nodes is Falcon Air Force Base, which is about 20 miles due east of here.

The next function is Space Force Enhancement. Space Force Enhancement is commonly referred to as space support to the warfighter. All of our speakers have alluded to that eloquently this morning.

These are the services that we provide to ourselves in U.S. Space Command and NORAD, as warfighters and the services that we specifically provide also to theater commanders.

These services include space-borne warning for ballistic missile attack—both in theaters and in the strategic sense. I'll come back to that in a minute with regard to the extraordinary improvement that we will realize with Space Based Infrared System (SBIRS). The next one is the weather service that we do from space. Weather is extraordinarily important to warfighters for obvious reasons, but in today's modern battlespace, if you're going to attack something with precision, usually it involves infrared systems. When you have moisture, infrared systems have limitations, so it's important that warfighters know exactly what the weather is in a very timely manner.

The next one is the category of space-borne communications. All of our speakers, particularly Bob, have talked about space-borne communications, and I'll come back to that in a second. Space-borne intelligence is accomplished by Jeff and his people, and he spoke about that. Of course, navigation (read GPS) is a very important function in today's battlespace to provide us the precision that we need to perform attack functions and other navigation capabilities.

So those five things are the services that we provide under the category of Space Force Enhancement. I'll talk a little bit more about that later as we address how we have normalized and operationalized our capabilities to deliver those capabilities.

The next mission is Space Control. This has to do with space superiority. There are three functions to Space Control specifically, including space surveillance, protection, and negation. It's like air superiority; you have to know what's in the air space or the space, then you have to protect your capabilities, and you need the capabilities to deny the other side. We are working on technologies to field capabilities that ensure that we have space control and space superiority.

And the last category is space force application. This is the business of applying force or capability either through space, like an ICBM, or from space. Currently, we do not have forces assigned in that category.

It's like air superiority; you have to know what's in the air space or the space, then you have to protect your capabilities, and you need the capabilities to deny the other side.

So those are the four UCP missions that are given to us as a unified command. We have two other missions. The first is to represent the other theater CINCs and functional CINCs in their requirements business. This is a very key point that I would like to make to the forum, because I think it's important to our colleagues in the civil sector and the commercial sector. It goes back to our obligation to Mr. Davis and Maj. Gen. Dickman, in that we must understand our missions and the capabilities that go with those missions and then properly articulate them in requirements. We have done that in a process called the Mission Requirement Process. In each of our four mission areas we have listed the capabilities under each one. We have looked out 25 years into the future so that we can look back and merge those with possible technologies and get out of the boxes Mr. Davis has mentioned. This is important so that we can influence where we want to go instead of reacting to where we may be going, and make the appropriate changes. As a matter of interest to this forum, we do this through our chief of plans, who is Army Brig. General Joe Cosumano. You're all invited to access that process. I don't have his phone number, but you can find it, and we welcome your input. We're very proud of this. It allows us to suspense ourselves, if you will, in a process that leads to operational concepts that are pertinent and updated, ultimately leading to an operational requirement that Bob needs, to be an architect of any program. He absolutely has to have that and a Mission Needs Statement. Those are our obligations, and those are our promises to the secretary and the architect. I might say that Maj. Gen. Lance Lord, who is out here somewhere in his Air Force hat, does some heavy lifting, if you will, in this category, because he is the chief of plans of Air Force Space Command. Lance Lord and Joe Cosumano are partners in this process because the Air Force contributes a majority of capabilities, TOA and people in terms of our space capabilities.

We have suspensed ourselves, in summary, in these four mission categories with the subcapabilities to ensure that we have a Mission Needs Statement, an ops concept, and an Operational Requirements Document so that we can proceed with our acquisition programs. While I'm on these requirements documents, let me assure you again this year, as I did last year, that I think we understand two very important points. The first point is that the process needs to be coordinated with our partners in the commercial sector. Your voice and your opinions do count. We want them, we can't field the equipment without them.

This leads to the second major point, if we don't go through some pain and agony up front to produce a quality document, we will not successfully achieve the outcome. I'm talking about affordability, achievability from a technical perspective, and testability. If we write a requirement document that we can't test, afford, or technically achieve, we need, through a cooperative process in our relationship with our commercial partners, to go back and review it and change it, so that we get it right. This must be done before we give it to Bob, the secretary, and before the Joint Requirements Oversight Council reviews it and validates it, as Mr. Davis mentioned in his speech.

It's vital to be able to afford our space control operations around the world as we operate our space-borne systems.

That's a summary of representing the CINCs in these processes that lead to the acquisition programs and fielded capabilities—and we play very heavily in that. We take it very seriously, and I think we've made great progress in the last two years in this regard.

The last major mission area that we're assigned is to plan for, and prepare to field, operate, and execute a system for the defense of North America. I'm talking about a ballistic missile defense system, referred to as National Missile Defense capability. Out of respect for my Canadian colleagues, we refer to it in NORAD and U.S. Space Command as Ballistic Missile Defense of North America. There's obviously some debate going on with regard to when and what this system may specifically be, but it's our job as warfighters to be prepared to field and operate it from an operational perspective, and we want to be ready. As I've mentioned before in speeches and in testimony, we've done a lot of thinking about the operational concept, and we finalized it in a draft concept of operation so that we can be ready to go when called upon. This is significant in that BMDO and Gen. Mal O'Neill can use this concept of operation as they model and simulate their technologies that will lead to a compliant and effective system.

Going back through these missions, let me remark briefly about several requirements leading to programs that will improve our capabilities. First, in support to NORAD, our program to upgrade the capabilities out at Cheyenne Mountain, which is the command and control node for both organizations, is well on its way. It's a four-phase program costing over a billion dollars. We're well into the second phase, and it's on track. This is vitally needed to get us the capability to execute our forces appropriately. The mission of warning will be well-served by the fielding of SBIRS, and we're looking forward to the initial operational capability (IOC) of the low system after the turn of the century. As I earlier mentioned, we are thinking about Ballistic Missile Defense of North America in our concept of operations document.

With regard to Space Force Enhancement, and I hope we get into questions about all of these missions, the evolved expendable launch vehicle program, as we evolve it into a family of systems, will meet five mission area requirements. The first is that we need to safely get into space with expendable vehicles. We need assured access to space. We need to make sure that we can get the launch manifest up there and meet the requirements of all of our customers. We need to be able to do this responsibly, whether we launch from an orbit or we do it from the surface of the Earth. We need to do it in a timely fashion so that we can meet the needs of our military customers and our commercial and civil customers that share our launch infrastructure with us. And lastly, and most importantly, the real reason that we're doing this program is we need to get up there more cheaply, more inexpensively. We've articulated this in the requirements document. We're working with our partners in industry to finalize it, and I think we're well on our way. I should mention, and Mr. Davis mentioned this in his talk, we need to be able to operate our systems around the world more cheaply, and we're looking at doing that. It's vital to be able to afford our space control operations around the world as we operate our space-borne systems.

With regard to Space Force Enhancement in the strategic sense and the theater sense, SBIRS remains absolutely vital. We've got the technology; we have a solid requirements program, and we're looking forward to fielding this system. Not only will it better serve us in the strategic sense as we execute our attack warning and assessment mission specifically in NORAD, but it will really help the theater commanders see the cooler burning and shorter burning tactical missiles around the world. We really need this system. As all of you know, these missiles continue to proliferate. It will also give us some technical analysis capability of the battlespace as we look at it around the world. Since the last meeting when we were still finalizing it, we have consensus of a requirement and that was a big, big factor in getting this program going.

I'm pleased to report that we have followed the administration's and Congress' guidance on convergence on our weather satellite programs between the NOAA and Air Force Space Command, with regard to how we operate, and become more efficient and thus save money on our weather satellites. That's well on its way and will happen in 1998. In the communications business, all of our speakers alluded to it, our command is responsible for writing the overarching requirements document for the Advanced Military Satellite Communications program. We are about to finalize that, and in fact this summer Maj. Gen. Bill Donahue, Adm. Dave Frost, and I will take this to the Joint Requirements Oversight Council so that the architect and secretary can get on with their jobs. I think that's one of the first three major architectures that Bob Dickman has taken on.

Let me tell you what the user wants. They want unlimited access and unlimited bandwidth. We're going to have to balance their desires with what the commercial sector and what technology can bring, but we're going to do our best to meet their needs. As Bob mentioned in his opening remarks, a Global Broadcast Service is a good example of what the commercial sector has offered. We need to get at it quickly —smoother, cheaper, faster. We plan on doing that. The secretary's working on this very hard, and hopefully this spring we will test and prove this capability in the Joint Broadcast System that we will deploy in support of our troops in Bosnia.

To put this commercial sector technology and the need to leverage this technology in perspective, let me provide an illustration. Assume you are trying to get a high resolution photo to a strike pilot on an aircraft carrier. Using the UHF system to deliver this photo—as Kathy Laughton was talking about in her talk—it would take you all night and half the day to deliver one picture. That's not acceptable. If you use the high band with the DSCS system that our Army colleagues operate, it would take you maybe 10 minutes to deliver this picture, but nothing else would go through the "pipe." With GBS, you would be able to deliver a picture in about five to six seconds. And not only will you be able to deliver photos, but you will be able to deliver motion or television and text and all the things that our warfighters need. It is really important to people in brigades, on bridges of ships, and even to the pilots in the cockpit that we get on this system, and we're committed to doing that.

This is a part of the overall architecture and satellite communication system that we are writing a requirement document for. We have gotten the message with regard to commercialization and outsourcing and leveraging what our colleagues in the commercial sector bring. With regard to intelligence, being able to deliver intelligence is vitally important and I hope we can get into discussions on this subject. We'll deflect all the questions on the GPS policy to Secretary Davis. We've just had a new policy signed by the president, which I think sends a strong message to all of our civil and commercial partners that we need to leverage this wonderful capability in a cooperative way, while not giving up our military capability to deny the other side and protect our side. And that's what this policy basically says. We know that technology as evidenced by three major scientific reports can lead us to alternative means to performing military capabilities of protection and assurance. We can use GPS while making sure that our commercial and civil partners can still use the system. So we have this new policy and that's good.

Before we have our panel members come back up here, let me now talk a little bit about normalization and operationalization. I've tried to describe this to you, and all of our panel members have alluded to it. I think it's really important that we understand that we are warfighters and that we translate what we do into understandable accessible language to our colleague warfighters around the world through our component commanders.

We know that technology as evidenced by three major scientific reports can lead us to alternative means to performing military capabilities of protection and assurance.

Dave Vesely mentioned one step and that was to put our component commanders in the loop through their command and control nodes so that we can execute our missions appropriately and effectively and support those warfighters in the field. Our Space Warfare Center (SWC) at Falcon AFB continues to operate and serve not only the Air Force but all of our services with regard to procedures and doctrine development. We recently stood up a test squadron at Falcon. We still are heavily involved in TENCAP activities so that we can leverage capabilities and translate them into usable concepts and capabilities. I'm proud to let you know—in my Air Force hat—we are going to integrate a space division into the weapons school at Nellis Air Force Base. This space division will not only teach space but will graduate space warriors along with their colleague airplane drivers and intelligence officers and their weapons controllers. That's a powerful message to this forum. The first class, as a matter of fact, is in session right now. In addition to the weapons school, we also have orientation courses and staff officer courses at Falcon AFB and Vandenberg AFB. So we have tried to normalize our operations so that we can effectively operate.

Our three component commanders mentioned what they do for warfighters in the field, and we in U.S. Space Command have promulgated a policy that describes how we organize our space support teams. Let me just briefly mention this. We do it for the Joint Force Commanders from the Unified headquarters here in Colorado Springs. We have space support teams that support all the Unified CINCs. They plan, exercise, help them write their integrated war plans, and then they deploy with them. And that's very effective, very well-received.

I think people tend to forget that of the over 450 satellites we've launched in our history, the vast majority of them have been very small satellites.

Likewise, the three component commanders have space support teams—each for the respective theaters, so that we can deploy this knowledge, help, assistance and support respectively to theaters of operation. To help us do this, we have animated constellations on a computer screen so that even fighter pilots can understand what they look like, what their coverages are, and what their schedules are. In my previous position, that service and that capability was not offered. We're very proud of that capability. It's called the Theater Support Operations Cell, or TSOC. We've also normalized our operation so that we have the proper training courses, flight manuals, and the proper focus on commanders' being mission-ready. Not that we're trying to copy the aviation model, but we're taking this a step forward, out of the box to make sure that we can deliver our capabilities in an effective manner.

And last but not least, we have certainly gotten the messages that I've mentioned before, that we need to leverage what the commercial sector brings to the table. I want all of you to know that we have gotten that message again.

Ladies and gentlemen, it's again a pleasure and an honor for me to be back and be your moderator today. I would like to now ask our panel members to come forward and take your places. Thank you very much.

Q&A

Gen. Ashy: We have a lot of great questions here, and the first one, I guess, will go to Jeff Grant and Secretary Davis, if he'd like, and perhaps Bob Dickman. It has to do with cooperation between DoD and the NRO with regard to small satellite technology. The question specifically is, are DoD and NRO really interested in small satellite technology?

Mr. Grant: I think it's a matter of public record that Col. Pete Rustan, who was the successful program manager of the Clementine program, joined the NRO over a year ago. He runs an organization in the NRO that is focused on small satellites and their applicability to the intelligence problems we're confronted with today. We can't go into detail about the success that Pete's having, but from my perspective we are very serious about this activity, we're fully investigating the applicability of satellites of a variety of sizes to address the requirements that are coming out of the services and Gen. Ashy's organization, and I think we have a rich history of launching small satellites. I think people tend to forget that of the over 450 satellites we've launched in our history, the vast majority of them have been very small satellites.

Gen. Ashy: Bob Dickman, do you want to go next or the secretary?

Secretary Davis: It's really a two-part question. The first one is cooperation between NRO and DoD, which Jeff glossed over a little bit, but it's implicit in the question. The answer is yes, cooperation is alive and well and it's working. Specifically with regard to small satellites, and I'll steal this from Pete Aldrich, who taught me this long ago, small and large are units of measure. They're not moral judgments. I think what we really need to look at and focus on is not whether something is small or large but what the requirement is, what kind of technology do we need to satisfy that requirement, what's the operational utility of it, and then if the solution ends up being small, so be it. If it ends up being large or very large, so be it.

One of the things that I think we sometimes tend not to focus on is, small does not necessarily mean inexpensive, Jeff. We need to keep that in mind as well. People usually think of small as being inexpensive, and I think there's a real role at this point, given how well we can do certain technologies now, and the inherent smallness of some of our launch vehicles. Capability to launch small satellites, we need to focus on that more. Again, I just remind you that small or large are not moral judgments. I used to be invited in my old job to an international small satellite organization panel every year, and after I kept saying that small was not inherently good, they stopped inviting me back, but we do need to focus on it. I think the short answer is we do need to do more in that area, and you're going to see more cooperation between the NRO and DoD publicly on trying to do that.

Gen. Ashy: Bob Dickman, do you want to make a comment?

Maj. Gen. Dickman: We aren't trying to drive our architectures toward or away from small satellites as Secretary Davis just said. The solutions will lie where the solutions should be. Certainly large numbers of proliferated satellites are going to be small by today's standards and we're looking at that kind of concept as well.

Gen. Ashy: As the moderator, I'd like to make a short comment. In addition to what has already been said, I recently got a clear message from one of the distinguished persons sitting in the audience that we really need to look at the requirement, and what we do has got to be based on the requirement with regard to resolution, etc. This drives the physics of what you're trying to do, whether it's constant steering, or resolution requirements, and so forth. My summary is, we all need to take a look at "smaller, better, faster, cheaper," but we also need to integrate our requirements very carefully in this process because it drives what we can and what we can't do.

The next question is really not a question, it's a comment and I just want to acknowledge this to the person who wrote it because it's a very good point, and I certainly received the message, and perhaps, Gen. Hill, we can work on this. It has to do with complimenting the contractor display booths next door, and the suggestion is to next year have our components display what they deliver to the field and what the troops use. We'll take that on and try to make that happen next year, with your concurrence.

The next question has to do with our space support teams, and I'm going to let Dave Vesely handle this question as our lead spokesman. The question: How do they coordinate specifically their activities in theaters of operations and will they ever work themselves out of a job? I think it's a very good question. The answer is yes, I hope they will.

Maj. Gen. Vesely: Let me talk to the Air Force side of this. Our Air Force space support teams belong to a squadron, the 76th Space Operations Squadron at Falcon AFB that reports directly to me. They have teams dedicated to each theater and so, for example, they have a team that is dedicated to Europe, another one to CENTCOM and they deal directly with those theater air component commanders, and we're focusing on the air component commander's problem. They are in the theater frequently, longer than they'd like to be, but that's the way the business is. They plan with them, they integrate space into their war planning, they actually write the space annex to the war plan, they train with them when they have training events, they exercise with them when they have exercise events, be it a blue flag, green flag, red flag, Ulchi Focus Lens, Internal Look, I can go on, and they really become an integral part of that team. They sit side by side with that air component commander in his air operations cell.

I have team members today in Vincenza, Italy, sitting in the CAOC (Combined Air Operations Center) giving daily advice on space systems and what those systems can support. They also have an educational role. They will go educate air component staffs on what space can provide. They are positioned at Falcon for a good reason, and that is, they are co-located with the Space Warfare Center leveraging TENCAP projects and technologies that are ongoing.

My summary is, we all need to take a look at "smaller, better, faster, cheaper," but we also need to integrate our requirements very carefully in this process because it drives what we can and what we can't do.

The team members themselves have a very long and intense training and certification process. They have to certify to me that they can in fact represent me in theater—and that's the relationship. They are my personal representatives to the air component commander in that theater and they are my tie to him. They help me know what that theater commander's facing, what his intention is, what he wants to do, so that we can help support them. When I stood the squadron up in December, I gave them the direction that Gen. Ashy gave me, and that is, work yourself out of a job. Make space such an integral part of military operations that every commander knows how to do it and how to exploit it, and we'll get out of the business and make it a normal, routine part of warfighting.

Gen. Ashy: Kathy, you or Bill want to comment on that? You're very integral to this process.

Rear Adm. Laughton: Yes sir. Of course, I'm very proud of our Naval support teams and we are certified by Gen. Ashy's people. Our process is a little bit different in that we start at the point in time that the battle group starts its initial work up. And our space support teams work with the Marines, and with the carrier battle groups all the way through their pre-deployment work up into the deployment and post-deployment phase. We're hand-holding them regardless of what is going on.

We also work with the battle group commander himself, and every battle group commander on the East coast comes to see me and goes through an intensive set of briefings on what our space support teams can do for him before he ever takes his battle group to sea. Just as Gen. Vesely mentioned, we are also working ourselves out of a job, primarily because we're standing up our operation center so that I can, through the use of video teleconferencing and other training mechanisms, hand-hold that battle group commander all the way through his process, and we can do it at any level, whether it's a C2W officer working his problem or the flag officer himself. And we already have the tools and capabilities to do that. Gen. Vesely mentioned TSOC. TSOC has become a critical element to that and, in fact, in 1998 I put together a POM issue paper to buy TSOCs for every battle group and every Marine unit, so that they will in fact have that training tool with them, and will be able to diagnose whatever questions they have. We feel this will be a very effective training program for the Naval units.

I hope that we train ourselves out of business so this culture will infuse itself into our various theaters throughout the world with trained people not only as specialists, but as knowledgeable warfighters.

Gen. Ashy: Bill?

Brig. Gen. Nance: The Army's process is similar to what's already been mentioned. Bill Hoyman and his staff spend a lot of time getting into the theaters and providing information to the theater CINCs and the lower combat operating activities about the capabilities of the space support teams. I work with them identifying that capability, and I can support their operational plans. They also participate extensively in theater exercises and warfighting experiments that are conducted to ensure that that capability is demonstrated to those folks. Members of the various theater commands are invited to come to the Army Space Command and have an opportunity to witness the capability of the space support teams. Another thing that they're doing is actively looking at where the Army is going in the 21st century, and the exercises and plans that are being set up to identify and demonstrate that. The Army Space Support Teams are providing systems and capabilities that can be demonstrated in those exercises.

Gen. Ashy: I think it's appropriate to ask Jeff Grant to comment here, because he has a function that is similar to Space Support teams that is absolutely vital for delivering a very key service to warfighters. Jeff, would you like to explain briefly how you all are organized there? You mentioned it in your talk.

Mr. Grant: I mentioned at the intro, the Operational Support Office (OSO), an organization formed a few years ago that has as its focus exercise support. And we have supported OSO personnel on-site typically between 70 and 80 exercises worldwide, and through a whole variety of levels of activity, supporting CINCS. Most recently you will find OSO employees being dispatched on teams so that the vagaries of how you task and use intelligence collection systems can be better articulated to the ultimate user. We have committed to providing personnel worldwide to support those kinds of efforts.

Gen. Ashy: Very good. Just as a comment from me, it goes back to operationalization and normalization. I hope that if I don't do anything else on my watch, I hope that we contribute toward this notion—a change in culture with regard to understanding our war time tasks and how we support others with war time tasks and missions. As I mentioned, we created this from U.S. Space Command as a policy. Our component commands have organized themselves to deliver these capabilities, and I think we're doing it. It has to be a change in culture. The capabilities have to be assessable and understandable. That's what TSOC is all about. That's what our warfighting schools and briefings are all about. The answer to the question is, absolutely yes. I hope that we train ourselves out of business so this culture will infuse itself into our various theaters throughout the world with trained people not only as specialists, but as knowledgeable warfighters.

The next question goes, I think, to Gen. Dickman. The question is, what is the relationship of the Space Architect office and the NRO?

Gen. Dickman: I think I'll share this answer with Jeff. We agreed some time ago as we tried to figure out how to work together, that our commitment would be to one architecture. The organizational structure to make that happen may evolve over time, but right now our commitment is to one architecture. Jeff has responsibility down into the NRO which does its program differently from the DoD. I work the white side, but we are in the process now of figuring out how to exchange people and exchange information on virtually everything we do so that when we do bring a program forward, to the Joint Space Management Board, it has the complete understanding from both Jeff and me, and the commitment from both organizations that we can execute the program. Jeff?

Mr. Grant: I can only emphasize the comments that Gen. Dickman made. We both have bosses who have told us that we are going to work together very, very cordially and productively, and so to that end, Bob and I meet routinely. Our organizations have interactions at the working level as well as the senior level, and we meet at the JSMB with programs that we'll be discussing within the intelligence community and the defense community. It's a new relationship, it's growing, its gotten off to a slower start than either one of us would have liked, but it's clearly a relationship that's going to stand the test of time.

Gen. Ashy: Secretary Davis, would you like to say a word about that?

Secretary Davis: I agree with both answers. There are really two factors we need to keep in mind here. One is not necessarily any unique organizational relationship. That may in fact be part of the solution to the process to get to the solution. What we need, as Bob said, is a single architecture, and that's what we need to keep focused on. However, having said that, the actual charter of the Joint Space Management Board refers to a national security space architect, whatever that creature happens to look like, and that's the road we will slowly proceed down. The presumption is at some point we will end up with a single national security space architect. In the long term, it is, as they both said, it's cooperation, and that's going well. It is my clear judgment that ultimately we need to be focusing on the probable solution of a single national security space architect.

Gen. Ashy: Thank you, and while the secretary has the floor, another question. You addressed this in your talk, but the specific question is, when will there be a new space policy? Since we're kind of on that, how about addressing that please, sir?

Secretary Davis: A new space policy? Well, we've been fighting it out across the entire federal government for about a year to come up with a national space policy. Yesterday, I read on my mobile E-mail that there should be a meeting of what we call the deputies, and those are the deputy cabinet secretaries from each of the departments that are involved in space, toward the end of April. We have been going through a whole series of issues. When you think about national space policy, you have a mix of it sitting here at the table. We had to figure out what is intelligence space policy as opposed to defense space policy—is that the same thing as the national security space policy?—and figure out what the merits are. Then the wordsmithing takes place, and back and forth staffing those through the Department of Defense and intelligence community. Then while that was going on, there's something called civil space and something else called commercial space, and so as we sit here, it's about finished, at least in terms of the national security side. It is up to the National Security Council at this point and to the White House—and hopefully we'll have this thing wrapped up by the end of the month. It's been dragging on, but we're about there. And then after that, there's a whole series of policies that should spin off from that, a DoD space policy internally, an international cooperation space policy for Department of Defense, a whole series of others that will follow.

Gen. Ashy: Thank you, sir. Staying with Gen. Dickman and Secretary Davis, the next question has to do with space architecture and how it fits into the overall formulation of DoD space policy, doctrine and tactics. I could ask Maj. Gen. Dickman to lead off.

Maj. Gen. Dickman: Sir, let me ask my policy mentor to do that if I may. We really feed into Bob.

The presumption is at some point we will end up with a single national security space architect. In the long term, it is, as they both said, it's cooperation, and that's going well. It is my clear judgment that ultimately we need to be focusing on the probable solution of a single national security space architect.

Secretary Davis: That's sort of like the old question, when you're in college and you're worrying about your exam and the question comes to define the universe and give 12 examples. I don't know quite how to answer that question. It's so inter-related. If you could really draw a sequence and do it right—and of course we don't live in a perfect world, so we can't—we should go to the warfighters and the warfighters would say here's how I want to fight my war in 20 years, 15 years, 10 years. We'd sit down with the technology people and say, OK, let's go design the following systems and develop the technology we need to do it. We'd go to the comptrollers and get a blank check and proceed to industry and award a lot of contracts and, meanwhile, the military side of the house would be heavy in operational exercises to be ready to use these things.

Unfortunately, that's not the world I live in, certainly, and so what you end up with is an iterative process in terms of a national space policy. I addressed that. We have a good example of how the process has to work, the GPS policy that was announced two weeks ago tomorrow by the president. It's an iterative process. When the policy came to us in the Department of Defense, we voiced our concern about shutting off things like selective availability, the wisdom of that, and also the reality that the accuracies of commercial systems over time will rival or exceed what we're doing with the augmentation systems. So we have to take the reality then of, No. 1, the policy, No. 2, the world we're living in, and No. 3, the possible technology to counter the problems that may arise. When you look at the scenario that we may be fighting in in a given situation, the way the world exists today, we may have troops deployed in an area that is mixed with civilian forces, with friendly forces, and with hostile forces. And at the same time you may have aircraft flying over that area that are civilian aircraft, and you have to have the technology, and the policies, and the doctrine, and the operations in place to be able to continue to receive the signals that you're interested in. Use those and deny them to your opponents without grounding the airliners in the process.

When you look at the scenario that we may be fighting in in a given situation, the way the world exists today, we may have troops deployed in an area that is mixed with civilian forces, with friendly forces and with hostile forces.

That's a good case study of how we have to make all this work. Part of it is to go do architectures and think about it far enough in advance. In some cases we have to change the way we operate a system, and some of those are lessons learned from the downing of our pilot in Bosnia and how we put technological and in some cases operational fixes in place there. And others are things we have to address in the longer term. That's not, clearly, a precise answer, but it's a very hard question and if that were easy probably none of us would need to be employed or on this panel to try to fix the things that don't go right. Bob, let me pass it back to you. That's the context, and it's not something that's a yes or no question or an answer, unfortunately.

Maj. Gen. Dickman: I think we are going to have to work through the next year over a very practical dilemma in that regard, and that is that Secretary Davis has set out as his own goal and has made commitments to the Congress to deliver a space master plan. What we have found as we've been through two-thirds of the first architecture for Military Satellite Communications (MILSATCOM) is that the dialogue that has to take place between the architect function and, for example, U.S. Space Command to really work through the requirements, is not in the sense of how many two dot four circuits between two points, but in the vectors of what is the requirement that will support where we think the warfighters are going to evolve in 15 years, which is a much harder question to answer. That process of working through the requirements and working the technology is not something that happens very quickly.

On the other hand, delivering a Space Master plan in a year will presume some overarching decisions or perhaps solutions with respect to where architectures are going to head. And so, the person that Bob has working on that, Army Lt. Col. Sam Gemar, is closely aligned with my office. I have somebody working with him to try to make sure that our architecture and what they are doing are consistent, but I think we have a very interesting challenge to marry my function, which is moving much more slowly than Mr. Davis!

Secretary Davis: Let me just add one more comment. The way I would describe it typically is, you need a set of goals, and Bob alluded to this. We have the National Security Space Master Plan Task Force working, but it's almost like driving down the road. You don't necessarily need to know precisely where you're going, but you need a general direction. If you want to head from here to L.A., or if you want to head generally west, and if you're heading down the road, if you have no set of goals, every time you hit an intersection you have three choices. Do you go straight, do you turn right, or do you turn left? At any given time, if you have your set of goals in place, you may mess up one of those decisions at an intersection, but over time you'll head in the right direction. That's what we're trying to do at a general policy level. However, on a day to day basis, it is not necessarily wrong if we take a left or right turn because that's where the technology is, that's where the operational doctrines say we are. That's the world situation we happen to live in, but we simply need to do a better job of figuring out what our guide stars are for the long term.

Gen. Ashy: Thank you, gentlemen. The next question is another great question. It reads like this: The Air Force provides the majority of the budget for space systems, so why doesn't the Air Force just fund it all? I'm going to ask my components to all comment on what I'm about to say is the answer, and then if they agree with me, they can say it, and if they don't agree, they can say that also.

Let me give you somewhat of a lengthy answer to this. The answer to the question is integral to how we're organized. You have to look at how we're organized. We've been through this with the Roles and Missions Commission. There have been some ups and downs with regard to this, but we have all concluded, I think, in a consensus manner between the services and the CINCs and certainly from our perspective in U.S. Space Command, that we've got it right. When you consider Goldwater-Nichols and the two options that the law gives you, you can organize a unified command in one of two ways; the first option is that you can do it as functional components, like air, land and sea. When you think of the operational medium of space along with the other operational media of air, land and sea, and by the way, it is recognized in our joint thinking that way, there are no air, land and sea portions in space. Space is space. Space is a place. It's a vacuum. So that leads you to rule out the functional componency, which leads you to the second option of service components of an Army Space Command, an Air Force Space Command and a Naval Space Command. Turns out it looks like a duck and quacks like a duck and that's the way we have it now.

We have concluded that it not only meets the intent of Goldwater-Nichols but we've got it right. The reason that we have it right is that it respects the respective services, views, and core values and missions, if you will, with regard to contribution. The Air Force desires to make a measured contribution and the Army and the Marine Corps and the Navy insist on having access to the requirements process and the operational processes by making some contribution. I will tell you as feedback from our services and CINCs that this arrangement is absolutely acceptable to the services and the CINCs. And so in summary, the Air Force can make a major contribution. The Army, the Navy, and the Marine Corps can also make a contribution. The best part about this, it really ensures that all three entities can receive space benefits in a one-third, one-third, one-third fraction—those are not precise—but it assures access and it assures our customers that they can get the capabilities that are absolutely vital to winning in the battle space. That's my answer to the question. I'd like to let Kathy give her perspectives and see if she agrees or disagrees. As a component commander, I'm sure she'll agree.

Rear Adm. Laughton: I absolutely agree, because quite frankly "if it ain't broke, don't fix it." And the system "ain't broke." We have learned that through intensive study. The real issue and the real discussion that should go on is not who is funding what, but are we doing the requirements analysis in a joint fashion, and how are we doing that. And while we in the Navy don't have a lot of our Total Obligation Authority going towards space systems, we are absolutely committed to playing in the joint world, both with USCINCSPACE, also with the major programs such as SBIRS, and we have naval officers working those issues day in and day out alongside their Air Force and Army counterparts. And indeed, we have made a heavy commitment to Maj. Gen. Dickman's people so that we can leverage whatever we are spending in our TOA in joint fashion. That's really what we have to do.

Gen. Ashy: Bill would you like to make a comment?

Brig. Gen. Nance: Yes sir, I would agree also, and I would add, and really it's a compliment to the process of determining requirements, the way that that is being run, it gives the services the opportunity to come to the table and identify what the service specific requirements are, and also to speak for what they believe to be the needs for the theater CINCs, and then in a joint community, in a joint forum, have the opportunity to wrestle with those issues around that and come out with a program and a process that satisfies all of our requirements. Thank you, sir.

Gen. Ashy: Dave, you can make a comment, but I think I can speak for both of us unless you want to override me.

Maj. Gen. Vesely: I thought you put it superbly well, sir.

Gen. Ashy: Let me just add, there were two other options with regard to organization that lead to the answer to the question. It was proposed a year or so before I got in this job that perhaps air and space were kind of the same. It was the aerospace and the Air Force was in charge, which I think was implied in the question. That absolutely did not sell because the air and the space are not the same. They're not the same operational media. And so having a specified service was not concurred on and I agree with that. I will tell you that the current Air Force Chief of Staff agrees with that view.

And the fact that we have an architect and we have a long range planning process I think are testament to the way we are effectively operating.

There is one other option, and that is creating a new service. I think the consensus is that we ought not to do that, but certainly I predict that that will be looked at again in the future. However, I think it's in our interests now to continue with the unified command with service components that access to the requirements process through the Joint Requirements Oversight Council as promulgated by U.S. Space Command, working through their service components to come up with some excellent requirements so that

Bob Dickman and Bob Davis can do their jobs. And the fact that we have an architect and we have a long range planning process I think are testament to the way we are effectively operating. So I hope that answers the question. Bob Dickman, you can say something if you want to.

Secretary Davis: How about Bob Davis instead? Every time a question like that comes up I feel like asking, well, we may have an Air Force but they're not in charge of the air. I think the Navy would dispute that. The Marines and the Army have an awful lot of pilots. I even hear debates that you need the best hand-eye coordination to be a helicopter pilot. At least that's what the Army guys keep telling me. It's an interesting question that keeps popping up. The answer is not to just give everything to the Air Force. The Air Force may have 90 percent of the people, and 90 percent of the funding, and even perhaps 90 percent of the expertise, but they do not have 90 percent of the use of space. If you had to pick somebody to be in charge of space and in fact be the space service, we'd have to look clearly at giving it perhaps to the Army. Not because that's where the funding and the historical expertise have been, but that's where an awful lot of the communications get dumped to. That's where an awful lot of the data requirement is generated from. That's probably the wrong answer, too.

While I acknowledge, of course, that we are the best in the world in space and will remain so, there are other countries that do have technological interests and capabilities that they bring to the table that they are willing to share in certain instances.

The thrust of the question is interesting. The presumption is that the Air Force is the multi-user space acquirer. The Air Force steps up to that. On the Global Broadcast Service the Air Force volunteered, and we accepted their generous offer, to fund the Global Broadcast Service in the out years, which is the Air Force's responsibility. But they stepped up to the task. It doesn't, however, mean you take the other 10 percent of the programs away from the other services, because it has to be imbedded in their thinking. As a matter of fact, I think it would be a mistake because one of the goals and challenges that I have is to try to get better imbedded in each of the services education and training, the way they recruit people, the way they assign people, the way they develop people to get space thinking into the very psyche of the service. And that would be a step in the wrong direction if we simply said space belongs to the Air Force.

Gen. Ashy: Thank you. In summary, we fight and execute our military missions as joint, combined commands as supported or supporting. We are organized in the unified command of U.S. Space Command in accordance with Goldwater-Nichols with service components. All of the services and the CINCs are satisfied and comfortable with how the services can contribute, no matter what the portions are. They certainly all have access to do their missions of organizing training and equipping, and we can do our job to provide the services of combat capability either as supported or supporting. It's been a great debate. I'm sure it will continue a little bit, but I think we've got it right and I'm pleased to report that the Roles and Missions Commission agreed with us. Most importantly though, our customers, the services and the CINCs, are happy. The next question I think applies to the secretary and Bob Dickman again. The question has to do with international activities and arrangements and cooperative efforts leading to agreements in the overall master plan for space capabilities. I'll let you gentlemen handle this in your order.

Secretary Davis: One of the priorities that I and Dr. Paul Kaminsky, the Undersecretary of Defense for Acquisition Technology—my boss—and the secretary of defense and the director of Central Intelligence Agency have is better international cooperation in space for a whole host of reasons. One is, ultimately it's cheaper. Other countries do bring money to the table, and in this environment that's important. Another reason is technology. While I acknowledge, of course, that we are the best in the world in space and will remain so, there are other countries that do have technological interests and capabilities that they bring to the table that they are willing to share in certain instances. Another reason is the world we live in today. It's coalition warfare, it's cooperative warfare. We have troops in Bosnia with our allies. We had somebody shot down in Bosnia, as did the French. We need to be able to communicate. Well, "no" is no longer an acceptable answer. I think that if we have somebody, a U.S. soldier in a foxhole, and a French or a German or British soldier in a foxhole down the road, and they physically can see each other, I don't think any of us want to be in the situation of trying to explain why they can't talk to each other.

We need to fix those programs and the way you fix them is to plan ahead of time and not jury-rig it. We have had some discussions in the eight months I've been here with the French, the Germans, the British, the Canadians, the Australians—I'm probably leaving somebody out, but that's an awful lot of people—in how we better go about cooperating. A lot of these areas of discussion have focused on communications, but not solely. We've talked about early warning. Other countries are interested in that. We've had discussions on GPS and imagery proliferation around the world. The dialogue is very robust and I would expect we would see more of it, rather than less, in the future.

The last point, the question that touched on policy: Since we're about to have a new national space policy and we have already started trying to write what the DoD space policy will be, it will be my intent to come up with DoD international cooperation space policy so the guidelines are clearly laid out for the entire Department of Defense about how we go about doing our business. And the presumption is that cooperation is to our benefit. To the extent that we come to agreements, we would pass those agreements in terms of cooperation to Bob as he's planning his architecture, because other countries have different requirements. We would fold those requirements in his planning process.

Maj. Gen. Dickman: I think a year ago we had the process a little bit backwards. We almost had a program that we were trying to embark on in the MILSATCOM: an International Military Communications Satellite, and every MILSATCOM architecture that was brought forward had to be measured against whether INMILSAT could fit into it properly. Now we're working on what are the architectures, and then what are the technologies and the opportunities for international cooperation, And it gives us an awful lot more flexibility on both sides, both for Secretary Davis to work a number of countries that we don't have to box out because they're not part of a specific program and for us to have a lot more flexibility on the architecture side as well.

Gen. Ashy: Jeff?

Mr. Grant: The Brown Commission Report that was recently released on looking at the intelligence community and how it should be organized spoke to growing international cooperation in the area of space reconnaissance, so this area will be clearly investigated in the near term.

Secretary Davis: Let me just add one final comment. For those of you from industry that are out there, our intent is not to try to usurp your role. It's really to come more to government-to-government agreements, setting some ground rules as to what the requirements are, how we would want to proceed in an acquisition sense and then to the extent that using communications systems, as an example, that we come to an international agreement on common communication systems within the bounds of the architecture that Bob Dickman develops. Within the agreements, we would go out with a request for proposal saying we have money and a requirement. Here's the document that we want you to go build something against, but embedded in that document it may well say, that in fact, you have to have participation from country X or country Y and that you must plan to produce some percentage of whatever the work share is in that country and a certain percentage in the United States. I then see our role as simply getting out of the way and letting industry seek its own level, its own partnership with foreign commercial firms in the other country.

Gen. Ashy: I think related to this, just as a comment from Space Command's perspective—and perhaps the component commanders would like to comment briefly—and we've learned this lesson time and time again, is if we don't think through in this complicated world that we've evolved into, with regard to how we share data and communicate data not only amongst ourselves as we've talked about today, but with our allied partners, we will have a tough road to plow. I know I learned this in the theater of operations before I came to this job, and we see it day in and day out, whether we're supporting a theater of operations or we're executing our own mission. We need to think this thing through, and if we can't share data, or use common communications systems, space borne or otherwise with our partners, then we will have a difficult task. Dave, you or Kathy or Bill want to mention that? I know you see that day in and day out in your support to the warfighters.

One of the things that we've learned when we talk space assets is that we need to really understand what other nations bring to a table and how we in fact communicate.

Rear Adm. Laughton: Yes sir. As you know, the Navy routinely exercises with allies of all nations. In my life I was very much involved with some of the international warfighting communications issues, the CCEB of course which runs out of the joint staff as well as Australia, Canada, New Zealand, U.K., and U.S. One of the things that we've learned when we talk space assets is that we need to really understand what other nations bring to a table and how we in fact communicate. The key to that is to sign up to the international standards and to build them into all of our systems, both our space systems and our other communications systems so that in fact we can take advantage of the inter-operability issues. The other thing that we've been very proactive on in terms of our own TENCAP program is refining projects which give us direct benefit to the allied problem, and one of them that we've worked through very effectively is a thing called radiant mercury, which in effect sanitized a lot of what we do helping us become very inter-operable with our allies.

Gen. Ashy: Bill or Dave?

Brig. Gen. Nance: Yes sir. I concur with the idea that we need to ensure that we have the ability to share capabilities with our joint partners in theaters. Whether it is communications or missile warning or intelligence information, we need to work to do that. And in doing that, look at the architecture and protocols that provide us the opportunity to do that.

Maj. Gen. Vesely: I would just emphasize that my dealing with those air component commanders around the world—they can't very well devise a scenario where they're not in a coalition. It really is something that's got to happen. And we're doing it day to day.

Gen. Ashy: I think it bears comment here that in a cooperative way, following on the secretary's remarks, is that we here at U.S. Space Command are heavily involved with cooperating with our partners around the world with shared warning. This will be much improved when we get a Space-Based Infrared System (SBIRS). From the theater perspective we have created this system as executed by our components, and they all referred to it in their talks on how we share ballistic missile warning in consonance with the political policy that is promulgated. So we've built this system, the Theater Event System, where we can easily and effectively share warning with partners when it's decided that we should. This gives us, going back to the question, stability and deterrence throughout the world and I, from a personal perspective, think this will become increasingly important as ballistic missiles proliferate. Thank you, lady and gentlemen on those responses. The next one goes to Jeff, I believe, and the question is, what is the risk associated to the downgrading of NRO-produced data? On the one hand, it is more useful to the warfighters, but are we jeopardizing the very sources and the methods on which we depend?

Mr. Grant: That's an excellent question—and I may not be the right person to answer that from a number of perspectives, but let me take a shot. The systems that we've operated over the decades, traditionally with the Cold War mentality and the security systems that surrounded them, made the data very limited in their distribution, very limited. As we became more involved in not just the planning timelines—which have been in literally weeks, months, years—but started having systems that were relevant in execution timelines, it necessitated the data to be available to a broader variety of folks. We've tried to isolate the data from the systems that collect the data in terms of how the systems are controlled and who has access to them, but indeed as time marches on and we find ourselves with many of our systems products very widely available, those delineations become less and less clear. The risk I think we face is that as more and more folks have access to more and more of our products then the very real opportunity to take reasonably small steps to limit their effectiveness is very possible. Those trades take place not within the NRO at all. Those trades take place between the people who use the data. The feedback that we get from our military users is that the trade is clearly for broader access to the information that comes from these systems, albeit at some risk, but those trades have been made, and that's what we're doing.

The systems that we've operated over the decades, traditionally the Cold War mentality and the security systems that surrounded them, made the data very limited in their distribution, very limited

Gen. Ashy: Thank you very much, Jeff. The next question, I believe, goes to the secretary. It is, what is the idea behind the Joint Space Management Board and when will it meet for the first time?

Secretary Davis: The idea behind the board is that there has not been in the past a mechanism to formally reconcile differences of opinion or fact, on issues that involve space. Nor has there been a formal mechanism to prevent things from diverging and to make sure positive things happen up front because of a planning process. So the function of the Joint Space Management Board is to have all the stake holders—Gen. Ashy sits on the board, I do, Bob Dickman, the NRO, and all the services and intelligence organizations are involved—to be involved up front in the space process. The board was created officially in December. The executive committee met on Dec. 20. The issue at that point was who would be the acquiring organization for the Global Broadcast Service. NRO had proposed doing it, the Army was interested to some degree in doing it, and so was the Air Force. That was the issue and that was the preliminary meeting.

The executive committee is composed of four people, the Undersecretary of Defense for Acquisition, Paul Kaminsky, the Vice Chairman of the Joint Chiefs—at that point it was Adm. Owens—and from the intelligence community it was George Tenet, the Deputy Director of Central Intelligence Agency; and under his old job, Keith Hall, as Executive Director for Community Affairs in the intelligence community. The first full board meeting will be in early May. We're trying to get schedules worked. I'm excited about doing this because for the first time we have a mechanism in place where we can take issues to them up-front and say, "Here's the direction we want to proceed." And one of the examples is the National Security Space Master Plan. We have a team that's starting to work on it and we want to present to them the timelines, the direction we want to take. Then our intent would be to come back with a product for them in early December, saying, "Here's what we think the National Security Space Master Plan ought to look like," and get their approval or changes as necessary. The verdict as to whether this works and how well it works will be decided over the next six months.

I think everybody involved in JSMB is excited about using it. It sets the agenda, as I said before. The charter for the JSMB actually mentions something called the National Security Space Architect, and we have to grapple with that. Keith Hall, in his job as director of the NRO, and I have been tasked, and we have our staffs working to come up with the terms of references, to start looking at NRO programs and how we perceive their ability to meet Department of Defense requirements over the next 10 years. So there's a lot of things happening in the background, but in early May should be the first meeting.

Gen. Ashy: Thank you, Bob. The next question I think could be led by Bob Dickman, with perhaps comments from Jeff Grant and the secretary. The question is, with the recent space industry mergers, are we in danger of a monopolistic problem for developing space systems and especially launch systems?

Maj. Gen. Dickman: I think the competitive juices are flowing as well as ever. The number of competitors is an awful lot smaller, but my sense, especially in the launch area, in the small end, for example, is that we had so many competitors that two-thirds or three-quarters were doomed to failure because the launch manifest wasn't going to sustain anything like the number of companies that were coming forward. I'm not particularly concerned that we're going to lose either the industrial base or the competitive nature of being able to do acquisitions.

Gen. Ashy: Jeff?

Mr. Grant: I probably run hot and cold on the consequences of the merger activity we see taking place only because I'm concerned about some of the consolidation of expertise into essentially just one company, in a number of cases. The mitigating factor to that is the explosion that we're seeing in commercial base business areas, which are being done by companies that have a tighter turning radius than some of the larger companies. And from our perspective in the NRO, most of our technology work is done at the unclassified level and so we encourage our folks to do business with a broad range of industry and are always willing to take in good ideas, whether they come from large satellite contractors or small satellite contractors.

Gen. Ashy: Thank you gentlemen. We've just about run out of time. I'm told we can go over by a few minutes and then the panel will be followed by a short video that Steve Scott will introduce. There are still a lot of great questions here. The next one has to do with EELV. The question is, why fund an EELV program at all, and why not just purchase launch services directly from industry, or the French, for that matter? Go ahead, Bob Davis.

Secretary Davis: That's a good question. I'd love for industry to just be willing to volunteer the $2 billion necessary to do EELV. So that would be my first choice. I don't see that happening. So the choices really are in front of us as you look across a range of launch capabilities we have out there, as Bob Dickman touched on. The small launch vehicle, I think, is a healthy enough industry and our policy is that we will not step in and try to develop or subsidize to any great extent the small launch industry. It's just not necessary for us to do that. When you look at the range of medium to heavy lift that we need for DoD and NRO payloads, we're slowly being eaten alive by the costs of launch. That is, the launch rate has gone down, the costs of launches are going up to unacceptably high rates, and as you look out beyond the turn of the century, some of the heavy lift payloads, given the launch rate, could potentially cost us three-quarters or a billion dollars apiece to launch, and that's unacceptable.

And from our perspective in the NRO, most of our technology work is done at the unclassified level and so we encourage our folks to do business with industry and are always willing to take in good ideas, whether they come from large satellite contractors or small satellite contractors.

So what's the solution, since industry, and rightly so, is not going to step up to solve our problem (although they are to some extent, trying with Lockheed Martin and the Atlas development and McDonnell Douglas, with their Delta developments, to make their medium capabilities commercially viable) as a result of one of Tom Moorman's efforts, the famous Moorman option 2, the $2 billion option, is to go do EELV. I've sat in on half a dozen briefings by vendors and people in the Department of Defense in the last month, and I think the program is going well.

It will pay for itself very quickly, in terms of reducing costs. Given the potential, from a briefing that I saw yesterday, to reduce what is now costing us a lot on the Titan 4, is great. We could be launching things for a third or a quarter of the cost very quickly, once we get EELV up there. So it's being cost driven—we are not reinventing the wheel. These are technologies that we know how to do.

The next question usually pops up: Why do we want to do EELV when the salvation of all humankind is the RLV program? And while our salvation may in fact be RLV eventually, that's a fight for a different day. EELV will pay for itself before the RLV is ever realized. If NASA is successful in what they're doing, and I certainly hope that they are, EELV will have paid for itself. And then there are intangibles that you can't really price out, in terms of the speed with which you can launch. You can launch on demand.

I think we're all aware of some of the lengthy static displays of Titan 4 vehicles. It's a good vehicle, but it just takes too long to get some of these things launched. One of the most exciting outcomes of EELV, I think, will be our capability to simply get things in orbit, reasonably quickly.

Finally the question is, why don't we just buy launch services? It's a good question, and I have been asking the same question and frankly don't get anyone saying that that is not something that we should be aggressively pursuing as an option. I would think that the point that we would insert that into the EELV competition is still probably two years down the road, when we would go to the EMD selection process in the acquisition cycle and say in fact we do want to buy a launch service. That is a leading option at the moment. We're looking at it. It may be the right solution.

One of the most exciting outcomes of EELV, I think, will be our capability to simply get things in orbit, reasonably quickly.

Gen. Ashy: Bob Dickman, do you want to say anything?

Maj. Gen. Dickman: I would reiterate what Secretary Davis just said. I think the DoD money, the government money, was a nudge that industry needed to do some things that they'd been looking at for a long time, but for whatever reason were unable to push themselves over the brink. The cryogenic upper stage for Delta, the integration between Atlas and Titan are clearly things that didn't come out of the EELV, but without an EELV they weren't happening. I think an area where EELV may be decisive and what we're going to struggle with very hard over the next few years is what happens at the heavy end. The commercial industry will sustain itself only to the point where a vehicle can carry the largest economically feasible communications satellite. That would mean if heavy is defined as anything over that, the Titan IV class, we will be the only customer for that, and there's a question whether we can afford that or whether that would force us to de-optimize an awful lot of satellites to be on a class vehicle that isn't consistent with the physics of the satellite.

The other alternative to that is whether or not a heavy vehicle in our country can dual-manifest payload. We don't do that today. Ariane does it all the time. EELV may provide some of the impetus and some of the ability to spend some money looking at how we can make an economically viable commercial variant of an EELV so that those costs get amortized across the bigger spread.

Gen. Ashy: Thank you, Bob. I would also like to comment perhaps slightly in deference to previous comments here. I think the question is a very important question. We need to remember what the mission is. We often say, in U.S. Space Command, when we're reviewing something, "It's the mission, stupid." We need to keep focused on the mission. This is an assigned mission. As I commented, and I think the secretary commented earlier in his remarks, we all respect the notion that we need to continually review the mission. But assuming that the mission is valid, and it's an integral part of space force support with regard to assured military access to space, that's what EELV is all about.

It's an expendable vehicle that will assure our access as a cheaper way to space. That's the purpose and the objective of the program. This leads us to the question of ownership, not who does it and how we do it specifically. The ownership of this mission will be a military mission. That's delegated from DoD to the U.S. Air Force and that's why Dave Vesely coordinates all that and executes it. However, we have all gotten the message that we need to do this better, smoother, faster, cheaper. So we can out-source, privatize, and contract out. We are all for that, and I would argue that we do that now. It's not blue suiters launching these expendable vehicles, and blue suiters won't do it in the future. Contractors do. Our commercial partners do, as we have outsourced this owned, controlled mission. And I predict that this will not only stay valid, but it will grow in the future. Ladies and gentlemen, you've been a great audience, we've had a great panel. We've run out of time here and I've gone over the time allotted and I apologize to the Foundation so that will have to be our last question. Would you join me in thanking a very great panel?

Symposium Luncheon Presentation— NASA and Space: Enhancing Life on Earth

Introduction: **General James E. Hill, USAF (Ret.)**
Chairman of the Board
United States Space Foundation

Featured Speaker: **The Honorable Daniel S. Goldin**
NASA Administrator

Gen. Hill: This is a person who needs no introduction. And in most cases then they'll go ahead and introduce the speaker and say what they have to say. I'm not going to do that today because I am certain that there is not a single person in this room who does not know who Dan Goldin is. If you've had anything to do with space, or have been involved with NASA or industry or any of these activities that we talk about in this symposium and are here to take care of in this symposium, you know Dan Goldin.

I will tell you a couple of things about Dan, though, that you may not know. He was appointed the administrator of NASA in 1992 after 30 years in the aerospace industry. Many of you would not realize that he was 30 years in the industry *before* going to Washington. He doesn't look like he's that old. I see him quite often and he looks like a very young man so it is hard to tell how he could have been there 30 years, but he has. Before the appointment he served as vice president and general manger of the TRW Space & Technology group in Redondo Beach, California, and served 25 years with TRW managing the development of production of advance spacecraft, technologies, and space science instruments. He has led NASA through its most challenging years and he has brought new energy and strategy and efficiency to NASA. Please welcome Dan Goldin.

Mr. Goldin: I am thrilled to be here. I want to talk today about the subject on this program, "Enhancing Life on Earth." Whenever people think of NASA and think of enhancing life on Earth, the first thing that comes up is Tang and Velcro.

Well, let me dispel the fantasies about that. NASA did not invent Tang and we did not invent Velcro. We used them. It helped do what we do, but we touch people in unbelievable ways. And this came home to me during these last two weeks I've been traveling. The members have been on recess, and I have been visiting a number of their districts to interact with the children. I spent a good part of each day for the last few weeks talking to elementary, middle school, high school, and college students. And if anyone thinks there isn't excitement in America about the future, try it for a few weeks; you'll come alive. It's unbelievable.

But there is one experience that struck me very deeply. I went to an elementary school in Sydney, Maine, to talk to the students, and I walked into the school with all the suits. There were about five suits walking into the school, and the kids said to us, "We don't want you to talk to us, we want to talk to you." Then for an hour they put on a computer display that was mind-boggling. These children, third and fourth graders, took LANDSAT images, SPOT images, and they were doing environmental and agricultural analyses to help the local community.

A little third grader stood up and spoke with such poise and confidence. He had his classmates project computer images on the screen and would change the images. He told us how he took this big picture of Maine and narrowed it down to find a bog and to figure out where plowed fields were. That's how we touch America—not with Tang and Velcro and gimmicks. It's very, very important to understand that, because many people say, "Well in order to justify this space program, tell us what you're going to do for America today," but that's not what we're about.

What I tell people is that NASA's not about tech-transfer. If you want a tech-transfer organization, go to private industry; don't come to the federal government. Don't buy technology by the yard. NASA is about bold and noble tasks to open the air and space frontier. It's about research that goes 10, 20, 30 years out, and it's about the possibility of payoff that we don't even know about. We can't go testify and say, "Well, if you give us money for the Space Station, we're going to cure cancer." That would be inappropriate. Yet, there is this desire to survive in the near term. American corporations are under unbelievable stress. They can't have a research and development program that goes out much beyond three to five years for product development. They can't go back to their shareholders and carry investments on the books for 20 years out. So people say, "Well, let's privatize space! Companies will go invest, and in 30 years they'll get money back from the moon." That's unrealistic. But what we will do is answer fundamental questions that the human species has worried about for centuries and millennia. In doing so, we will perform basic research and technology and then we can find the payoff. Let me give you an example, just one example of what I'm talking about.

One need only pick up almost any newspaper in America or turn on to any major broadcast or cable news station, and you'll hear all about the cosmos with the images from the Hubble Space Telescope. In the last year, we have actually photographed a planet around a star within 30 or 40 light years from Earth, and that planet is in the life zone. That's important news that makes front page coverage. With the Hubble, we've gotten images of galaxies that we believe go out to the very beginning of existence. That's front page news. So we don't have to sell the American public short and say they need Tang and Velcro. They need intellectual nourishment, and they understand the impact of research. But while we have the Hubble Space Telescope, let me tell you what happened. When you take pictures of galaxies and stars, you're trying to pick out very faint light from very, very high background noise. In the process of doing that, you need very advanced digital image processing.

But the fundamental issue is, as a nation, we have got to go to the outer boundaries and we cannot apologize for our space program by talking about Tang and Velcro. We don't have to apologize because we are exploring the unknown. We don't have to apologize because we're doing research that won't have payoffs for 10 or 20 years.

You need very advanced focal planes. Well, the medical community came to us and said, "You know, the images you take with the Hubble look exactly like mammograms, and what we want to do is find micro-calcifications in women before they get very big." The problem that the medical community has now is, when women go in for a mammogram, with the resolution they now have, growths must be pretty big to detect. If they have to do a biopsy, it's thousands of dollars and very, very painful. We transferred the technology from the Hubble to the medical community, and small companies and big companies are getting in on it. We believe the resolution is going to go way up for the mammogram, and because we could so precisely locate the microcalcification, they are using a needle instead of a biopsy to determine whether the women have cancer.

When the Hubble Space Telescope was being sold to Congress, we couldn't stand up and say, "Hey, fund the Hubble and get a better mammogram." But the fundamental issue is, as a nation, we have got to go to the outer boundaries and we cannot apologize for our space program by talking about Tang and Velcro. We don't have to apologize because we are exploring the unknown. We don't have to apologize because we're doing research that won't have payoffs for 10 or 20 years. All one need do is ask almost any American, "Do you think we're going to have a robust country in the year 2020?" And almost everyone will say, "Of course. Yeah, we got problems now but we'll work 'em out." If we're going to have a robust country in 2020, it is legitimate that this nation expend a very small fraction of its resources on things that go out that far. So when I talk about tech-transfer and when I talk about R&D, I'm not talking about Tang and Velcro. I am talking about exploring the unknown.

To explore the unknown, we had to restructure NASA. If you look at NASA, we were organized about constituencies. When I got to NASA, I asked our employees, "Who are your customers?" And with all due respect, they said, "Rockwell, TRW, and McDonnell Douglas." And I said, "You have got to be kidding." They said, "The scientists and the universities." I said, "This is nonsense. The customers for NASA are the American people, the taxpayers who pay for the program, not the NASA scientists and engineers, but the people who need the benefits from this program decades out." As a result, we had the shuttle. The shuttle cost was at over $4.5 billion a year and was going to go up to five or six billion a year. And everyone—and again I don't want to be demeaning of the intent—everyone was happy making good profits on the shuttle. But we never asked the question: Do we have too many people on the shuttle and are we making the shuttle safer? That's the object.

Then we took a look in the science area. I was told then, you must have 19 percent of the budget devoted to space science, that we have to have $400 million a year for space physics and so much for astrophysics and so much for planetary science. Why? Because if we don't fund space physics at $400 million a year, they won't have continuity of funding in the universities. That's poppycock! That's not what our role is; our role is to have free flowing, peer reviewed research and let scientist go after scientist to get the very best idea in front of the public.

So the problem was, instead of asking fundamental questions that were multi-disciplinary, that the American public could understand, we had constituencies in different areas. Good people, a system that was set up that didn't change with the times. So, we developed the strategic management system and a strategic plan. It's available. We've made copies available to Congress, every NASA employee has one. Hopefully our contractors have them. We've worked with different societies; Arnauld Nicogossian and the American Astronautical Society have worked with us. We tried to talk to our customers across the country in town hall meetings. What we came to was a conclusion that we have to answer basic questions, and let me list them for you here:

- Where did galaxies, stars, and planetary bodies come from and how did they evolve and interact? How does this knowledge enhance the quality of life on planet Earth?

- Are there places that had an environment, have an environment, or might have an environment hospitable to life of any form—even single cell life—or to human commerce?
- Is life of any form unique to planet Earth?
- What technologies must be developed to open the air and space frontier to answer these basic questions?

That is the direction that we are going in at NASA. When you ask these questions and talk about it (I just talked to about 15 different schools, and thousands of people), everyone understands those questions, but they didn't understand $400 million to space physics and so many dollars to planetary science and so many dollars to a shuttle. So, I think we are now beginning to connect with the American public. Life is not just about survival; it's about hopes and dreams, it's a search for the understanding of life. It's looking up at the galaxies at night and wondering, are we alone? Where does it end?

We also need intellectual nourishment; that's necessary to fuel future endeavors. Let me give you a few examples. We have to understand the laws of physics, about the generation and transformation of energy and the generation and transformation of matter. If you look up at the heavens, there is a lot of knowledge to be gained. We talked about building a super conducting super collider in the deserts of Texas, and I don't want to say that that's good or bad. I think that it was a very noble feat, but it didn't get funded. If you take a look out at the heavens, there are processes that take place around heavenly bodies that we believe are 10 million times more energetic than anything we could have generated in that super conducting super collider. Clearly, we couldn't have made the microscopic measurements locally for transformation. But we don't understand these phenomena, and if we want to rewrite physics textbooks, we must look up at the heavens across a variety of spectrums.

We don't understand a lot about the formation of matter. We know and we believe that you can, in a chemical manner, generate the basic proteins that are the building blocks of life, some of the amino acids. But then a very funny process takes place when you build up from these building blocks into a living cell. We have a sense that comets and asteroids have these building block proteins, but what happened to cause life to take place? We just don't understand. We believe Earth formed about 4.5 billion years ago, and after some hundreds of millions of years, single-cell life formed on Earth. We had single-cell life on Earth until about 500 million years ago, and then in a 10-million-year period, we theorized something magical happened, and we basically went from single-cell plant and animal life into very complex life form. We don't understand. But if we are ever to effectively combat disease as we know it today, we need an understanding of that, and for that we have to look out at the heavens, at the stars, at the planets, and the planetary bodies. Doing this will allow us to rewrite physics textbooks, biology textbooks, medical textbooks and chemistry textbooks. It is fundamental, and you don't have to justify to the American public day by day by day by day. We have to give you near-term benefits. America has to look over the horizon. That's what we are all about. We do things to understand our basic planet. How do the laws of nature interact so that when you look at the oceans, the atmosphere, and the land, you can understand that interaction? And is it possible to understand the naturally occurring forces and the human-occurring forces on our planet so we can create predictive environmental and long-term climactic models?

Life is not just about survival; it's about hopes and dreams, it's a search for the understanding of life. It's looking up at the galaxies at night and wondering, are we alone?

This is an unbelievable task, and our present computers are probably one million to one billion times too slow to do this. Our algorithms are incapable of doing it right now, but over a 15-year period we believe we are going to make it happen. Let me give you an example of one of the issues we are working on right now—the El Nino condition. For some reason, periodically, there is a hot spot in the center of the Pacific Ocean. As this hot spot starts moving, there is a wave that moves across the Pacific Ocean toward the west coast of the United States. How do we know? We built the Topex Poseidon spacecraft and we measured the surface of the sea level. We measured it in centimeters, and we saw this heat wave traveling. So you say, "Well, how does that relate to life in America or around the world?" Last year Los Angeles got 50 inches of rain, when it should have normally gotten 12. And you go out to the Midwest and the farmers were dying on the vine, and in other places they had floods. If you could predict that a number of years in advance, think of the impact we will have on our society. You don't need Tang and Velcro to calculate what would happen to our society if we could predict the long-term climate—an accurate Farmers Almanac, if you wish.

I was recently testifying before the Senate, and Sen. Stevens of Alaska came in. I thought he was going to beat me up over 10 different subjects and he surprised me. He said, "Dan, why aren't we moving faster on Mission to Planet Earth?" And I said, "Sir, we are moving as fast as we can." And he said, "Do you realize the insurance industry of America is unbelievably concerned that they don't know the impact of what's happening to our environment on their future liens against the insurance policies they have. They worry about whether the sea level is going to rise a foot." Think of the impact of what would happen if the sea level rose a foot. Now, I'm not being a hysterical environmentalist, but we're talking about trillions of dollars worth of impact. It could devastate the economy of this country. We at NASA will resolve this problem. We'll do it for the lowest possible cost, but we will resolve this issue. That's not Tang and that's not Velcro.

Another major issue coming down the pike is information systems. Information systems are going to change everybody's life but people don't know it yet. I was talking to farmers and people in rural areas of Montana. They have a low-value-added agricultural forest products, mineral-based industry that is going to change radically. In 1860, 53 percent of Americans earned their living in agriculture. Just two days ago, *USA Today* reported that 1.9 percent of Americans earn their living in agriculture. But those who work in agriculture are going to be touched by information systems.

Information systems are going to change everybody's life but people don't know it yet.

Let me give you another statistic. A few years ago 3 percent of Americans earned their living in information intensive technologies. Predictions say within 30 or 40 years, 50 percent of Americans are going to earn their living in information-intensive technologies. It is going to change everything about everything on this planet. In 1984, 80 percent of a computer was built on a production line, 20 percent was information systems. In 1990, 20 percent of a computer was built on a production line, 80 percent information systems. Today, less than 10 percent is hardware. So, these production line jobs are vaporizing and everyone is wondering, "What's happening to me?" No one is bad, but technology is marching on, and if we don't educate and we don't prepare for this revolution, it isn't going to happen.

We are working with a number of farm implement companies to put robots in their tractors with signals from a Global Positioning System and from our remote-sensing spacecraft. I hope they will be mostly commercial so farmers could farm by the yard. We're doing it right now, today. So think about a farmer who has his family farm, but he is not computer literate and can't get on the Internet. He's not going to be able to manage that farm and get the productivity that he needs. So it's here, and it's coming. We asked an investment banking company to do a study for us. They believe there will be a $10-to-$20 billion-a-year industry in remote sensing. And that budget in remote sensing is a meager budget of a little over a billion a year. Rather than industry coming to NASA and looking upon Mission to Planet Earth as a place to gain profits, we really need to work in a partnership with industry to transfer technology, so industry takes the job over from NASA and we solve all these other issues I talked about. The finances and profits are going to be in the information technologies not just in the spacecraft area.

Aeronautics—it is a $100-billion-a-year industry. For 25 years, the long-haul jet transport business in America dropped one point per year. We have lost 25 percent market share. In the next 15 years there will be about $1 trillion worth of business in long-haul jet transports, not supersonic. Supersonic is another quarter of a trillion dollars, and hopefully, we'll work that as well. To turn this around, you have to have the most superior technology in the world, the best manufacturing procedures at the lowest cost, and there are things that no one aeronautics company could do. It's not corporate pork when NASA develops new design tools that enable companies to cut their cycle time down by a factor of two. That's what we're about. It's not Tang and Velcro.

Communications—I just picked up the *New York Times*, and read an article about a petroleum exploration company that was all excited about a new technique they had that was information intensive at the site, but there was no way of getting the data out. We made the Advanced Communication Technology Satellite available to them and they're using this at 620 megabytes of data that you can get in pulses. They are using this to find new sources of oil. If you go back about six or seven years, before we launched the Advanced Communication Technology Satellite, the foreseers of doom and gloom said, "NASA just wasted a half billion dollars on technology that industry should have been working on." But industry didn't have the money to work KA band at that time. And now America has a leadership role in KA band technology because we didn't listen to all the people who knew with certainty what couldn't be done, and we plowed ahead. We are now in the process of signing an agreement with the American communications industry—not just people in space communications, but terrestrial communications. So NASA is going to work in a team approach with the communications industry, such that we will have the same relationship as with the aeronautics industry. It is very exciting, and guess what they told me was the No. 1 priority for NASA? They said they are worried that with a seamless global information system, that they would not be competitive because space launch was much too expensive. They said they cannot live with $10,000 a pound. Their spacecraft had come down in cost by a factor of five and soon would be coming down a factor of 10, and launch has consistently been $10,000 a pound.

Here's the greatest country in the world and we haven't developed a new rocket engine in 25 years. We spend billions of dollars on propulsion. Again, I don't want to be critical of the people, but the system is sick. Billions of dollars in government expenditures, significant profits, and NASA, the U.S. government, and industry did not develop a new rocket engine in 25 years. We're willing to settle for second-rate performance out of our launch vehicles. The payload mass fraction of American launch vehicles today is about 2 percent. Europe and Japan have about 3 percent. There are technologies that could get us to 10 percent, but we're so focused on a program that should be 10, 20, 30 years out, that all we want to do is push the near term. We're so afraid of failure that we're afraid to fly things because they may fail. We're going to change that. I'll talk about that in a minute.

I could go on and on, industry after industry, but my point is, NASA is more than Tang and Velcro. We are going to answer fundamental questions, and in answering these fundamental questions we are going to be forced to develop technologies that no one even thought about.

One of our goals is to send an armada of robotic spacecraft to every important planetary body within our solar system over the next 15 years. In 1992, the average cost of a scientific spacecraft at NASA was $600 million. It took on average eight years to develop. In 1992 we had only two planetary spacecraft scheduled for the rest of the decade. Each of these spacecraft was in excess of a billion dollars. But we just started 10 programs. I would like to just read these out loud and give you a little sense about it. By the way, the scientific community and many in the engineering community said, "You must have big spacecraft, because without big spacecraft you can't do good science." Well, in October of 1993, we started the NEAR spacecraft and within 27 months it was launched. It is on its way to an asteroid three years out. This fall we're going to launch a lander that is going to go to Mars. We're going to launch an orbiter that goes to Mars; it will get there in July. We're going to launch a lander in '98 and an orbiter in '98. We're going to launch a microprobe in '99 that's going to be a spacecraft about the size of my fist, with a seismic station that's going to go on to Mars. We're launching a lunar prospector next year to see if there is water on the moon. Clementine gave us some sense that there might be some water in the southern craters on the moon. Lunar Prospector is going to find if there is water there. We're then going to launch a spacecraft called Stardust. It's going to rendezvous with a comet, go into the comet's tail, and collect some of the comet's dust. Perhaps we'll get some building blocks of proteins and put it in one sample container. Then it is going to fly and collect some intergalactic dust, put it in a second sample container, and return it to Earth for analysis. I see a grinning fellow here who is building it. And it happens to be a small company.

We have Deep Space 1; we're going to put in an electric propulsion system. We spent 35 years developing electric propulsion. We're going to fly it in a year or two and we are going to prove that electric propulsion works so we'll be able to enhance our planetary missions. We have Deep Space 3, which will be launched in 1999. We're going to put interferometers into space and, based upon knowledge on the ground, we're going to test out these interferometers to establish that we understand technology so that we could be able to image planets within 100 light years of Earth, if they exist, that are Earth size. But let me tell you how difficult this problem is. In order to make these measurements, we're going to have to build light buckets that are meters in diameter, we'll have to separate these light buckets by kilometers, and we'll have to know their position to within a trillionth of a meter.

So with the metrology techniques we are going to develop for programs like Deep Space 3, we are going to be working cooperatively with the lithography industry to help it develop leap-frog changes in fueling the information age for America.

We'll have to physically place them to a fraction of an inch, and we're going to have to locate them in an orbit somewhere out by Jupiter. The reason we go out to Jupiter is, we have this dust in our atmosphere, and when the sunlight reflects off it you get what's called zodiacal light that saturates the sensors. That's a tough problem. And when you take a look at the surface finishes that we have to put on these telescopes, the surface finish will have to be 10 times better than anything we've had. But isn't it interesting, that the lithography industry is just panting to work with us because we are beginning to saturate out in terms of building next-generation semiconductors. So with the metrology techniques we are going to develop for programs like Deep Space 3, we are going to be working cooperatively with the lithography industry to help it develop leap-frog changes in fueling the information age for America.

Now, there are 10 spacecraft here; the sum total of those 10 spacecraft is $1.3 billion. We started the first one in October '93, that is when we began the design. The last one is going to be launched in 1999.

So in six years we're going to launch 10 spacecraft. The average cost is $130 million.

Now, that's not enough. Ed Stone [director of the Jet Propulsion Laboratory] has taken the challenge to cut the cycle time down to a year and a half for spacecraft and to get us well into the tens and millions of dollars, because the vision we have is not a dozen spacecraft a year— but we want to launch dozens of spacecraft a year. I submit, I went to the rendezvous of Galileo with Jupiter and at that time, I was beat up because we're stopping the big programs at NASA. I submit that that's one heck of a lot of science. Then I asked the wonderful people out at JPL to do a calculation: Using today's technology, how much would it cost to build Galileo? One-fifth the price. Using technology from the new millennium program in the year 2000, one-tenth the price. My challenge is—don't measure dollars going in to measure the vitality of NASA, measure the science that is coming out. And I challenge everyone in the room to throw off your old habits and say, if it has to be big it doesn't have to be heavy. If it has to be big, it doesn't have to be expensive.

So here's a second challenge I pose to the astrophysical community. I said I want a Hubble Space Telescope that's one-thirtieth the weight and one-thirtieth the cost. They held a workshop down at NASA Goddard, and are actually talking about it. When we built the Hubble, we built it exactly like you build a telescope on the ground. We took glass and we ground the glass and we polished the glass and we ground the glass and then we set up a metering truss to get the primary and secondary mirrors together and we ended up with a 25,000 pound system that only cost $2 billion and took a decade to develop. Then we launched it into orbit, and we were a little myopic. A little astigmatism didn't work too well. So we had to spend a half billion dollars to go fix the Hubble. This is a day and age when we understand adaptive control systems. This is a day and age when we understand new materials.

My challenge is—don't measure dollars going in to measure the vitality of NASA, measure the science that is coming out.

So here is the challenge, and we have all the people in the room that know how to do this, use laser beams for stiffness and not materials for stiffness. Think about a membrane that's adaptively controlled so you never have to check it out on the ground, and you launch it into space, you deploy the thing, and have just a floppy structure with a membrane for the collector, and this country could have the most unbelievable telescopes for a variety of applications. But it's simple, and part of the problem we had at NASA is we got so enamored in having organic programs, programs that took on a life of their own, that saving the programs was more important than answering fundamental questions. So organic programs are out and technology is in, and what we're doing is, we have a technology program that's baseline. We're going to have test launches through the new millennium program, so we'll design a little, build a little, test a little, design a little, build a little, test a little.

We now have renaissance in flight and our aeronautics program where we are building X-planes. We just rolled out an X-plane at McDonnell Douglas—two aircraft, piloted from the ground, $17 million—design, development, fabrication, and initial operations, 18 feet long, wing span 10 feet, no tail. Now, that's one heck of a plane for $17 million. So I challenge everyone: Get rid of your old habits, you don't need big bucks.

The problem we have, there is such resistance, and people hold on so long that they—and again I value my relationship with members of Congress—but every time a corporation goes to the U.S. Congress to protect jobs and dollars in their district, you take life out of the nation's space program, and you don't answer fundamental questions. And, I ask you to go home and search your soul tonight and look in the mirror and see if maybe, maybe one or two people in this room do this. We're going to fight to the end, door to door and street to street. We are not going to destroy America's space program to protect jobs. We're going to generate a future for this country, and that's the direction we are going in.

Now, I am very proud of the relationship that NASA has with our contractors and our scientists. And frustrated as I am, I am also happy. I'll give you a statistic. The General Accounting Office did a study of NASA in 1992, and the average cost growth on our programs was 77 percent. We were sinning real bad, along with the Congress and the administration, because we kept changing things, and we would never identify the requirements in the beginning. We are now having a 5 percent underrun, after we descoped all the programs and in almost all cases held the schedules. The only place we're missing schedules is where we had problems with a new series of launch vehicles, and we fell behind on a few, but other than that, schedules have either held constant or been accelerated. That is one heck of a record for American industry, American universities, and a government agency. We have Centers of Excellence at NASA. This is a very tough job.

The president asked us to cut our budget without canceling programs, and I am proud to say in the last few years we have just slashed the budget; we took it out of overhead and bureaucracy, and we didn't cut programs. But what have we done? We found that at each NASA center, good people, government employees had marketing teams that would stroll the halls of headquarters looking to start hot dog stands, scientific hot dog stands, and technology hot dog stands. This didn't add value, and they had their industrial counterparts walking side by side with them. They had the Chamber of Commerce supporting these activities; it takes life out of the program. Now we have some resistance, and I understand the human aspects of this, but America will never do the things I just talked about if all we do is protect scientific hot dog stands. We intend within the next few years to have no overlap within the NASA program. We had five centers doing similar things. We had five airfields with planes when we could operate with virtual presence on planes. We had five centers that were responsible for expendable launch vehicles. Fine, and good people are getting very concerned about their survival, but we all have to do is say we're here to support the American people. That survival is more important than anything else in our future. We had an imbalance in the space program.

In 1992, 49 percent of the budget went to human space flight, and about 30 percent went into aeronautics, technology, and science R&D. We are now at 39 percent for human space flight and 43 percent for aeronautics, technology, and science R&D. We're getting a shuttle with a much higher reliability, while we took the budget down and cut the percentage, and the budget came down. In 1989, on ascent, the shuttle had a 1 in 78 probability of not making it. Today it is 1 in 246, and it is going to continue to go up, and we're going to announce very soon a new investment program in shuttle reliability. That's how you get reliability, by designing it in, not inspecting it in. There is a very high concern that the shuttle is not going to be safe because we're changing it. You know people are saying, "If it ain't broke, don't fix it." The shuttle ain't fixed yet. And we're going to fix it even better. We intend to go from $10,000 a pound, where we are today, to $1,000 a pound in launch. This is a national priority. The budget came down; we reprogrammed a billion dollars; we didn't go whining back to Congress saying, "Hey, we want to start a new program, we need new money." We prioritized what we were doing, and we made a billion dollars available. There are RFP's (requests for proposal) out right now for the X-33 and the X-34. The X-33 will be about Mach 17, and the X-34 will be Mach 8. In May, we're going to fly the DC-XA with a whole host of new technologies in it. We'll get some data back, and we will not have to wait 10 years and spend 10 billion dollars and have an organic program. We had a goal of having spacecraft not cost $600 million a copy; today they cost $200 million a copy. We want them to cost tens of millions a copy at the turn of the century. We don't want them to take eight years like they took in '92 or four years like they take now. We want the cycle time to be one and a half years from design to launch. This is the direction we are going in.

Another thing we are proud of is we have converted 40 percent of our procurement budget, and we have taken NASA out of the role of being a system integrator. We have handed over to industry the Space Station. We're in the process of transitioning the shuttle, and I know people are worried. They say, "How could NASA get out of the business of operating the shuttle?" Well I ask you, with the wonderful aerospace industry we have in this country—control rooms are being built, launch centers are being built, spacecraft are being launched with a very high precision—how are we ever going to open the space frontier if the government does everything? How would you like to fly on American Airlines or United Airlines if the federal government operated it? Why are people so terrified of going to the finest aerospace companies in the world and asking them to operate the shuttle? We can't be afraid of change in America. I want to tell you, good people are worried about non-problems. I also want to say we're going to make the shuttle as safe as humanly possible, but you can't go to the frontier and get the rewards if you're not willing to take the risks and your stomachs are not strong enough for it. I cannot stand up here and guarantee you that the shuttle will fly without a problem. But I'm also confident that America is not going to shirk and get all hot and sweaty if we have a problem. We'll fly again very, very soon if we have a problem, and we'll make it better and better. But we can't be afraid of turning government functions over to industry. We have got to open the space frontier.

I also want to say we're going to make the shuttle as safe as humanly possible, but you can't go to the frontier and get the rewards if you're not willing to take the risks and your stomachs are not strong enough for it.

We had a bidders conference at NASA because we are getting out of the space operations business. We're getting out of the space information business, and we're going to bring in industry. We thought about 50 people would come, but more than 300 showed up. We're going to have a wild and crazy competition, and we're just going to get the government out of the operations business. All this adds up to about $4 to $5 billion a year out of a procurement budget that's $11.5 billion. I am very proud to get the government out of things it doesn't need to be doing and in the meantime strengthen American industry. The president has been very supportive of this.

We're downsizing NASA. We signed up to eliminate one-third of our work force and roughly half of these people are gone, without any forced NASA-wide layoffs so far. We're going to go from 25,000 employees to 17,000, give or take a few, and a total work force of 215,000 to 160,000. We are about half way there on the contractors. The amazing thing is, our productivity went up 40 percent. It's unbelievable; we started 30 new programs while we cut the budget 36 percent. We didn't do it alone; everybody in this room did it. We changed our attitudes; we changed the approach. So I am very, very optimistic about the future.

I am optimistic that together we're on the right path and I want to read something to you. I was on talk radio on Tuesday in Kansas City, Missouri. Someone called up and said, "Dan, have you ever been to the Linda Hall Library?," and I said, "No, I don't even know what the Linda Hall Library is." They said, "Do you realize the Linda Hall Library is the largest scientific library in America?" I said,"No." They said, "Why don't you go over there?" So I went over there and I met some fantastic people. I said, "Show me something really fun." So they took out a book for me. It had a deer skin cover, and the book was written by Nicholas Copernicus of Turin, printed in 1543—and these hands touched that book. It was unbelievable. Now Copernicus was exploring the unknown, and he wasn't trying to develop Tang and Velcro. He had unbelievable pain and suffering, as did Galileo, who followed him. And I touched Galileo's book also. Galileo took that book with him to his deathbed. Galileo had the courage to say that Copernicus was right. The Earth revolves around the sun; the sun does not revolve around the Earth. He had unbelievable pain and suffering. And the church absolved him just a few years ago. I hope it doesn't take that long for me. But in the book the publisher wrote—and it was really wild, I mean this is just a hundred years after they started printing books—the publisher said, buy this book, read it and enjoy. Thank you very much.

International Space Station and Space Launch Capabilities

Master Moderator: **Steve P. Scott**
Program Development Manager
Rockwell Space System Division

Session Chair: **Lon L. Rains**
Editor
SPACE NEWS

Speakers: **Prof. Ernesto Vallerani**
Chairman
Alenia Spazio, Italy

Dr. Alexander N. Kuznetsov
Deputy Director General
Russian Space Agency

William MacDonald "Mac" Evans
President
Canadian Space Agency

James P. Noblitt
Vice President & General Manager
Missiles & Space Division
Boeing Defense & Space Group

Michael W. Wynne
Vice President & General Manager
Space Systems
Lockheed Martin Astronautics

Thomas R. Rogers
President
Space Transportation Association

Mr. Scott: Lon Rains will be leading the afternoon's session on the International Space Station and Space Launch Capabilities. Lon is the editor of *Space News* and brings with him a broad knowledge of international space programs as well as an in depth understanding of current political and econmic issues. Lon, please come up to the stage. Ladies and gentlemen, please give a warm welcome for Mr. Lon Rains.

Mr. Rains: The topics of this afternoon's session cover two of the costliest activities in space: the International Space Station and space launch.

With political support in Europe and the United States now secure, the focus in the International Space Station program now shifts to getting the hardware built, launched, and assembled on time. Russians and Americans have had their bumps in the road this year—both in hardware development and in reaching an agreement on the amount of money to be paid to Russia and in getting that money transferred to the Russian organizations building the hardware.

The challenge facing all of the Space Station partners over the next several years is a big one, and I look forward to hearing our panelists discuss where things in the program stand now and how well they are positioned to fulfill their mission on time and on budget.

Space launch, which has always been the most expensive part of any space endeavor, is undergoing a period of profound change. Competition in the industry is growing, and as it does, the business is becoming increasingly international. Our panelists today will talk about the state of the industry today and where it is headed in the future.

Our first speaker is Professor Ernesto Vallerani, chairman of Alenia Spazio. He was the local project manager and later the technical director for the space lab program for Air Italia. He became the general director of the space sector in 1980 and was appointed to his current position in 1991.

Prof. Vallerani: Thank you very much. Ladies and gentleman, I would like to speak about the Space Station as an opportunity to expand space activities and explore its utilization. After several years gestation and quite a number of difficulties that have greatly modified its design, the International Space Station has passed the critical point in the decision process and now is finally facing the more technical difficulties that any space program has to suffer before the maiden injection into orbit.

The start of operations of such a complex system, which comprises the contribution of so many different countries, is undoubtedly going to mark a profound change in the way space activities will be conducted in orbit in the future.

We all know the controversy originated in the United States by a part of the scientific community against the realization of such a costly program; the debate has spread around the world, and in many cases fierce disputes have arisen.

The intention has been to make the Space Station the symbol of a "dividing element," with partisans in favor and others against. Not only have different concepts on how better to accomplish the scientific research in space have collided, but mainly interests of various nature have clashed. Notwithstanding that the echoes of such a battle are not yet fully softened, there is, at least with the exclusion of the most aggressive opposition, a widespread acceptance of the fact that the Space Station is going to be in short time a reality one has to live with, and the sooner its potential is understood the better.

The availability of a large, permanently manned space base in low-Earth orbit, designed to become a laboratory to conduct a large variety of experiments in the yet unknown space environment, will prove to be a very powerful tool to expand and to spring the research in different fields.

The utilization of the Space Station has the potential to stimulate the enlargement of research to different fields of activities not yet touched by the initiatives so far undertaken in space.

The number of hours during which working activities and scientific researches have been performed in orbit is still limited, even if largely increased over the last years, to draw any conclusive assessment of the real value of the potential of operating in the space environment.

Very encouraging results have been so far accumulated, and a number of promising perspectives are being unveiled; it is time now to engage systematic researches in different directions to be in the position, later on, to reap the reward.

A fundamental feature of the actual Space Station is its international nature; the presence of the Russians—in addition to the Europeans, Japanese, and Canadians—has rendered the approach more complete and really worldwide. The United States has maintained a position of leadership that is needed in any enterprise, especially of such dimensions, but the weight of the partners has increased, leading to a more balanced situation.

The enlargement of the number of countries involved in the construction of the International Space Station Alpha has introduced additional complexities in the design of the whole but has enlarged the commitment to utilize it to a wider community of scientists and researchers across the world.

The challenge of the Space Station is moving from its design and construction to its utilization; it is true that a lot has yet to be done, to come to the completion of its final configuration in orbit, but even more has to be conceived, planned, and definitively agreed upon on its utilization.

The Space Station represents an extremely engaging enterprise requiring commitments over long periods of time.

The front end of this endeavor is the design, development, and construction of the various elements forming the space base; of equal challenge and importance are its utilization that requires the mobilization of the scientific communities and of the advanced technology operators and its operations that implies a new integrated approach involving industrial capabilities and resources.

Italy, from the very early dialogues with which the U.S. government was opening in 1984, the possibility of participating to the allied countries, has demonstrated a strong and continuous interest in participating in the Space Station.

Participation, for us, has always meant a share of responsibility in providing elements at the level of hardware/software, that is to say, a participation in the construction of the Space Station. Our interest, from the very beginning, has gone beyond this point, having in mind the utilization and the operation of the Space Station as reflected in the NASA-ASI agreements.

Italian Contribution to the ISSA

For several years, the Italian government has had a positive attitude toward space activities, and our budgets have been progressively increasing, especially after the foundation of the Italian Space Agency in 1988.

Space has been, and is, considered important for many aspects: for the potential of the applications, such as telecommunication, Earth observation, and meteorology as well as for the scientific opportunities opened in different fields, and last, but not least, for the technological developments space activities require to be developed to accomplish complex missions successfully.

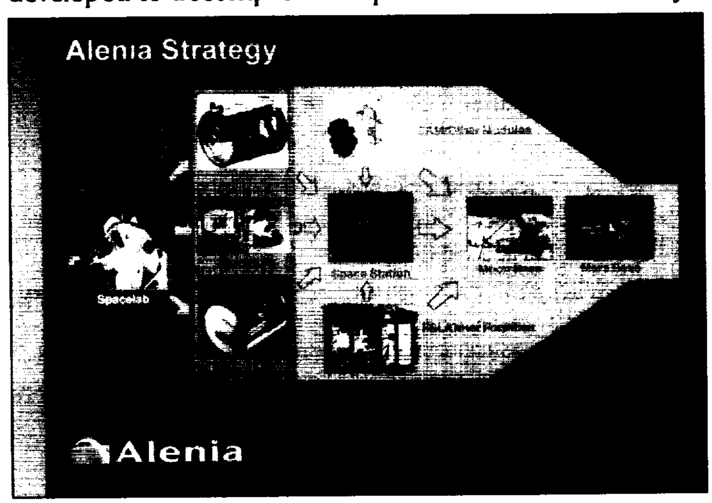


Fig. IS-101

It has been recognized that without a competent and solid industry, specifically dedicated to, and deeply specialized in, space activities, no real progress can be achieved and no benefit from the investment made can be sought, and the spinoff from space programs cannot be diffused to other fields.

For that reason, selected aeronautical and electronics industries have been favored in their specialization to become an integrated space industry, as has been the case of Alenia Spazio that has progressively grown from subsystem-level entities to a system-level industry with full capacities to design and construct complete sophisticated systems with the support of other specialized industries *[Fig. IS-101]*.

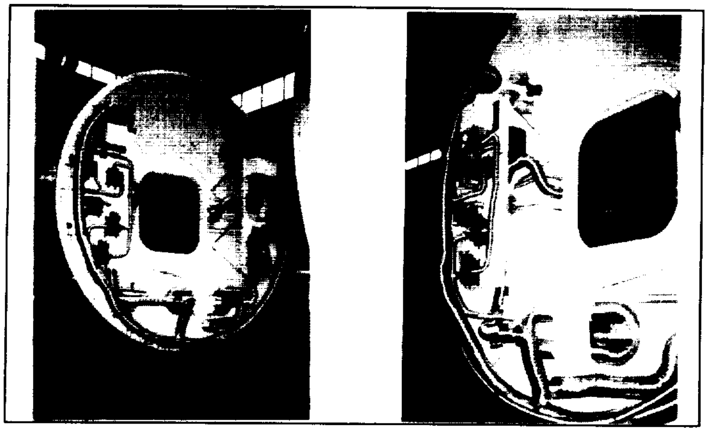


Fig. IS-102

A constant line in the strategy of our country in dealing with space matters has always been to favor "international cooperation."

Italy has supported the creation of the European Space Agency and has largely contributed to funding the European programs; in parallel, our government, recognizing the leading role of the United States in the space field, has favored, as much as possible, cooperation with the United States.

NASA and ASI, the Italian Space Agency, have enjoyed several bilateral cooperative programs, such as Tethered, Lageos, SAR X, and IRIS, that have strengthened the links between the two space agencies as well as the ones between the leading industries in the two countries.

The attention of our governments to capture the opportunities of participating in new challenging ventures, full of potential for the future developments, and the willingness to reinforce the spirit of cooperation with the United States have, since the early phases of the initiative, made Italy a strong supporter of the Space Station.

Our strategy of participation has materialized along two lines. Within Europe, Italy has been, together with Germany, very active in supporting the Columbus program, that, born as a bilateral German-Italian program, only successively was transferred to ESA to become the basis of the European contribution to the Space Station Freedom *[Fig. IS-102]*.

In addition to such an initiative, our country has conducted discussions and negotiations with the United States that have led to a memorandum of understanding between NASA and ASI, signed in December 1991, that has established a bilateral cooperation between USA and Italy through which Italy provides to NASA the pressurized logistic carriers named MPLM (mini pressurized logistics module) to serve the operation of the International Space Station Alpha *[Fig. IS-103]*.

In conjunction with the critical period our country has been experiencing in the last years, also

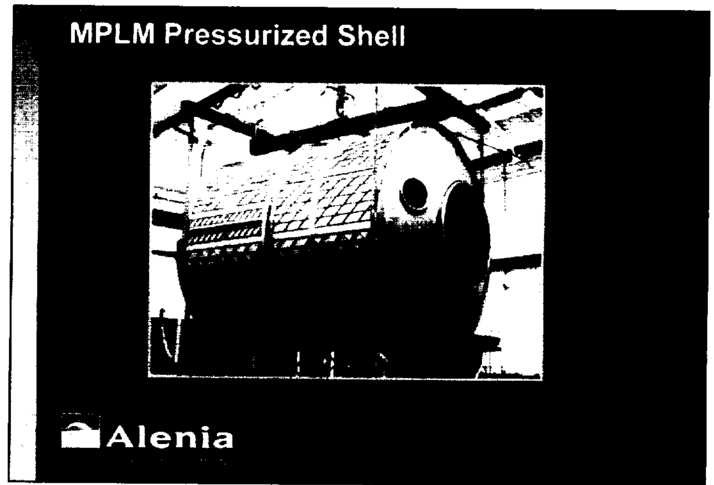


Fig. IS-103

the space activities have suffered not only from financial limitation but also, and even more, from the crisis which our space agency has been facing as a result of personal internal conflicts that frequently have had anything to do with the revision of the strategies that are by someone requested to happen.

The old dispute on the scientific utility and justification of the Space Station has been reopened, and an attempt has been made by few representatives—exponents of the scientific community—to raise the issue of blocking the continuation of our participation to the Space Station, proposing other programs considered more efficient to respond to their scientific interest and to the ones of industries excluded from the agreed and approved programs.

In view of the ministerial conference held in Toulouse in fall of 1995, these issues became very hot, but finally, as one could reasonably expect, the Italian government, through the voice of their minister of research, confirmed, even in presence of the financial limitations that are troubling almost all the countries, our support to the European programs and, in particular, to Columbus that was fixing definitively the European participation in the International Space Station Alpha.

Meantime, thanks especially to the action of our ministers of foreign affairs, continuity was ensured to the bilateral cooperation between NASA and ASI, and the full line of involvement in the cooperation effort in support of the Space Station was maintained and confirmed.

The aftereffects of the polemics are fading, even if the results of the "Commission of Five," established by the minister to provide elements on the strategy for future space activities, have turned out not favorable to the Space Station and its utilization.

Recently, at the end of March, ESA signed with DASA-RI, the prime contractor of the Columbus Orbiting Facility program, the contract for the execution of the C/D Phases, finally authorizing the

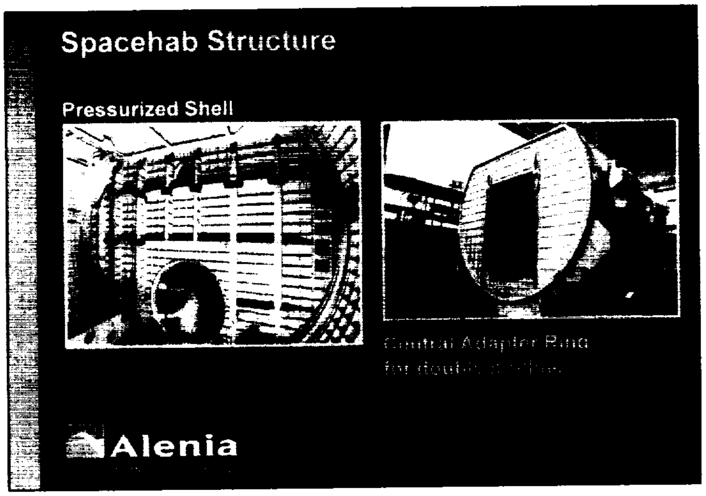


Fig. IS-104

go-ahead on the construction of the flight hardware. Meanwhile, Spazio Alenia is progressing with the final discussion with ASI to obtain the contractual coverage for the completion of the MPLM program.

The activities on the logistic modules are well in progress, and ASI, with our support, has actively participated the last week of March, to the NASA IDR 2A held in Houston.

In our facility in Turin, the construction of the first full module of the engineering unit has been recently completed. The complex welding of the various panels of the outer shell has been performed with extreme success, after the process was qualified through a comprehensive set of tests on parts representatives of the various configuration.

The design activities are progressing as well to match the planned delivery of the first flight unit in March '98, in order to satisfy the December '98 date for the first flight. From there on, the Italian logistic modules will serve the Space Station in its construction phases and, later on, will be used to support the operation of the ISSA.

It has to be understood that the three MPLM modules provided by ASI to NASA are the only pressurized carriers foreseen to fly on board the orbiter to be utilized to service the International Space Station.

The Italian pressurized logistic modules will be used to transport supplies and materials, including user experiments of mass up to about 10 tons; they are designed to provide two major features simultaneously: logistic carrier supporting passive as well as active, capable of being flown numerous times, and elements providing habitable work space to allow operation in orbit.

The high level of involvement of Italy in the ISSA program, as briefly outlined and recalled, is clearly the demonstration of the conviction that the Space Station is seen by us as an extraordinary opportunity to expand space activities.

Not only has the government been investing in the Columbus and MPLM programs supporting ISSA, but industry, at least our industry that has for long time supported these initiatives also when lacking complete funding of the activities in progress, has also invested in production facilities and tools as well as in technological developments to maintain and improve our position as leader in Europe in the design and construction of pressurized manned modules.

Our conviction that the Space Station is going to represent a fundamental step in the enlargement of space activities worldwide has led us to engage ourselves, as much as possible in every venture linked somehow to its operation and development. An example, dating back several years, is the fundamental role our company has had in the development of Spacehab *[Fig. IS-104]* that now is successfully flying on board the orbiter in its mission to MIR.

In the expectation that once operative the station will prove capable of further growth, we are continuously searching for opportunities to support such potential.

In the last months, we have been engaged in proposals to offer to NASA derivatives from our basic logistic module to serve as housing of the centrifuge that is needed to expand the research capabilities of the existing ISSA in the growing field of life sciences.

Our attention is as well focused on what are called space facilities, that is to say sophisticated equipment designed to serve a large community of users providing them with the efficient means to perform their experiments in space.

Space Station is quite a powerful laboratory, offering a large amount of valuable resources to the users; it is equipped with a variety of facilities to operate different types of researches and activities, but, for sure, once in operation it will require the development of many more of such facilities like furnaces, incubators, dedicated laboratories, and specialized equipment.

Alenia Spazio has been working for several years in this field, developing for ESA the autonomous fluid physics module (AFPM) and the bubble, drop, and particle unit (BDPU) specifically dedicated to experiments in fluid physics that have successfully flown, respectively, on the Spacelab D2 mission (April 1993) and on the Spacelab IML-2 mission (July 1994).

Alenia Spazio is the candidate prime contractor for the fluid science laboratory (FSL), reconfigurable, multi-use equipment to carry out numerous different fluid sciences experiments as part of the ESA's microgravity program, to be launched with COF in the year 2002.

In addition to these activities performed on agency contracts, we are evaluating the opportunities to develop specialized space facilities to be offered to the future users of the Space Station.

If private capital has to be invested in space activities to prepare for an expansion of the sector, we believe this could be a promising area of high potential due to the positive effects it could have on the expansion of the Space Station utilization, in general for scientific, but also technological, purposes.

Another outstanding opportunity to expand space activities beyond the area of design and construction of flight hardware is offered to industries by the need to ensure the Space Station all the services that are required to support, maintain, and operate it in orbit.

As part of these activities to be conducted on ground, Italy is also engaged in the construction and implementation of an ASI center located in Turin, called ALTEC (ASI Logistic Technological Engineering Center), aimed at supporting the Italian and European utilization of ISSA by providing engineering logistic and payload integration services.

Alenia Spazio is the leading industrial contractor for the development and, later on, for the operations of such a center. The center is already operative and has supported with success the Euromir 95 mission, in particular the three Italian experiments (T2, Verification Approach for Microbial Contamination; T4, Human Posture Experiment; and T7, Robotic Experiment).

Perspectives of Expanded Utilization

The many studies on Space Station and its utilization, the first dating back nearly 30 years, were targeted at identifying as many as possible fields of utilization of the permanently manned space outposts and promising areas that would justify the large investments expected to be made to develop the Space Station.

There was a time when electrophoresis, protein growth, crystal formation were identified as potentials to generate the "none product" of extreme value that by itself would have justified the return of investment on the Space Station.

Too much expectation was raised for such types of activities with strong commercial implications that, with only limited research background, would have immediately achieved striking results; we too often tend to forget that the amount of time dedicated to conduct research activities in space is quite limited and that a large number of different initiatives have surfaced without having the real opportunity to explore in depth the potential of each single research.

The decision to embark into the development of the Space Station was taken in the United States without proof that its utilization would have led easily to definitive positive results; the same happened when Europe and the other countries like Japan and Canada decided to join. This attitude is absolutely correct; the Space Station is destined to become a multi-purpose, multi-discipline laboratory, able to operate in space for several years. It is a unique opportunity for research, in whatever field, to be conducted in the new environment typical of low-Earth orbits; unique point of view of our Earth as a whole; unique point of view of the universe free from contamination of Earth's atmosphere; unique point of experimentation of the absolutely new effects of microgravity; and last, but not least, unique opportunity to verify and to develop new technologies to be applied in the design and construction of the next generation of spacecraft.

The presence of man on board makes the difference with respect to what can be done with other space systems. The long duration of the mission and the unique factor that we can recover facilities, payloads as well as the products of the research introduces unprecedented possibilities and offers unique possibilities.

Being afraid to be asked, as it is said, "to pay the bill," a number of scientists of disciplines for which the Space Station does not offer a unique possibility, instead of orienting new researches on the exploitation of the Space Station potential preferred to continue to utilize, in a conventional way, smaller satellites and payloads for which they are convinced they are in the position to control better.

The presence of man on board makes the difference with respect to what can be done with other space systems.

Meantime, also the military interest has largely been diminished, and the delays introduced by the Challenger accident have discouraged the few commercial enterprises so that, at the end, the Space Station utilization was largely identified only with microgravity research in the fields of life sciences and material sciences.

It is time now to give vigorous support to an enlargement of the disciplines to achieve wider interests in Space Station utilization from different research communities, the scientific as well as the technological ones.

Now that the space agencies have secured the development of the various elements of the ISSA and that industries are all at work to meet the schedules of the delivery of the many parts that will finally match into the gigantic mosaic of the flying configuration, all attention is moving toward the utilization more emphatically than in the past.

As said, in its long design evolution the Space Station was always intended to be a manned orbiting laboratory for microgravity research, other disciplines being considered to the extent compatible with such a primary focus.

Although the various utilization studies so far undertaken by the involved space agencies have originated already different application concepts, only recently have areas other than microgravity gained greater attention and weight in the utilization scenario.

The evolution can be seen as a result, among other factors, of the changes in orbital characteristics and crew size that the new station has undergone.

The ISSA's orbital inclination—planned today to be 51.6 degrees, instead of the 28.5 of the Space Station Freedom, and its altitude being lowered from 500 kilometers to about 400 kilometers—make the station more attractive for disciplines such as Earth observation, remote sensing, atmospheric and ionospheric physics, and communication applications.

The reduction of the crew size from eight to six astronauts, in the fully operational phase, has favored payloads with a higher degree of autonomy and has enlarged the potential of robotized applications and of tele-science.

The Space Station redesign efforts have thus resulted in a sharper definition of the orbital complex capabilities and constraints and have prompted a reassessment of its utilization. As a consequence, though microgravity research still gets the lion's share, other areas, such as technology development and testing, remote sensing, and communications, have been included in payload increments at an increasing rate.

Indeed, the very characteristics of the ISSA complex make it an ideal outpost for those remote sensing and communications applications which require neither extreme ground coverage nor extremely accurate pointing, but which definitely benefit from ground track and orbital condition repetitions.

The prospect of enlarging interest to utilize the Space Station for different purposes seems to exist and to be slowly but steadily developing.

Furthermore, remote sensing and telecommunications applications operate over long time periods with minimal crew involvement, a bonus in the station's crew-tight operational framework. Communication and remote sensing equipment also takes up resources mostly at unpressurized locations and has moderate requirements that can be scheduled.

Mainly for historical reasons, the Earth observation and communications communities have only recently been involved in Space Station utilization promotion efforts, and, consequently, some catch-up activities are planned to review the potential applicability of payload elements being developed or envisaged in the EOB and COM fields to the ISSA scenario.

Laser interference and scattering instruments as well as radar for atmospheric (wind and rain) monitoring or for geodesy represent typical items matching, at first inspection, the ISSA constraints, as do instruments for atmospheric composition studies using optical or radio signal absorption by the Earth limb and optical communications systems.

It is worth pointing out that interference-based instruments accommodated on board the ISSA complex, as well as communications technology (e.g., laser- based, both transmitter and receiver) ones, would definitely benefit from the simultaneous presence on orbit of other free-flying platforms with similar instruments, e.g., the Envisat platform. Other systems, such as tether-based ones, may test alternate transportation, attitude control, and rendezvous and communications (ELF/ULF) techniques and, possibly, support station operations.

They would also levy very moderate, if any, resupply requirements on the ISSA logistic (i.e., transportation) system and would most likely not perturb the station's dynamical environment in the bandwidth relevant to microgravity investigations due to their small masses.

While the outcome of the assessments being carried out by the respective user communities and by the relevant agencies needs to be awaited before more detailed payload increment definitions can include EOB and COM payload elements, the relevance of ISSA for non-microgravity related, and for Earth observation and communications in particular, cannot be overstated, as the typical instruments adopted by these disciplines are usually well-suited for long duration, high orbital inclination space missions, with low crew involvement, reduced logistics, and moderate resource requirements.

The prospect of enlarging interest to utilize the Space Station for different purposes seems to exist and to be slowly but steadily developing.

We can notice more easily what is happening in Italy; several years ago, immediately before the Challenger tragedy, we performed a wide spectrum survey of the potential interests of the Italian scientific community and of the national research centers as well as of the high-tech industries, collecting a largely positive response.

The delays in the recovery of the flight opportunities and the continuous postponements of the Space Station operation have discouraged all the interested people so that up to some time ago there seemed that only very few were maintaining their interests.

Today, as the time when the station will be orbited draws near, and also due to the revitalization of the utilization programs in ESA, we can detect a rather favorable situation: At least 12 organizations in Italy are

ITALIAN SCIENTIFIC ORGANIZATIONS INTERESTED IN ISSA UTILIZATION	
MARS, Microgravity Advanced Research Centre, Napoli	Main field of interest: Fluid Science Focal point: Prof. R. Montil
IFCAM, Italian Research Council Genova	Main field of interest: Material Science Focal point: Dr. A. Passerone
Science Park S. Raffaele/DIBIT Milano	Main field of interest: Human Physiology/Biotechnology Focal point: Prof. P.C. Marchisio
Astronomical Observatory of Turin	Main field of interest: Solar Physics Focal point: Prof. E. Antonucci
University of Naples, Department of Engineering Services	Main field of interest: Earth Observation Focal point: Prof. S. Vetrella
University of Genoa, Department of Earth Sciences	Main field of interest: Crystal Growth Focal point: Prof. R. Bedarida
University of Rome, Department of Medicine/INRCA	Main field of interest: Human Physiology Focal point: Dott. F. Strollo
University of Rome, School of Aerospace Medicine	Main field of interest: Human Physiology Cardiology Focal point: Prof. A. Scano
Italian Research Council/MASPEC, Parma	Main field of interest: Material Processing Focal point: Dott. L. Zanotti
University of Udine, Department of Medicine	Main field of interest: Human Physiology/Biomechanics Focal point: Prof. Di Prampero
Polytechnic of Milan, Centre of Bioengineering	Main field of interest: Human Physiology/Biomechanics Focal point: Prof. A. Pedotti
University of Perugia, Department of Hygiene	Main field of interest: Biology/Contamination Focal point: Prof. M. Pitzurra
CARSO, Centre for Advanced Research in Space Optics, Trieste	Main field of interest: Astrophysics Focal point: Prof. R. Stalio

demonstrating sincere and definitive interest in the ISSA utilization *(see table above)*.

We expect that in a short time ASI will again take the initiative to give vigorous support in Italy to the utilization of the Space Station.

At this time we believe the Italians are in a quite favorable position: it must be recalled that as part of the NASA/ASI memorandum of understanding, Italy will receive from NASA free access to the Space Station for its utilization as a counterpart for the supply of the three mini pressurized logistic modules.

The wording of the agreement, under revision now to take into account the new situation after the extension of participation to the Russians, speaks of percentage of racks allocation, of external parts, of power, of crew time available for the Italian users.

These valuable possibilities, that some in our scientific community seem not to have fully appreciated—once properly advertised and transformed into real research plans—are going to stimulate vigorously, we believe, the research activities in our country in several fields.

Some indications of interest, also from the more advanced industries, seem to be coming to the surface; recently the Ferrari car manufacturer has indicated its intention to conduct experiments on board the station. We hope that many more will demonstrate their interest for such a type of research; in particular, the space companies themselves surprisingly have not yet fully evaluated the potential of utilizing the Space Station as a laboratory for their technologies and product developments. Several changes can be foreseen once we all will have available a fully operative laboratory in space.

Utilization of the Space Station

In past years, space programs have progressively become a test for international cooperation; the activities of ESA in Europe are by far the most eloquent example of how up to 13 countries have joined resources to achieve common goals. On the U.S. side, cooperation with different countries has been going on for many years and has given quite positive results. SpaceLab, the European laboratory that has flown 13 times so far on board the orbiter, is a remarkable demonstration that coordinated development of synergic flight products provide benefit on both sides.

At a national level, we just mentioned the relevance that cooperation with the United States has had for Italy and is having to support our space programs. Now we have in front of us the International Space Station Alpha, the most spectacular example of international cooperation. Americans and Russians are working together to build the largest space complex ever conceived, and Europeans, Japanese, and Canadians are part of the same team, providing their invaluable contribution to form a "unicorn" that for years will remain the symbol of a joint effort encompassing three continents and involving all the most advanced and technologically powerful countries in the world.

Let's not debate the way in which such cooperation has evolved and the reasons that have supported it; maybe we would discover that rather than a true willingness to join efforts in such an enterprise the driving factor was the need to share the investments and the risks. In any case, here we are, with such a complex structure of agreements and such a difficult mosaic of contribution, let's appreciate the final result that is quite remarkable: We will have the Space Station and the beginning of the new millennium.

The problem now is how the Space Station will be operated and maintained in orbit for its life, which is expected to last 20 or more years. The real cost to operate such an orbital complex will be one of the major, if not the major, factors affecting the success of its utilization.

Starting from the U.S. government, which does have the largest involvement, new schemes are being discussed. The so-called industrialization of the Space Station operations and logistics is going to open extremely interesting and challenging opportunities in new type of activities. After having developed the hardware and software needed to construct the international complex, industries must face, in the near future, the problem to offer services in support of the Space Station operations.

The station's international nature requires that a selected team of aerospace industries make a large integrated cooperative effort to offer a viable solution that will satisfy the requirements and needs of the involved space agencies and nations.

Initial contacts are being made to this extent among industries to prepare such undertakings that will have a fundamental impact on the equilibriums of the leading industrial entities all over the world.

In order to prepare the advent of the Space Station properly and to exploit its full potential, a plan for its utilization has to be elaborated. A strategy of utilization needs to be conceived and agreed upon in due time; that means several years before the utilization comes to action.

The complexity of the problem and the fact that a large number of actors are involved require that right now a highly coordinated effort has to be initiated by NASA and the other space agencies to mature the required solutions.

This problem, of course, is well evident to the responsibilities of the various organizations in charge of preparing these plans. In different countries, with different levels of maturity, activities are going on at all levels, from the competent authorities and agencies to the leading research centers, down to the single researchers.

The not too frequent opportunities to fly experiments on board Spacelab or Spacehab, and now on MIR, are used to advance research activities and to prepare for the oncoming Space Station era.

Some form of coordination exists between the activities performed and in progress or under study in the various interested countries. What we are afraid is not sufficiently developed is a common strategy to jointly plan the future utilization.

We must not forget that in a few months time the amount of payloads that can be operated on board of the ISSA will correspond, more or less, to all the payloads flown before on board the shuttle. In order to plan for such large possibilities, there is the absolute need to consider the utilization of the Space Station, the next large international cooperative enterprise that is going to last for a minimum of 20 years and, hopefully, more.

The planning, coordination, and control of such a complex of activities that entail quite a variety of different interests is a continuous effort to be made by a competent independent entity that has the power delegated by the governments to overrule the single tendencies.

An international super agency can be the answer to such a problem that seems to be, if not unsolvable, or at least very hard to solve.

The strategy for the partnership and for the promotion of non-partner utilization of the International Space Station, has been proposed as an argument of discussion in the international workshop dealing with "International Space Cooperation: From Recommendation to Actions" that the AIAA (American Institute of Aeronautics and Astronautics) and CEAS (Confederation of European Aerospace Societies) are organizing next May at the ESA facility of ESRIN in Frascati, close to Rome in Italy. If not solutions, we expect at least interesting discussions on this topic of vital importance to plan the strategy of utilization of the Space Station properly.

To build, to operate, and to utilize the International Space Station Alpha is the challenge of the many countries that have agreed to support this unique program. The availability of the Space Station is going to change the future of space activities the world over when, at the beginning of the new century, such permanent assembly of manned laboratories, continuously attended by expert researchers, will be orbiting. It will impose a new trend in how research and experimentation in different fields are done, like it or not.

Mr. Rains: Our next speaker is Dr. Alexander Kuznetsov. He's a member of the Board of the Russian Space Agency and the director of the Space Agency's department responsible for development and production of launch vehicles and rocket engines for Russian non-military space programs. Dr. Kuznetsov's department is also responsible for operating the facilities at the Baikonur space complex which had been turned over to the Russian Space Agency. His department also is responsible for maintaining ground facilities used for testing space equipment. Let's welcome Dr. Kuznetsov.

Editor's note: This presentation was titled Organization of Space Activities and International Space Projects in Russia, *by Alexander Kuznetsov.*

Dr. Kuznetsov: In my presentation, I would like to describe the structure of Russian Federal executive bodies responsible for space activities in Russia, as well as existing regulations for foreign economic activity in the area of space.

The Russian Space Agency was established by a decree of the president of the Russian Federation in

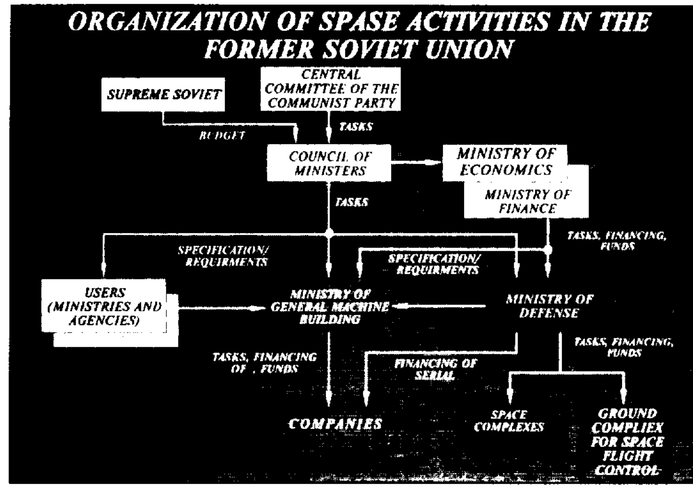


Fig. IS-201

February 1992, shortly after the disintegration of the former Soviet Union.

In the former Soviet Union, the creation of space technology was the responsibility of the Ministry of General Machinery, which had within its purview practically all the design bureaus and production facilities working in the area of space *[Fig. IS-201]*.

All of the government funds allocated for the development of space technology (both military and non-military), as well as rocket technology, were given to the Ministry of General Machinery. The ministry then used this money to finance all of the research and development programs carried out in the country. The Ministry of Defense of the USSR issued specifications and requirements for space systems and complexes which were developed for it , and participated in their testing. As far as non-military users of information obtained from space, such as the Academy of Sciences, Ministry of Communications, State Committees for Hydrometeorology, Mapping, and others, they were only informed of the parameters of space systems under development. Later such organizations received information from space systems, which they used for their purposes.

In the Soviet Union, operation of all space facilities (for both military and non-military purposes), as well as acquisition of space technology was carried out by the Ministry of Defense of the USSR, which had within its purview all spaceports, and ground facilities for space flight control.

Under such organization, non-military space technology received only leftovers from the country's space budget. Moreover, nobody even calculated the money assigned for non-military space programs.

In the last years of the USSR existence, an attempt was made to increase the role of the users by allocating them some space budget money to pay for R&D. At that time the Users' Ministries and Agencies became responsible for the development of space

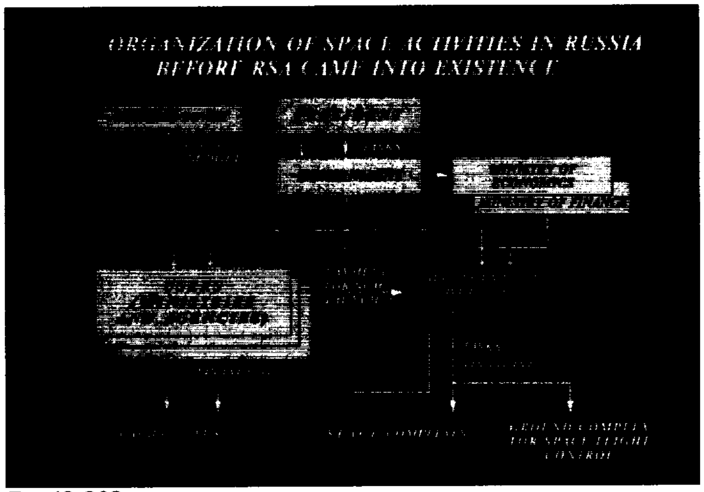


Fig. IS-202

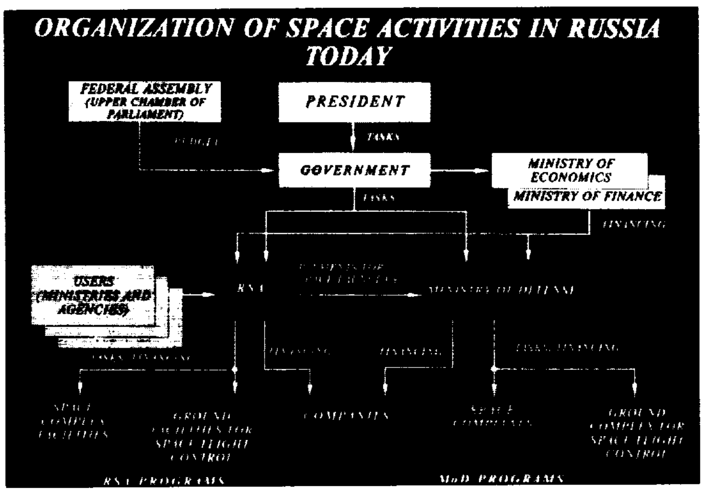


Fig. IS-203

technology for non-military application *[Fig. IS-202]*. However these ministries and agencies did not have qualified professionals capable of placing purchase orders, or controlling even satellite development programs—to say nothing of launch vehicle production or launch site operation. By that time the defense budget had been much reduced, and the amount of space technology purchased by the Ministry of Defense had dropped considerably. As an example, in 1992, production of the Soyuz vehicle—the main launcher of non-military satellites—was completely stopped.

In 1992, the government of Russia formed a commission headed by Yegor Gaidar, who was then prime minister, to evaluate the situation of Russian cosmonautics. The commission included leading scientists, designers, representatives of Russian ministries and agencies interested in the results of space activities. As a result of this effort, a decree was signed by the president of Russia which established the Russian Space Agency, and Yuri Koptev was appointed as its general director. The decree also defined the Russian Space Agency's purpose and objectives as follows:

- Carry out government policy in space exploration and use.
- Develop Russian Federal Space Program
- Operate as main customer of space systems and space complexes, as well as facilities used for science and national economy
- Provide coordination and support to commercial space projects.
- Cooperate with appropriate agencies in CIS and other countries in exploration and use of space.

The main purpose in establishing the Russian Space Agency was to divide non-military and military space budgets, and to have a government structure that would manage all the activates related to space exploration and peaceful use of space *[Fig. IS-203]*.

In 1993, main objectives of the agency were written down in the Russian Federation Law on Space Activity.

Today, the Russian Space Agency has the following structure *[Fig. IS-204]*:

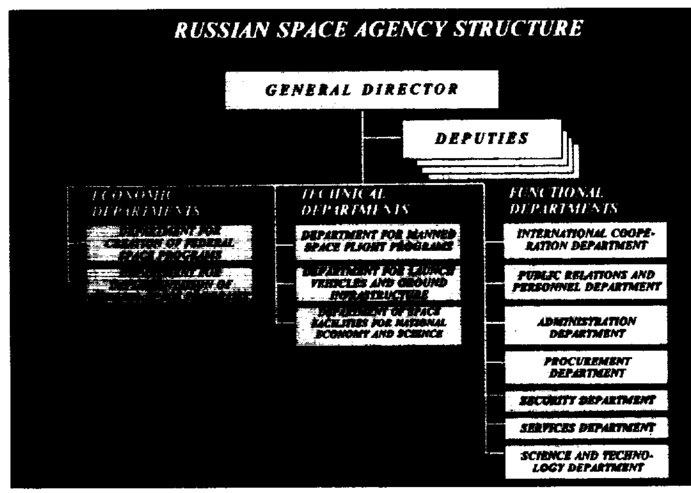


Fig. IS-204

Economic Departments

- Department for Creation of Federal Space Programs

  (Forms the agency budget and develops plans for the future)

- Department for Implementation of Federal Space Programs

  (Is in charge of financing of current contracts)

Technical Departments are responsible for signing and implementation of contracts (for R&D or for acquisition of space equipment), for coordination of the activities of companies working in space industry, and for operation of ground facilities in their specific areas.

Technical Departments

- Department for Manned Space Flight Programs

- Department for Launch Vehicles and Supporting Infrastructure
- Department of Space Facilities for National Economy and Science

Support Departments.

As a result of restructuring, in 1995 the Russian Space Agency took over the control of the following assets: part of the Baikonur Space Complex (which accounts for about 60 percent of Baikonur total value); three ships of the space flight control, trajectory measurement and telemetry complex; cosmonauts training center.

The biggest challenge was to maintain the required level of Baikonur operation (especially very active operation of the Soyuz vehicle) in the conditions when military professionals were being replaced with civilians. However, we have coped with that task successfully. Thus, at the latest launch of Soyuz the ground team included 70 percent of professionals from industry *[Fig. IS-205]*.

Transfer of the Baikonur facilities to Russian Space Agency has given us guarantees for fulfillment of our international commitments. All Russian manned missions are accomplished only with use of facilities which are in our purview. Likewise, pre-launch operations for the Proton and Soyuz vehicles to put into orbit foreign payloads will also be done at the Russian Space Agency facilities.

The Russian Space Agency coordinates the work of 42 research institutes, design bureaus, and production plants.

It should be mentioned that the relations our agency has established with industrial companies are absolutely different from those they used to have with the Ministry of General Machinery, in the times of the Soviet Union.

In those times, industrial enterprises fully depended on ministries in all issues, such as production plans, levels of salaries, finance, and other funds. All materials and equipment were distributed by ministries; directors of enterprises were appointed by ministries, and so on.

This situation has changed. Now the Russian Space Agency has contractual relations with Russian companies. That is, it contracts them for development, production, and other work as required by the Federal Space Program. According to Russian laws, interference into company operations is not acceptable.

Now a few words about the attitude of the Russian Space Agency to the privatization of space industries. We are not trying to expedite this process, although we are not against it. Those company directors who have realistic plans for cost reduction and attracting additional investments after privatization will always enjoy our support. Among Russian companies which have recently completed their privatization documents are Energomash, Moscow Electromechanical Equipment Plant, Motor Design Bureau, and others. Gaining more independence is good primarily for large companies with high level of diversification embracing space and non-space products. In the long run, RSA should retain several government research institutes and design bureaus that would provide expert evaluation of space projects, and do research and development in key areas of space technology.

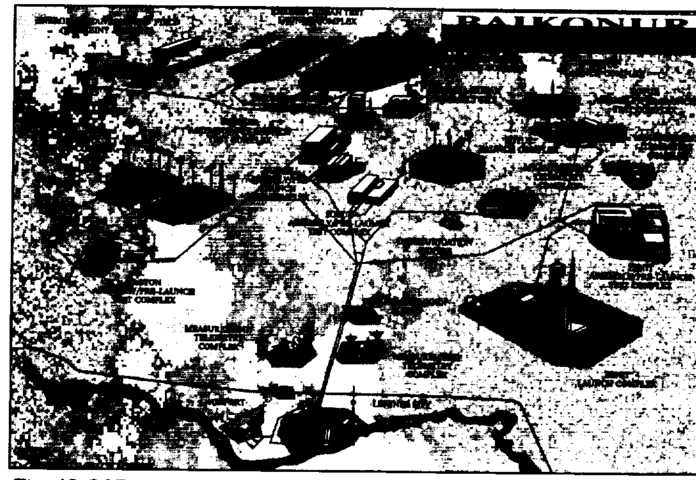


Fig. IS-205

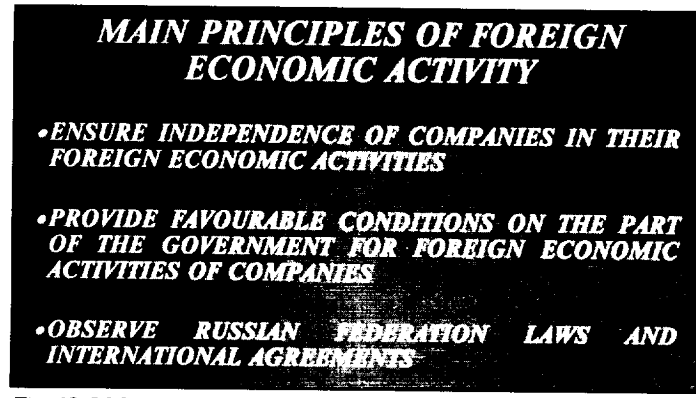


Fig. IS-206

Space industry companies also enjoy complete freedom in their foreign economic operations *[Fig. IS-206]*. The role of the Russian Space Agency consists of creating favorable conditions for their cooperation with foreign partners. As a rule, we act as guarantors in large-scale commercial projects. In addition, we make available for them our ground test stands, and space complexes. We also ensure quality control and reliability control during the manufacturing of space equipment to be used for commercial space projects.

Russia participates in the Regime of Control over Proliferation of Rocket Technologies. In this connection, Russian laws establish certain export control procedures for space technologies and equipment

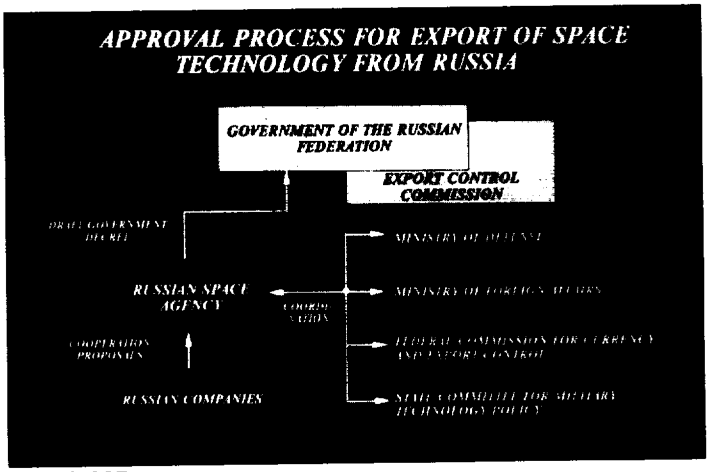


Fig. IS-207

coming under this regime *[Fig. IS-207]*.

I will not talk about the development and sales of weapons and munitions, as this is beyond the RSA competence. I will only address procedures established for international cooperation for peaceful use of space.

RSA reviews proposals submitted by Russian companies, prepares drafts of Russian Government Decrees and sends them to appropriate ministries for coordination and approval. The MoD evaluates projects and concludes that the project does not involve development or sales of weapons. In such cases, coordination with the Government Committee for Military Technology Policy (responsible for weapons trade) is not, as a rule, required. Russian Federal Commission for Currency and Export Control sees to it that the project agrees with Russian national laws for control over proliferation of rocket technologies. Ministry of Foreign Affairs verifies that the project agrees with Russia's international obligations. After all of these approvals are granted, the project is reviewed and approved by the Government Commission for Export Control, chaired by Oleg Soskovets, First Deputy to the Prime Minister of Russia.

We have gone through the above procedure twice in connection with one of the largest commercial projects between Russia and the United States in the area of space technology—the one dealing with joint development and production of the RD-180 rocket engine by Pratt & Whitney and NPO Energomash. In May 1994, the Russian government signed a decree approving deliveries of the RD-180 engines to the United States for launching commercial payloads. Later, Lockheed Martin came with proposals to use this engine in the EELV program which require the use of the engine for launching U.S. government payloads. In this connection, it became necessary to form a U.S./Russian joint venture and eventually establish production in the U.S. The Russian Space Agency has worked these proposals with Russian Ministry of Defense, and other Russian agencies, and finally submitted a draft decree to the Russian Government. The

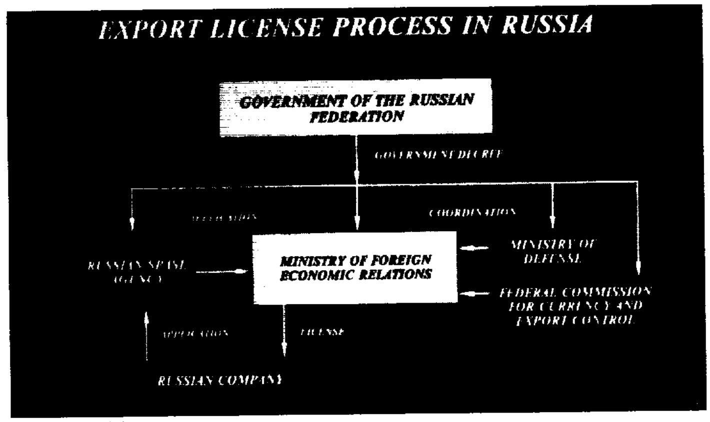


Fig. IS-208

decree was signed by Russian Prime Minister Victor Chernomyrdin on March 25. This document provides the legal basis required for the implementation of the RD-180 development project.

Delivery of data, (such as research, design, or manufacturing data), as well as delivery of space equipment (engines and other products) require a license from the Russian Ministry of Foreign Economic Relations [Fig. IS-208]. Such a license is granted based on an application which Russian Space Agency submits to that ministry after approval by the Ministry of Defense and Federal Commission for Currency and Export Control.

Once again I would like to emphasize that the above procedures are established for commercial projects in the area of space, that is, those which do not involve the development or sales of weapons.

Weapons trade in Russia is under strict government control. All of it is carried out through the government company named Rosvooruzhenije. In this case, license is granted by the Russian Government Committee for Military Technology Policy.

I have gone into that much detail describing the functions of the Russian Space Agency, export license procedures, and the role of Russian government organizations, because most of the questions asked by our foreign partners pertain to these areas. I hope my presentation has offered you a clear picture of the organization of space activities in the Russian Federation.

Mr. Rains: Our next speaker is Mac Evans, president of the Canadian Space Agency. He has worked in the Canadian Space Program for more than 22 years and led the Canadian team that negotiated the Space Station Inter-Governmental Agreement and Memorandum of Understanding in 1984. Mac Evans.

Mr. Evans: Thank you very much. It is indeed a pleasure to be here at this symposium to talk about the Space Station Program. Particularly since I am one of a handful of people who helped give birth to this program more than 14 years ago, and one of the few who are still on the Program. It gives me great pleasure to be here to show you some of the concrete results that have been attained in recent years, particularly in the Canadian Program.

This is a view of the Space Station which many of you have seen *[Fig. IS-301]*. You all know that the International Space Station is the largest international research program ever undertaken by mankind. Thirteen countries are participating: but only the United States, Russia, and Canada are providing infrastructures. What I want to do is show you where the Canadian contribution is located, and it's the Mobile Servicing System, shown here in a semi-deployed mode attached to the mobile transporter which allows the robotic device to travel up and down the trunk structure to perform its assembly and maintenance tasks.

Canada's role in Space Station is to provide the robotics and to be the predominant player in use of these robotics for the assembly and maintenance of the Space Station. Our contribution consists of a large robotic arm, which we call the SSRMS, the Space Station Remote Manipulator System *[Fig. IS-302]*, to distinguish it from the Shuttle Remote Manipulator system or Canadarm. In fact, both these devices, the SSRMS and the Canadarm located in the shuttle, will have to work cooperatively in the assembly of the Space Station. This robotic arm is 17 meters long or roughly 51 feet. Unlike Canadarm, this robotic device is designed to be repaired in space, and so it consists of a number of ORUs, or Orbital Replacement Units. The unique feature of the arm is its double ended nature; if you look at both ends of the arm you'll see that they are identical. This allows the arm to be able to walk about the Space Station as it grapples onto one fixture and lets go of another—it is able to inch worm its way along. So a key technological feature of this arm is its duality and the latching-end-effector which makes this possible.

I'd like to now show you a few pictures of actual flight hardware and you eill see that we are quite a ways along in our program. Here you see some of the booms that form the robotic arm *[Fig. IS-303]*. These are flight booms undergoing tests at a facility in Ottawa. We're actually building flight hardware. Here we see another piece of flight equipment *[Fig. IS-304]*. This is the yaw joint, and you can see located on the other side of the yaw joint the electronic boxes that are used to control it.

I mentioned earlier that the latching-end-effector is perhaps the most complicated and sophisticated mechanical unit on the arm, and this is a picture of the flight unit *[Fig. IS-305]*. It's this latching-end-effector which will allow the arm to grapple onto the power and data grapple fixtures that are located around the

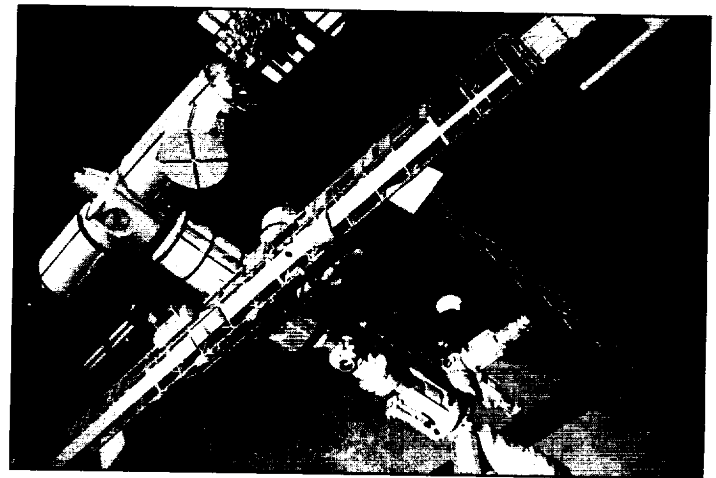


Fig. IS-301

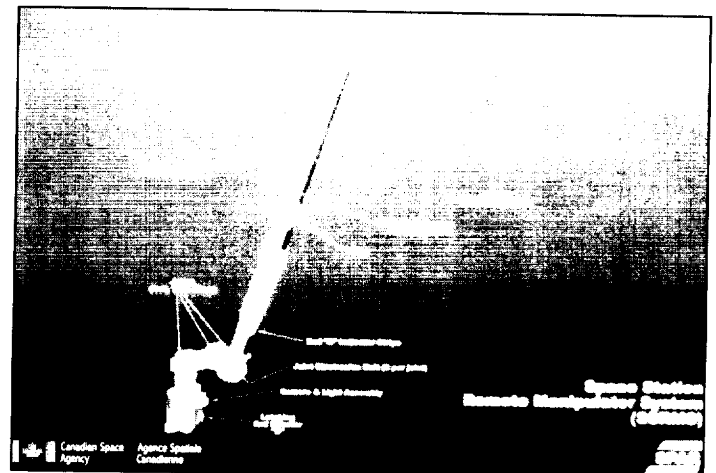


Fig. IS-302

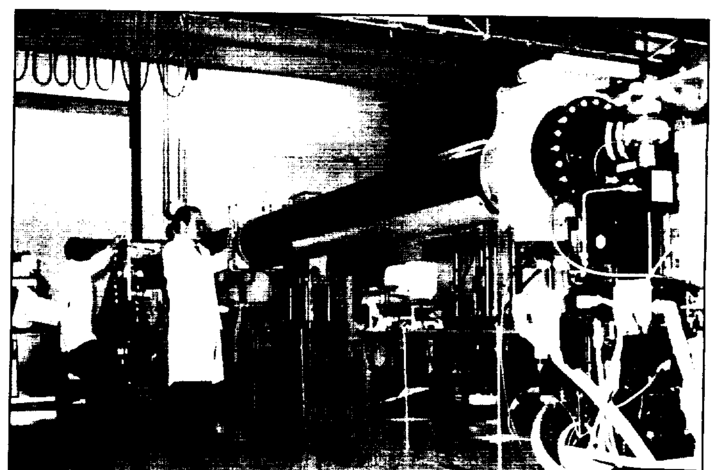


Fig. IS-303

station and allow it to firmly anchor itself. It is through this latching-end-effector and the power and data grapple fixtures, that the control system commands and the power to run the arm, are in fact transmitted *[Fig. IS-306]*.

And here we actually see one of the flight units of the power and data grapple fixture. Canada is supplying these throughout the Station. They are installed

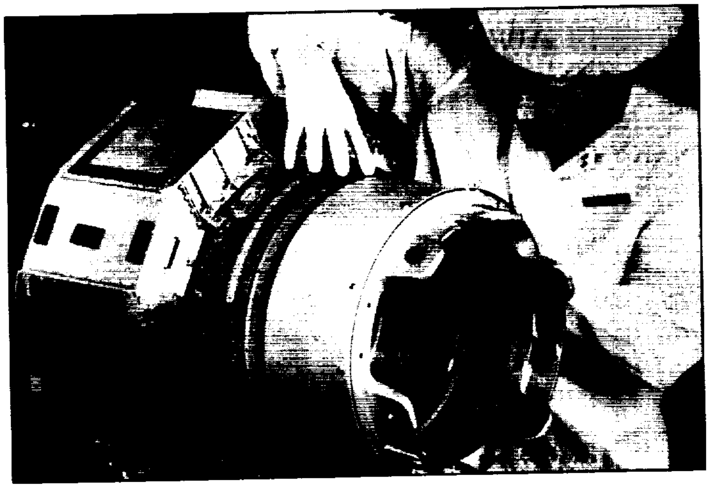


Fig. IS-304

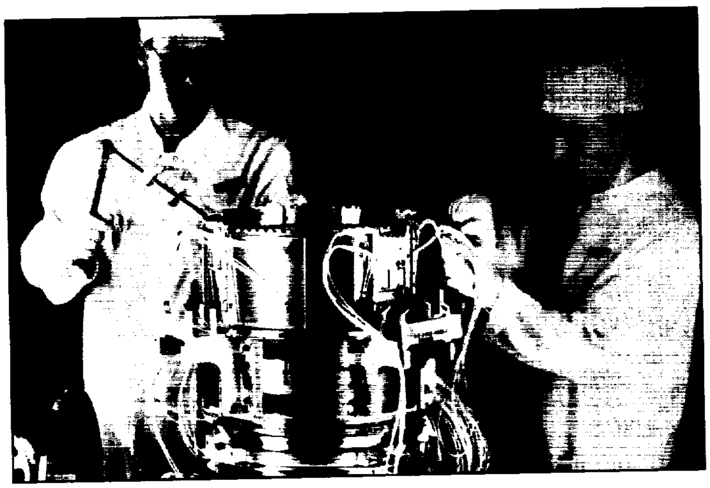


Fig. IS-305

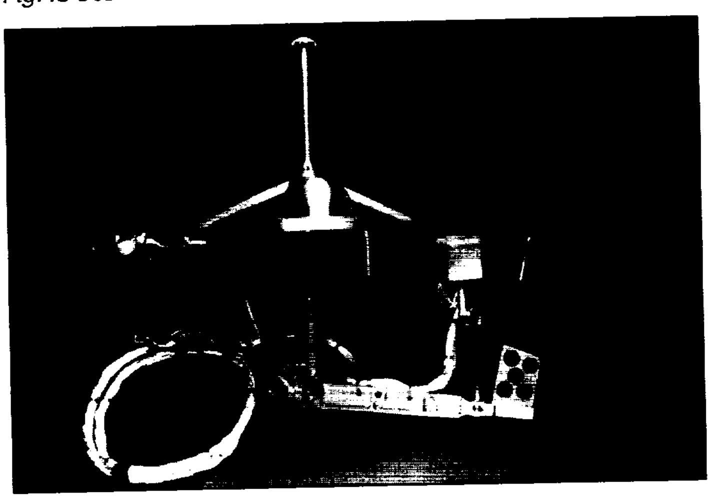


Fig. IS-306

in many locations on the Station and they in fact allow the arm to do its walking maneuvers. You can see the probe and some of the latching mechanisms. That is all flight hardware, and, at the present moment, our program is the integrational test phase.

Another part of our contribution is The Mobile Base System, the structure that the arm will sit on as it moves up and down the trunk structure. This is an

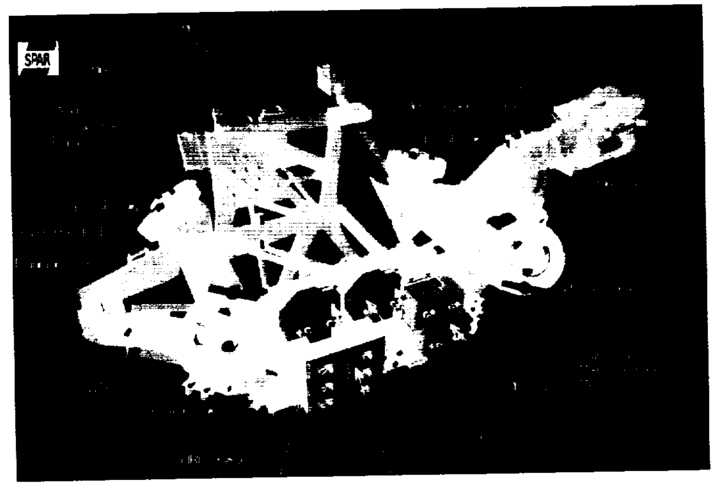


Fig. IS-307

artist's rendition of the Mobile Base System structure *[Fig. IS-307]*. It will be installed on the mobile transporter NASA is supplying. It is the base for the SSRMS as I indicated and it also has a significant capacity for carrying payloads and ORUs. This is the facility that will allow us to take ORUs out to a location on the station that needs an ORU replaced, interchange the ORUs and return with the defective unit. You will see four of those power data grapple fixtures on this base.

They are used for the arm and also for some of the ORUs. We're not quite as far along with the base as we are with the arm. The next picture shows the structural test article for this mobile base *[Fig. IS-308]*. It's a large unit. This is the qualification unit, assembled; it will shortly undergo structural tests.

All of this robotics equipment has to be operated. This is a mock-up of the robotics work station and we're showing it here in the Cupola where it will be installed *[Fig. IS-309]*. The Cupola is part of node one. NASA actually is prototyping the work station from Canada and that is a mock-up that we have done for NASA. So it is through a station like this that the arm will be used for its assembly and maintenance tasks.

These statistics show where we are in the program. We have basically finished most of our engineering and qualification articles (96 percent complete and 90 percent complete respectively); and for the RMS itself, about 70 percent of the flight hardware is done and for the MBS, about 50 percent. The SSRMS is to be launched in December 1998, with the MBS being launched in July 1999. We are way ahead of schedule in terms of meeting those dates, and our equipment will be finished and delivered well in advance of the date it is required. We are not only providing hardware for the Space Station, the next slide will show some of the ground equipment that we are producing.

This is the Space Station's operations and support center which is located at the Canadian Space Agency in St. Hubert in the province of Quebec *[Fig. IS-310]*. It's being shown here actually as it was being

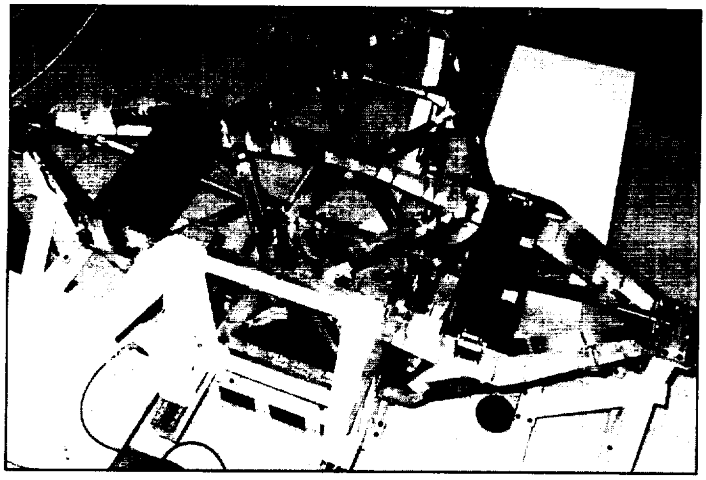


Fig. IS-308


Fig. IS-309

used during the STS-74 mission where the docking collar was attached to the MIR Space Station. This facility uses the same consoles that will be used at the Mission Control Center in Houston. It will be used as a backroom to the Mission Control Center during robotic operations on the Space Station. As we did for STS-74, this facility will be used to track and monitor the next shuttle flight STS-77, which will have a Canadian astronaut on board utilizing the Canadarm. It will be the second flight for Dr. Marc Garneau, the first Canadian in space.


Fig. IS-310

Finally, this is another view of the Space Station, and I just wanted to point something out here *[Fig. IS-311]*. The Cupola where the work station will be is located just about here on the Space Station. And you can see that the viewing angle from there to the trunk structure will be the primary home of the SSRMS. This means that artificial vision systems will be a critical component of this system. Canada has been leading the way in vision systems used in space. We've had several flight experiments, the most notable being the use of the space vision system during the docking maneuvers where the docking collar was installed on MIR during STS-74. The artificial vision system provided extreme accuracies in terms of alignment and positioning of the unit, and we're quite confident that this vision system will meet the requirements for the operation of the SSRMS; and in fact we are planning some additional flight experiments over the next couple of years to test out the flight equipment. The robotics components that we'll be supplying include the base for the system, the arm itself, the work station, and the artificial vision system that will allow the whole system to work together. We are on time, we are on budget.

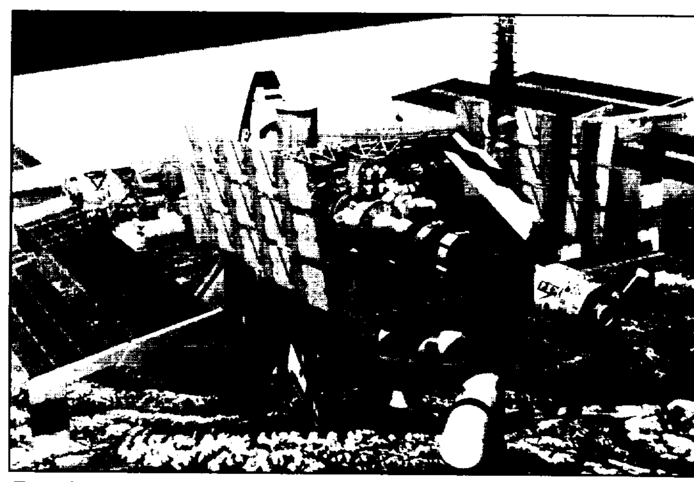


Fig. IS-311

Canada, like other nations involved in the Space Station, a couple of years ago, went through cost reductions driven by budgetary requirements. I'm pleased to say that we've been able to maintain our program within the reduced dollar values that the government has allocated to the program. Like Mr. Goldin was saying earlier today, the Space Station a few years ago represented more than 50 percent of the Canadian Space Program, it now represents about 25 percent. We are still able to meet our commitments to the international program. We are getting ready for the Space Station year. Our hardware is almost complete, as you have seen. Our ground facilities are being put in place. And our scientific community is flying precursor experiments on the shuttle and on MIR. And the latest mission to MIR delivered some of our equipment to the Russian Space Station.

But more importantly, when I look back at what I and many others felt at the time, was going to be one of the most significant outcomes of the Space Station program, namely the demonstration of the will and the skill of a large number of nations to work together to achieve something that we couldn't do individually. And when I see what we have accomplished today, it is more than any of us could have dreamed more than 12 years ago. I think it's a great testimony to the international space community that the Space Station program has survived all its difficulties over these years. We have expanded the network of nations involved. It is clearly going to be a very successful, international science and technology and space program. The current shuttle-MIR missions which have taken place and the ones that are planned are proof that the space-faring nations of the world are capable and willing to work together for the benefit of mankind. That will be the legacy of the Space Station.

Thank you very much.

Mr. Rains: Now, I'll introduce Jim Noblitt, vice president and general manager for Boeing, the prime contractor on the Space Station who is going to talk about the U.S. portion of the Space Station as well as give an overview of its progress. He's the VP and the general manager for the Boeing Defense and Space Group, Missiles and Space Division and the president of a subsidiary, Boeing Commercial Space Co.

Mr. Noblitt: Thank you, Lon (Rains). Good afternoon, ladies and gentlemen.

Hardly a week goes by that I don't read some report or hear a rumor about what's happening on the Space Station program. Sometimes the news is right on the mark, and sometimes it's off by a country mile. Today, I'd like to give Boeing's perspective on how things are coming along. I hope I'll be able to give you better insight into how the program is really progressing.

Not to keep you in suspense, let me say right up front that the station is progressing very nicely. Not perfectly—but pretty darn well.

Before I back that up with some facts and data, let me step back a second and put my remarks in context. Boeing, as prime contractor, is responsible for leading the industrial team that is designing and building U.S. portions of the station and for acquiring the FGB from Khrunichev in Moscow. NASA, of course, is our boss and leader of the international team building the total station. NASA is also responsible for what we refer to as the nonprime work associated with preparing for the operation and utilization of the station.

This is a computer illustration of the International Space Station after assembly is completed in 2002. At a mass of more than 900,000 pounds, it will be without question the largest and most capable object ever placed in Earth orbit *[Fig. IS-401]*.

It will be, by any measure, a world-class orbital research facility that is safe and very user-friendly—a facility where scientists can be highly productive.

Right now, we have a large part of the station design completed and are well along in the fabrication of the individual parts and components for the initial elements. Assembly and integration activities have begun and are picking up speed very rapidly.

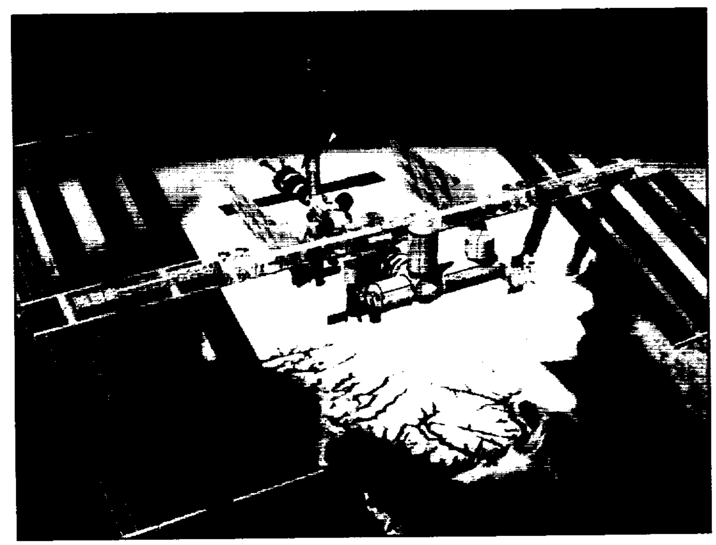


Fig. IS-401—International Space Station with assembly complete.

I can also assure you that everyone on the team is totally dedicated to seeing it is delivered on cost and on schedule. We believe it is essential to do so and demonstrate to the public and our governments' that the space community can deliver on its promises.

But no one is kidding themselves. This is an extremely sophisticated machine. I sometimes describe it as over 25 different spacecraft flying in formation. We know there will be problems and are being proactive in anticipating and dealing with them.

One area we are currently working is what we call "horizontal integration"—the job of assuring that the station will perform as intended once all the pieces are assembled on-orbit. This job is complicated because of the phased development in which individual elements are completed and launched over a four-and-a-half year time period. As a result, we can't assemble and check out the fully integrated station, or even many of the units, on the ground. This means we must be extremely rigorous in verifying that all interfaces are correct, prior to launch.

We are convinced that we have the right fundamental approach but are continuing to focus on the detailed plans to make sure we haven't overlooked anything. One encouraging fact is that the Russians have done this successfully on MIR.

I'd like to spend the next few minutes telling you where we are in getting ready for the first few launches—the area where most of our efforts are currently focused.

The first element of the station to be launched will be the functional energy block, or as we normally refer to it, the FGB. It is scheduled for launch from Baikonur on a Proton rocket in November 1997 *[Fig. IS-402]*.

This is a photo of the flight article in the process of being outfitted with equipment at Khrunichev in Moscow. When finished, this module will weigh about 20 tons and provide all the propulsion, attitude control, and power during the initial phase of construction. It is, in fact, a completely self-sufficient spacecraft.

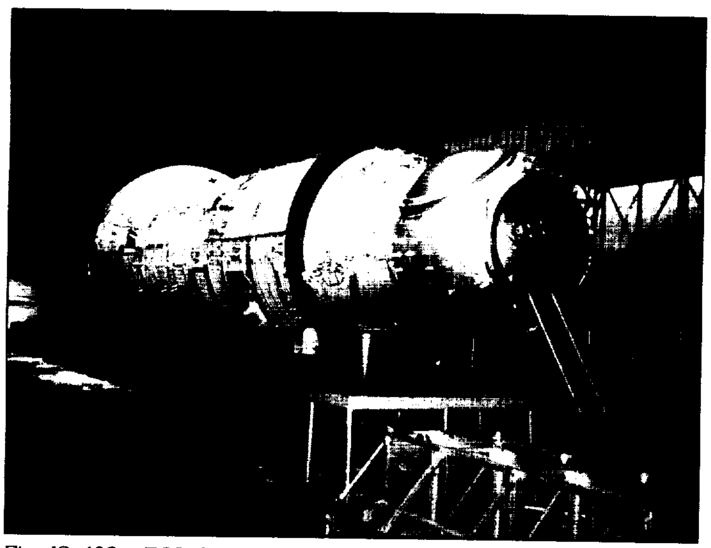


Fig. IS-402—FGB flight articles

You've probably heard the reports about a bulkhead being damaged during proof pressure testing. Those reports were correct. However, that damage has been corrected, proof pressure retesting was successfully completed, and the unit is on schedule for completion in November of this year. In fact, FGB body manufacturing was actually completed three weeks ahead of schedule.

I would add that Khrunichev is proving itself an excellent teammate. It is doing an outstanding job in building this unit and has my greatest respect.

This photo is of the two nodes being built in Huntsville, Ala. Each node is 18 feet long, 14 feet wide, and weighs about 6,000 pounds. It has six hatches that serve as docking ports for other modules.

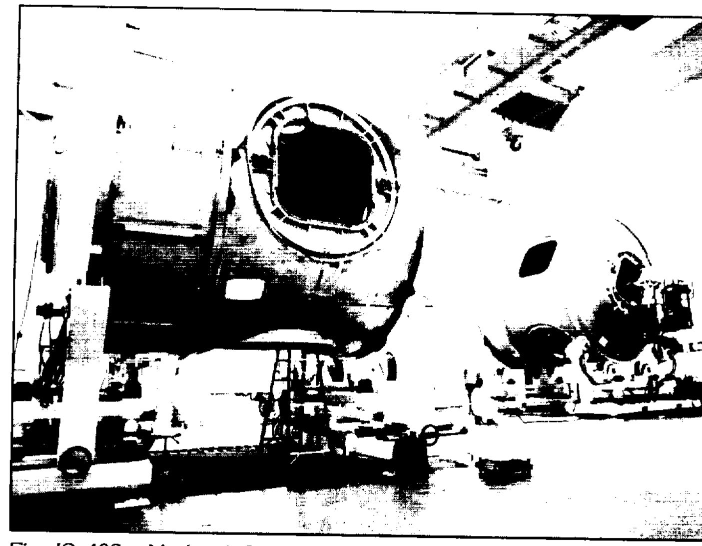


Fig. IS-403—Nodes 1 & 2 in factory.

The nodes are the connecting units between the various modules and docking ports. As you can see they have both completed initial fabrication *[Fig. IS-403]*.

Node No. 2, on the left, is the structural test article being used to validate the node's structural integrity. Since this photo was taken some secondary structural elements have been installed, and the unit is presently in proof pressure testing at Marshall. After testing is completed, this node will be outfitted and become Node No. 2, which launches in October 1999.

Node No. 1, on the right, has also completed structural assembly and secondary structural installation. It is presently being prepared for proof pressure testing. Our schedule calls for the unit to finish initial testing in June and be turned over to McDonnell Douglas for outfitting. It will become the first U.S. element launched. This will occur from Cape Kennedy in December 1997 on the space shuttle.

Node development has proved fairly challenging with several problems encountered while building the units. The most difficult of these occurred last fall and winter when we were welding the large cylindrical sections together to form the hull structures. We found the original tooling wasn't stiff enough to hold the tight alignment accuracies needed. So we had to redesign the tool, and this put us a few weeks behind schedule. Since then we have implemented work-around plans and recovered most of our schedule slips. We still have a way to go in catching up, and if all goes well, we will meet the June date for turnover to McDonnell Douglas. I'll have more to say about this in a moment.

Another challenging area has been the common berthing mechanism, or CBM. These units include the power bolts that mechanically connect the various modules together. They also provide the vacuum-tight seal needed to prevent leakage in space. There are six of these units on each node, one at each port.

The CBM development difficulties were due to the criticality of the functions being performed and the complexity of the mechanism. Recently, AlliedSignal delivered the first two actuator and control assemblies—the critical path item. A third unit is due shortly.

We have also redesigned the seal to correct some earlier problems. We now have a design that meets all our requirements and will prevent air leakage.

The current challenge is in node proof pressure testing. The stress analysts are concerned that a piece of secondary structure may, and I emphasize may, yield under design loads. It's a close call. To be safe, we have adopted a very cautious proof test approach. If initial tests to 40 percent proof pressure show there is a problem, we'll have to make a design change. However, in all but the worst case we expect to make the June completion date, and if the worst case occurs, we'll be no more than two weeks late—a delay that can be accommodated. In addition, we are presently working a schedule planning exercise to see if we can't build up some additional margin in the node flow.

Also, on the second flight are two pressurized mating adapters or PMAs. One of these units will connect the node to the FGB and provide a pressurized passageway between the two. The other will serve as the shuttle docking port *[Fig. IS-404]*.

The slide shows the engineering test article that was recently completed by McDonnell Douglas and is presently undergoing test. Fabrication of the first actual flight article has been started and is going very well.

The third U.S. mission, for which I don't have a slide, takes place in June 1998 after the first three Russian missions in the spring of 1998. These Russian missions deliver the service module, a Soyuz, and the universal docking module to the station.

Fig. IS-404—Pressurized Mating Adapter.

On this third U.S. mission is another pressurized mating adapter, the Z1 Truss with the control moment gyros, and the initial Ku-Band and S-Band communication gear. McDonnell Douglas has lead responsibility for this mission. Currently, the primary risk is with the CMGs, which are somewhat behind schedule in completing assembly, but no serious impacts are expected.

Fig. IS-405—Integrated Equipment Assembly.

This slide shows the integrated equipment assembly or IEA being assembled in Tulsa. It goes up on the fourth mission in September 1998. Doug Stone likes to say it's the size of a one-car garage *[Fig. IS-405]*.

It's being built by Rockwell and will house much of the electrical power control system. This includes the batteries, battery controllers, and power distribution equipment. Also, on the flight will be the early external thermal control system and the first photovoltaic array.

Engineering models of most of this gear have been in development test for some time, and flight units are now in production.

This is the solar alpha rotary joint that attaches to the truss structure and is used to keep the station's solar power array continuously aligned to the sun. Lockheed Martin is building one test unit and two flight units as a subcontractor to McDonnell Douglas. This work is on schedule *[Fig. IS-406]*.

Shown here is the solar array mast, which is the structural member for the largest solar array ever. It's built by AEC-Able under subcontract to Lockheed Martin *[Fig. IS-407]*.

The mast packs into a 7-foot long canister for storage on the shuttle. When deployed on orbit, the array will be 108 feet long by 37 feet wide. There will be eight such arrays on the station when it is complete.

This photo shows the two primary U.S. elements, the laboratory module and the habitation module in the factory at MSFC. Both units are made of aluminum—28 feet long, 14 feet in diameter, and each weighing about 6,000 pounds at this stage. As you can see, structural fabrication on both units is com-

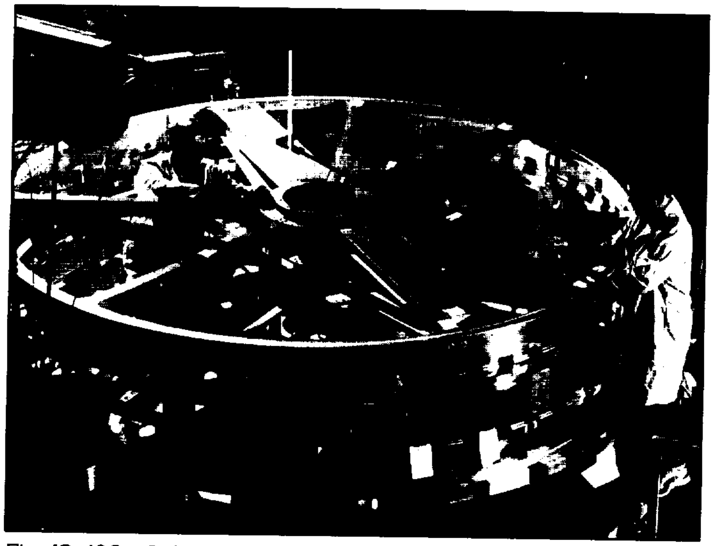


Fig. IS-406—Solar Alpha Rotary Joints.

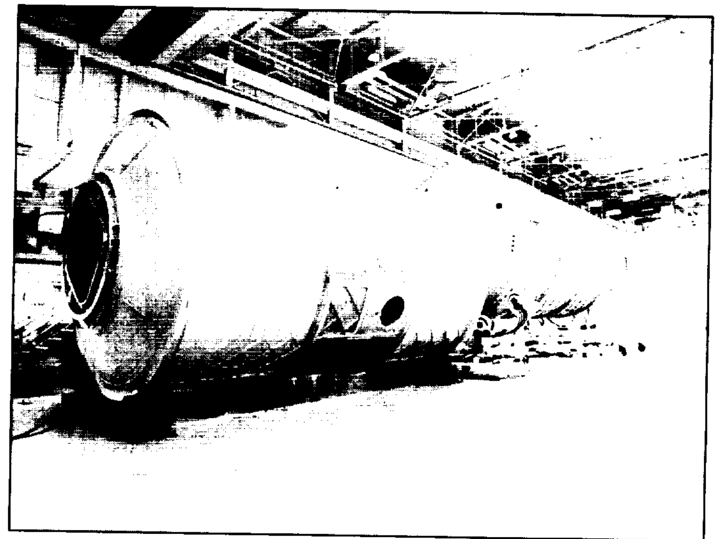


Fig. IS-408—Lab and Hab Modules.

pleted. The laboratory module will be delivered on the fifth U.S. mission, in November 1998. This is the module in which most U.S. research and scientific experimentation will be conducted. At present, machining has been completed, and mechanical equipment is being installed in the laboratory *[Fig. IS-408]*.

The top concern is associated with delivery of simulation software, which in turn affects development of the flight software. This area is also receiving considerable attention.

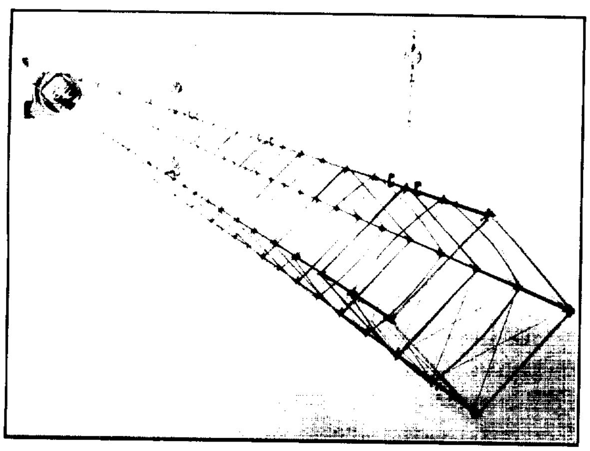


Fig. IS-407— Solar Array Mast.

The Hab, where the astronauts will eat and sleep, will undergo some machining and initial testing. Then it will be set aside to be processed later in the program. It isn't scheduled for launch until February 2002, one of the last units to be launched.

I put this slide in to make sure everyone knows what the station will look like at the completion of Phase II in March 1999. At this point, it will be functioning as the orbital research facility *[Fig. IS-409]*.

Another activity that's very important to the International Space Station program is the Phase I Shuttle-MIR program. The missions are providing two direct, invaluable benefits. First, they are giving U.S. astronauts hands-on experience flying on a real space station. I'm sure Shannon Lucid will have a lot of experience and ideas to share when she returns, as did Norm Thagard *[Fig. IS-410]*.

Second, the missions are providing an opportunity to test equipment in orbit and see what works best. The knowledge from both these activities is being used to design a whole lot better station than would be possible without the Shuttle-MIR missions.

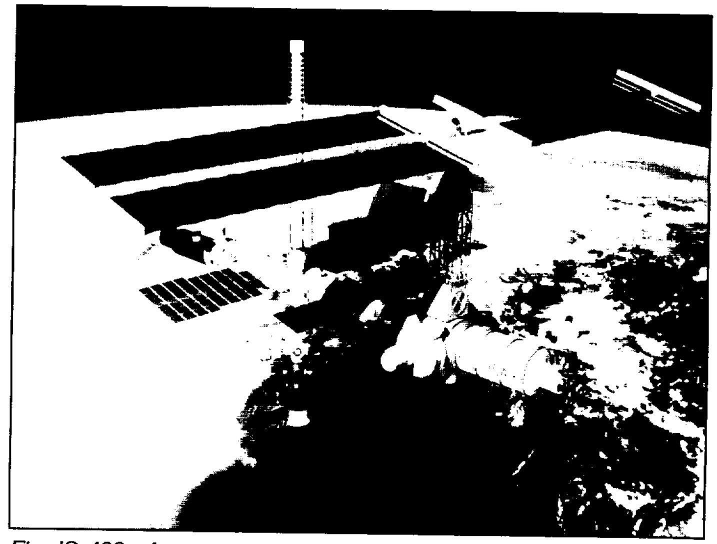


Fig. IS-409—International Space Station at Phase II Completion.

The bottom line is that the International Space Station is making excellent progress toward the first launch in November 1997 and the launches that will follow. Yes, we have encountered some problems and will face many more in the months ahead. That's to be expected on a program as large and complex as Space Station. But the really good news is that the team has

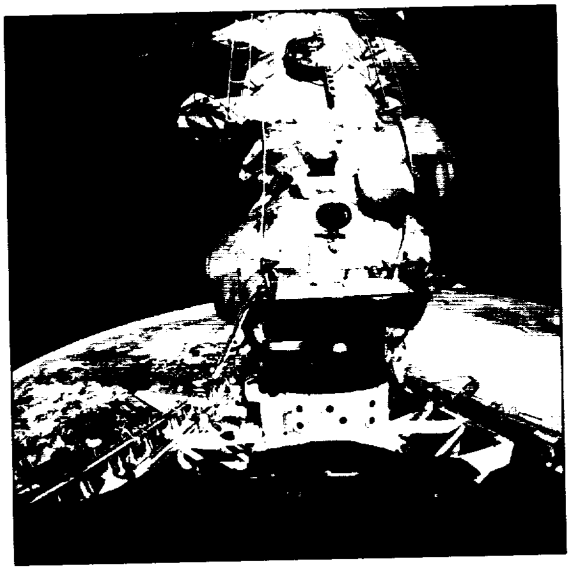


Fig. IS-410—MIR-1 docking chute with Shuttle.

been able to overcome every problem, to meet every challenge. I'm confident that, by working together as a unified team toward a common vision and with fierce determination, we will surmount whatever obstacles we encounter. I am equally confident we will produce a magnificent orbital research facility, within the cost and on the schedule that has been committed *[Fig. IS-411]*.

Thank you for you attention.

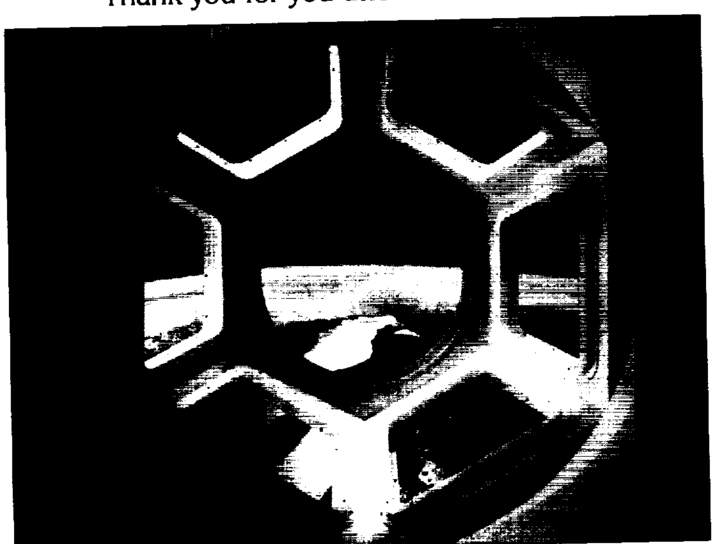


Fig. IS-411—Earth view through the Copula of the ISS.

Mr. Rains: Our next speaker is Mike Wynne, the vice president and general manager for Lockheed Martin Astronautics and Space Systems. He is responsible for Atlas and Centaur and was recently assigned responsibility for the Lockheed Martin Launch Vehicle and the multi-service launch system. And he also just returned from Russia where he was there for the first commercial Proton launch.

Mr. Wynne: Thank you very much, Lon. It gives me great pleasure to represent all those designers, engineers and production people at Lockheed Martin who put together this array of launch vehicles, as well as Khrunichev Space Center, builders of the Proton, who we proudly count in our product area *[Fig. IS-501]*.

The subject of my talk today is expendable launch vehicles and their trends. This slide *[Fig. IS-502]* presents a Lockheed Martin perspective on U.S. launch vehicles and trends. Existing families of expendable launch vehicles are evoving to a more efficient fleet of expendable vehicles while technology is being developed to demonstrate the feasibility of a fully reusable system. This development should permit the introduction of an RLV vehicle in the 2010 time frame.

My next chart presents a summary of the international competitive environment and the response that we're trying to bring to the marketplace *[Fig. IS-503]*. At the top of the chart is the array of launch vehicles associated with Lockheed Martin and Khrunichev

Fig. IS-501

Space Center through our subsidiary for sales, International Launch Services. International Launch Services markets the Proton launch vehicle, and I'm proud to say that I was present for the first, which I think was an historic event, launch of the Astra 1F Satellite for Luxemburg, from the Baikonur Cosmodrome. This demonstrates that what we are trying to do is provide flexibility to the commercial.

Our customers have a variety of requirements. You read about them, you see them, you understand them from a launch perspective *[Fig. IS-504]*. There's no doubt that vehicle ugpgrades and greater cost efficiency is a tenet of the commercial space satellite industry. That must go hand in hand, however, with improved reliability and greater performance. The customer expects 100 percent mission success and flexibility, but the bottom line is the industry wants lowest cost, on time, and reliable launch.

This is a graphic view of the Lockheed Martin's fleet of launch vehicles *[Fig. IS-505]*. And though we are working on the laws of physics, we have not performed quite as well as this chart might indicate. To

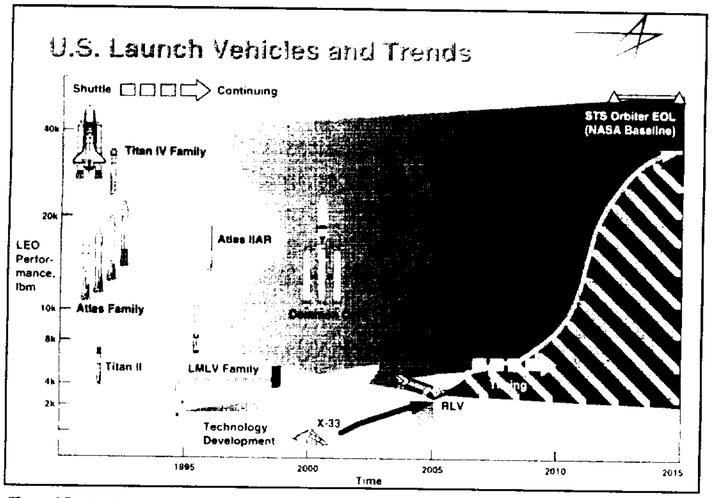


Fig. IS-502

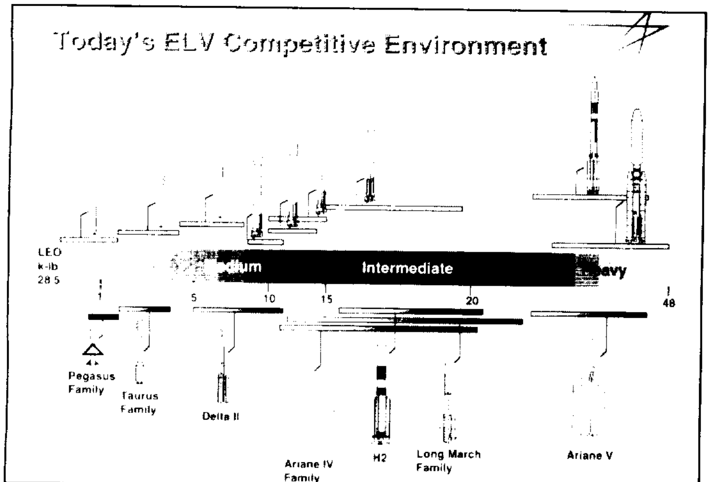


Fig. IS-503

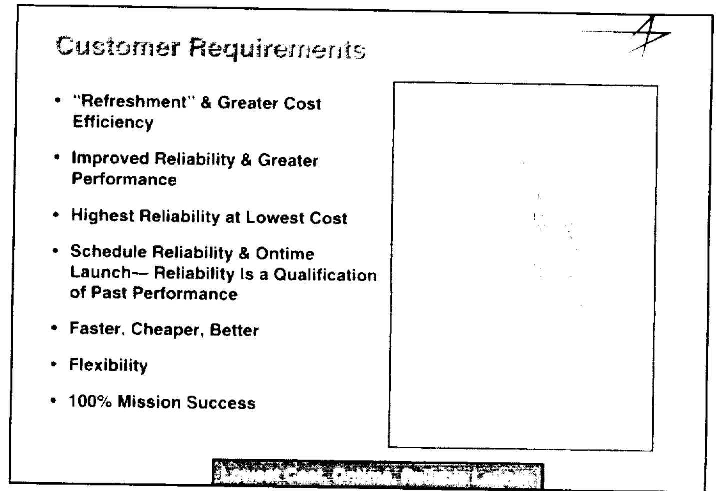


Fig. IS-504

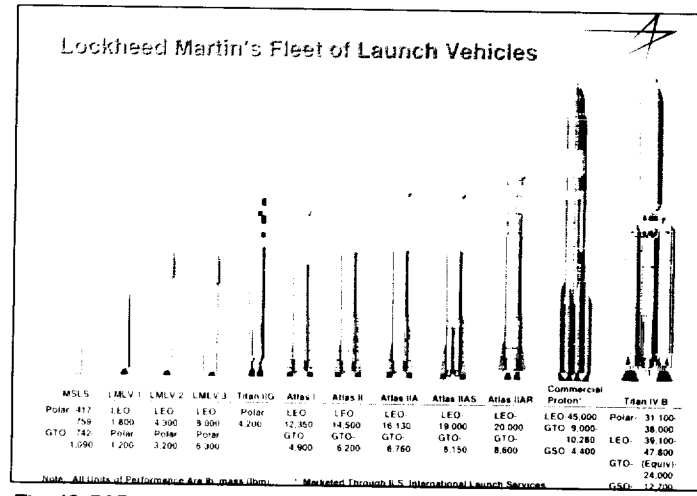


Fig. IS-505

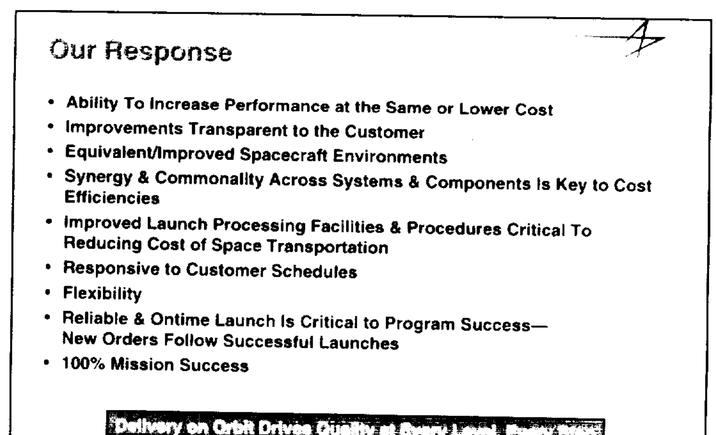


Fig. IS-506

correct the chart, the MSLS performance is to low-Earth orbit, not GTO as shown. The commercial Proton, as you can see, fits nicely into this family. The other one that I'll go into more depth on is the Atlas IIAR, which is variously referred to as the Atlas Re-engineering program, or the Russian engine application.

Our response to meet the customer's requirements is through investment and the ability to increase performance at the same or lower cost is a tenet of our investment *[Fig. IS-506]*. We are investing, not only in the Lockheed Martin launch vehicle family of three vehicles, but also in the Atlas II AR and in the evolved expendable launch vehicle program. Second, improvements must be transparent to the customer. We are a current provider of launch vehicles, and therefore need to provide the same characteristics and environments to our spacecraft customers that we have now. We are working to reduce costs by improving our launch vehicle processing facilities and the launch procedures. We realize that schedules are extraordinarily important to satellite manufacturers and their community of users as they must meet performance guarantees. There is no doubt that 100 percent mission success is the crowning achievement of launch vehicles, and we work very, very hard to make sure that happens. Delivery-on-orbit drives our quality at every level and at every step as we try to be the best in space.

I'd like to go into just a little depth of where we are headed with the Atlas II AR program, and bring you a little bit of insight *[Fig. IS 507]*. Atlas II AR program has a baseline performance of 8,600 pounds to

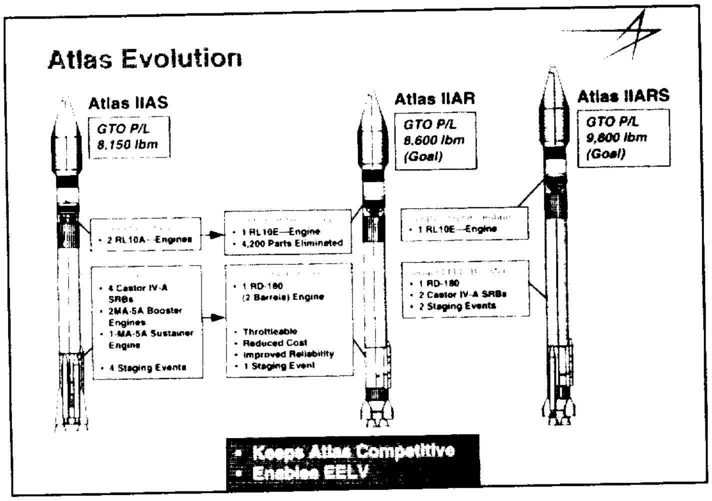


Fig. IS-507

Fig. IS-508

Fig. IS-509

GTO. It moves from four castors, two MA5A booster engines, one sustainer engine, to two RL 10's on the Atlas II AS to one RL 10 engine, and one RD180 engine. This simplification has dramatic impact on improved operability and reliability. But we're not stopping there. We're moving to a goal of 9,600 pounds to GTO with the application of two solid motor based on the Atlas heritage. The Atlas II AR's will still use one RL10 engine, and one RD180, but dramatically simplifies our move up the curve of performance and reliability. This vehicle will be available in the year 2000. This Atlas II AR will be available and has been sold for launch in December of 1998. Our purpose is to keep Atlas competitive world-wide, and of course, to enable our competitive posture in the evolved expendable launch vehicle program.

Now I'd like to expand upon the bottom of this rocket, which is our relationship in the international community *[Fig. IS-508]*. It is appropriate that we are on this panel today with the International Space Station and the Russian Space Agency, because the world of launch vehicles has dramatically moved from domestic to international applications. The basis of our future is international cooperation. It is interesting to note that the first Atlas launches this year are for Palapa for the Indonesians, Inmarsat and Sax for the Italians, which should please Prof. Vallerani very much. Our international cooperation is currently focused in two areas. First, Proton complements our launch fleet to expand our global launch services. Second is our partnership with Pratt & Whitney and NPO Energomash, which is a Russian space company, as Dr. Kuznetsov indicated, developing a rocket engine for the Atlas II AR. International cooperation has the benefit of expanding our marketplace and theirs in a dramatic and complimentary way. It provides enhanced launch availability and automatic launcher diversity to our customers. Finally, it combines the best in technology to provide efficiencies in the access to space.

Introducing the Proton to the commercial marketplace through our International Launch Services company has been an adventure *[Fig. IS-509]*. Lockheed/Khrunichev Energia (LKE) is the Proton marketing joint venture similar to Commercial Launch Services (CLS) which has been marketing the Atlas program. When combined, they form the International Launch Services team. It is interesting that, though we've been working collectively on this for some time, we did not realize how well we had established the International Launch Services name in the marketplace. At the recent Proton launch of the SES Satellite, one of the board members turned to our COO, Dr. Vance Coffman, and said, "What is Lockheed Martin doing here?" It was probably the wrong guy to say that to, but Dr. Coffman was pretty pleased at the end of the day that we had established the ILS name in such a rapid fashion.

Now a brief look into the RD180 *[Fig. IS-510]*. I think you all heard the basis of our search from Mr. Goldin's comments—that America has not invested in rocket propulsion in some 25 years. However, we found that the Russian space companies had in fact been working on and enhancing space propulsion, and could provide U.S. propulsion a leap ahead. The RD180 is really a "Freddy Krueger" approach to engine design, in that it is one-half of an RD170 with re-sized pumps and auxiliaries. What you see here are some of the new design and manufacturing products that have been completed by NPO Energomash and Pratt & Whitney.

We will co-produce the RD180 in Russia and the U.S., as was indicated by Dr. Kuznetsov *[Fig. IS-511]*. Through his efforts and those of the Russian Space Agency we have been cleared for co-production which will establish a solid industry base for ourselves and NPO Energomash. It's a great partnership. We've got a long way to go, but trust and teamwork have been the hallmark of this partnership. Together with the Russian government, we know that we're going to make an interesting mark in the history of space to come.

In summary, the merger of commercial and government business practices is key to U.S. launch vehicles' success in the future *[Fig. IS-512]*. We have a wonderful, cooperative spirit from the U.S. Air Force and throughout NASA to allow the success that we have had in the Atlas and Titan programs. There's no doubt in our mind that continued launch success qualifies the market; schedule reliability and cost is what wins new business. The U.S. government's support for the broad-based technology elements that you see here, including the RLV, has been marvelous. Our future is bright, the forecast is good, satisfaction of our customer demands and requirements is our objective. Our goal is to be the best in space. Thank you very much.

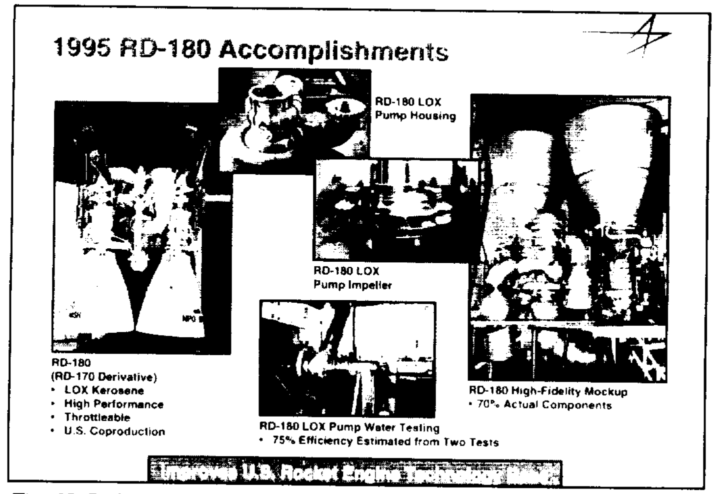


Fig. IS-510

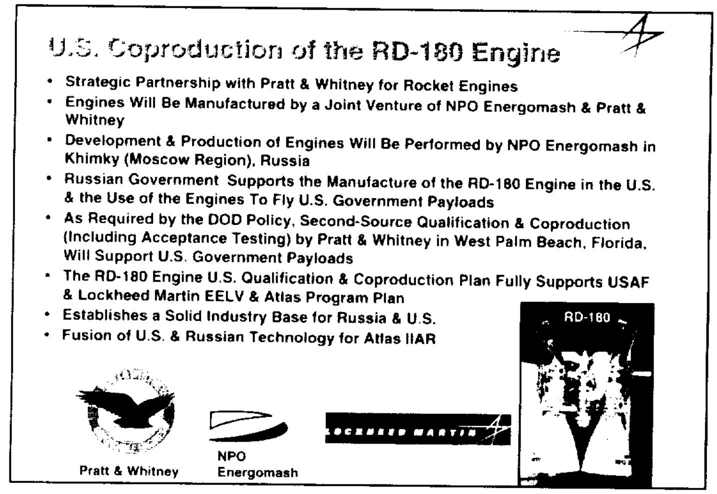


Fig. IS-511

Fig. IS-512

Mr. Rains: Our last speaker is Tom Rogers, and I know Tom wanted me to keep everything short, and keep his introduction short. He's the president of the Space Transportation Association, and I know he's got a lot he wants to say about space tourism.

Mr. Rogers: Thank you, Mr. Rains. Thank you, ladies and gentlemen. A short time ago, I was asked by the people here for the title of my paper. I quoted a president of the United States and now I find myself last on the agenda; there may be some causal relationship between the two. I quoted Harry Truman. He was asked at retirement by an enterprising reporter, "What was the most difficult thing, Mr. President, that you had to deal with when you were president of the United States?"—thinking that he had had to deal with Joseph Stalin, thinking he had had to deal with the dropping of the atomic bombs on Hiroshima and Nagasaki. He said, "Getting people to do what the hell they ought to have sense enough to do without my telling them." And that's the title of my talk today. The subtitle is "Space Tourism."

In 1996, Herman Kahn, one of the great scholars of the nuclear age, and I were talking in OSD, which is where I was at the time, and we came to two conclusions. The first was that we could not see that we would outlive the Cold War. And the second—recall that this was in the midst of the Mercury, Gemini, Apollo era—was that as soon as that war came to an end, all of this space technology would be used to get people up into space. Everybody wanted to go to space. Wrong. I did outlive the Soviet Union. Wrong. We're not sending people to space unless they are government employees.

Now, why consider space tourism today? There are four reasons. The first: There is a very large business potential in the carrying of people to and from space for short visits. The best estimates that we have today is that this business could amount to some 10 billions of dollars per year in gross revenues. Non-trivial. That is the amount of money in direct space related gross revenues in the entire satellite communications business today, including launch.

The second reason: What a wonderful market to add to the public market for the X33 follow-on vehicle-fleet market aspirations. That vehicle fleet will have to be privately financed, and therefore we will have to attract Wall Street investment of very large sums of money. And I can't help but believe that it will be very, very important under those circumstances to have a very large, straightforward, private sector market.

The third: The Japanese are very deeply and actively engaged in the pursuit of the space tourism business. They have been at it now for about three or four years. I know some of the principals doing this work there, and they are working very, very hard.

Let me show you the first viewgraph *[Fig. IS-601]*. It's the one that looks a bit like an acorn. That is the first conceptual design in Japan of a vehicle that would be designed to carry people to and from space. Quite different from anything that we see here to date. The next view graph shows two kinds of seating arrangements they are giving thought to *[Fig. IS-602]*. We see nothing like this in the United States today. Nor do I know of any plans for seeing such things as this. Who are these people? They came from: ALL Nippon Airways, Fuji Heavy Industries, Kawasaki Heavy Industries, Mitsubishi Heavy Industries, Nissan Motor Co., Shimizu, etc. Non-trivial.

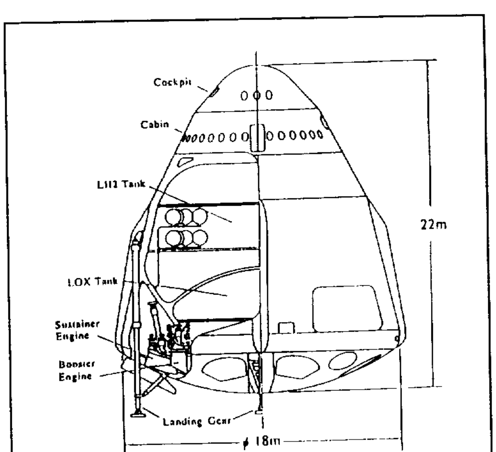


Fig. IS-601

How can I be reasonably sure that there could be a market of $10 billion a year gross revenues in the space tourism area? Because the Japanese have done something that has never been done before in the space tourism area: they've conducted market surveys. The first one was conducted in Japan over two years ago, and they asked, "How many people would be willing to pay how much, to do what, under what circumstances?"—and from that, derived the revenue figures. At that time I was convinced that the United States should conduct such a survey, and set out to try to see it come about, and I failed. Subsequently a survey was conducted of the United States market by the same Japanese interests. The results that they found were quite similar in most fundamental respects to what they had found in Japan.

Now as to the fourth reason. There is one thing that, over a long period of time, I have failed to persuade the NASA administrator of. I'm going to keep on working on him because he's smart enough and he will learn, and then we'll be off to the races. Of all the things which Dan spoke about here earlier today, that

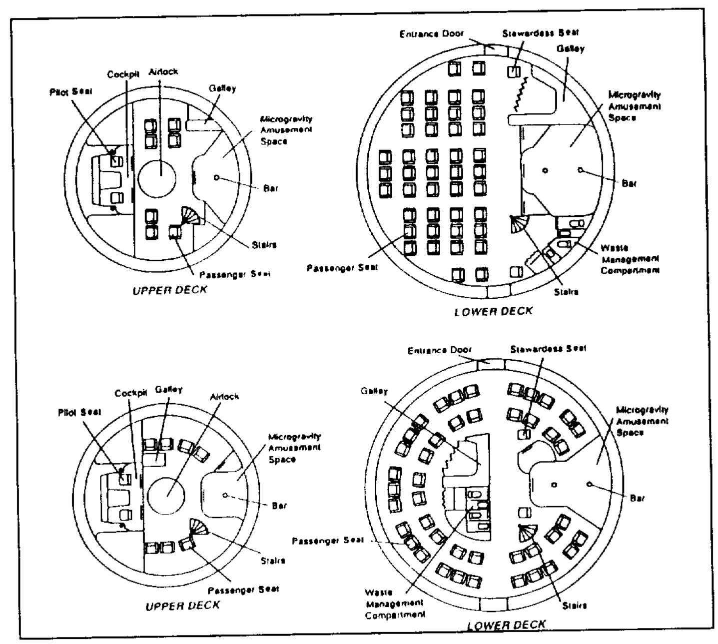


Fig. IS-602

NASA is doing and might do in space, all of the goals and objectives, let me ask you: which of them would you judge to be *quintessential American goals*? I would suggest to you: none. By the way, I'm a physicist, I love some of them. I'm a communications engineer. I love some of the others. But I'm also American, and I would suggest that by far the most important federal civil space goal, and indeed the most important national goal in space, is *to see space opened up to the general public. E pluribus unum*. One among many. We the people. By the people, of the people, for the people. I'm not speaking chauvinistically. I'm speaking of the American character and relating it to space activities.

We Americans, when we find something that is interesting enough to us and important enough to us,

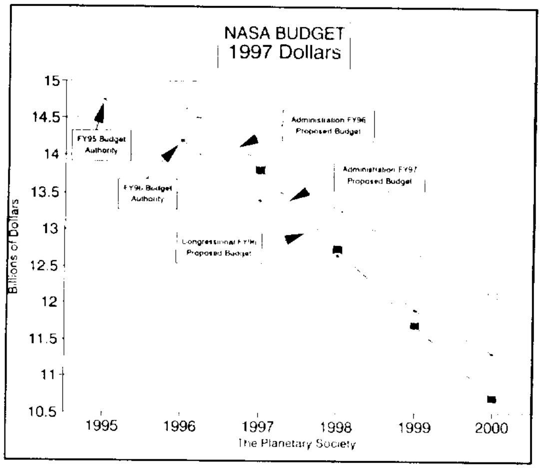


Fig. IS-603

want to engage in it directly, personally. We do it all the time. New highways, new schools. But not in space. Not in space. It is the considered and continued position of our friendly federal government that the general public should not aspire to enter space. In my view, that is not simply a mistake, it is an out and out *blunder.*

May I have the last viewgraph, please *[Fig. IS-603 from* Space News, *page 1, March 25, 1996]*? Look what's projected by the president of the United States for the NASA budget for the years 1998, 1999, and 2000. The first curve, the top one, is for a year ago. The second, this year. If you include a loss of purchasing power of some 3 percent per annum, by the year 2000 the federal civil space program will be reduced in purchasing power by 25 percent. If that persists for a decade, it will be down to 40 percent. Now I hope that we can get a lot more bang for the buck, as Dan is talking about, but I really don't think that we are going to be better off with a civil space program expenditure of $6 billion. And by the way, that last curve was laid out by the president of the United States in a presidential election year where he is very, very careful to choose his enemies, and to probe very, very sophisticatedly in selecting his soft spots in the body politic.

Why is this? I listen to Dan Goldin, and Dan waxes eloquently about all of the wonderful, exciting and interesting things that could go on, and finds large numbers of people a good part of the time who are interested in these sorts of things, and he talks about the stories in the newspapers and in the magazines. But there is no way to translate those vital intangibles, and I will agree that over the longer term they are vital to a quantitative exposition of an annual budget of $14 billion, or $1.4 billion or $0.14 billion dollars. We must really understand that what has been going on for the past 10 to 20 years, is that the things which the federal government has chosen to do in our civil space program simply do not interest enough of the general public. The money is not coming from a Medici prince. It is not coming from Lorenzo the Magnificent, but from taxpayers, who must decide, each time, what is the value of the next dollar to be spent: criminal justice system improvement, education improvement, air traffic control improvement, the delivery of health services, Social Security, Medicare, Medicaid . . . and when you compare these with what the federal government chooses to do in space—however interesting it is to scientists, technology developers, and engineers—our present civil space activities just do not find enough appeal in the American general public.

Space tourism would find such an appeal. There is no question about it. A few space-related polls were conducted in the United States in the 1980s of a slightly different character than most of the others. One further question was asked in three polls in the United States and one in the U.K. After asking all of the usual questions, "What do you think about space? What do you think about what the government is doing in space?"—one other question was asked, "What do *you* want to do about space?" And the answer then was—and it's been born out by the Japanese market studies in Japan and the United States since then—that 40 percent to 45 percent of the American adult population said, *"I want to take a trip to space."*

I submit that considerations of space—business, space transportation development improvement, competition from abroad, and expression of our national character—should see us building a space tourism business and thereby opening up space to the general public.

Late last year a formal agreement was reached between NASA and the Space Transportation Association. We are working cooperatively to address the question, "What should our country do to position itself to see a large space tourism business come into being?" We've been at it now for several months. We have a steering group now nearly completely identified, we are working on internal papers and you will be hearing something about it in the not too distant future.

Thank you for inviting me here this afternoon.

Q&A

Mr. Rains: If I could get all of our speakers to come sit at the table now, we've got a number of good questions. Our first question is for Dr. Kuznetsov. Can you say anything to ease concerns in the United States about Russia's commitment to the International Space Station program?

Dr. Kuznetsov: Within recent months, several events have taken place which clearly show that Russia will fulfill all of its commitments in the International Space Station Program. Last month the program status was reviewed by Russian Prime Minister Victor Chernomyrdin, who visited the Khrunichev Center for a detailed study of the project. The conclusion made by the prime minister is contained in his letter to Vice President Al Gore which was sent early April.

Mr. Rains: Could you also please comment with regard to whether Russia will be on time with its production of its hardware for the Space Station?

Russia will fulfill all of its commitments in the International Space Station Program. Last month the program status was reviewed by Russian Prime Minister Victor Chernomyrdin, who visited the Khrunichev Center for a detailed study of the project.

Dr. Kuznetsov: Recently the schedules were reviewed once again. It was evident that whatever deviations from the master schedule were observed, they were normal. They were deviations which typically occur in programs. So we ensure that the schedules will be maintained and met.

Mr. Rains: I'm going to skip around a little bit here and change topics. Tom Rogers, for you, in an era of increasing liability and lawsuits, what do you perceive as the insurance obstacles to space tourism, and are they prohibitive?

Mr. Rogers: That's one of the questions that we're going to be addressing in the study. By the way, that allows me to make an observation that I trust is important. We are seemingly committed to the use of the shuttle fleet and the Space Station to making inquiries into the physical and the life sciences. I'm for that. But we ought to be making inquiries in areas that lead to more commercial and industrial businesses as well. There are many, many questions such as the insurance question, questions of fear, questions of food, questions of clothing, questions of all kinds that need to be addressed in an ongoing professional R & D fashion, and I believe that the study will articulate many of these and will suggest things that the country should do to address them.

Mr. Rains: I've got another Space Station question. I'm going to direct this one to Jim Noblitt. I think that the person that asked this is talking about Space Station Freedom, and the question is, were the initial designs of the Space Station flawed or improved or were all of the delays of a political nature?

Mr. Noblitt: Well, I don't think that the design was flawed. I think we found a way to improve on that design. I think the reality was that there were cost and financial concerns that the administration believed needed to be addressed. What has happened during the program is that the overall cost of the program has been capped. The annual costs that were headed towards $3.5 billion a year have been capped at $2.1 billion a year. So I believe that we've come up with a program and design that meets all the original expectations, but at the same time lives within some cost realities that are essential for any program to live within. I would say that the program is as good as the Freedom program, and is a more affordable program. In addition I would point out that with the inclusion of the Russians in the program and the addition of their international participation, we've brought a lot more experience into the program that's been beneficial in a variety of ways.

Mr. Rains: OK, another Space Station question—and Jim, if you could handle this one, too. When will the first crew board the International Space Station, and what kind of specialists and scientists will get to go?

Mr. Noblitt: The first astronaut has been selected. Bill Shepherd is already in Moscow training as the first U.S. astronaut. I believe both the Russian astronauts for the first crew have also been selected. I believe they go up in about May of 1998—that's about the right time frame—aboard one of the three Russian launches. I believe it's the third one when the space vehicle acually comes up to the station so they have a crew return capability. They won't have much scientific capability at that point, but they will have astronauts on board at that time.

Mr. Rains: OK, I just want to follow that up a little bit. I'd like Professor Vallerani and Dr. Kuznetsov and you to all answer this: Has it been settled yet what the makeup of the early crews will be as far as nationalities? Has that question been resolved? How many people from each country?

Mr. Noblitt: The No. 1 crew has been selected. It will be two Russians and one U.S., I believe.

Dr. Kuznetsov: Unfortunately I am not involved personally in selecting the crews for the Space Station project, so it's hard for me to answer.

Prof. Vallerani: The other partners will be allowed to provide their own astronaut. If we just look to the Italian situation as part of our agreement, we have assured the presence of the Italian astronaut in the operational work, but downstream.

Mr. Noblitt: Yes, I think you need to recognize that the first few missions are primarily U.S. and Russian missions, so you would expect the predominant number of astronauts then to be operating the U.S. equipment and the Russian equipment. Later on downstream, I think you would find that more and more European, Canadian, and Japanese astronauts would be aboard.

Mr. Rains: Somebody just asked if the Space Station is geosynchronous, and no, it's not. Not by a long shot. For Mike Wynne, how does the Titan IV program fit into Lockheed Martin's EELV development effort?

Mr. Wynne: In providing assured access to space, the Titan IV program is really a foundation element. I think the challenge is to find better, faster, and cheaper ways to do that project, but clearly the goal of the evolved launch vehicle is to provide heavy lift through a modular approach and common core approach to that project. So we have great respect for the customers out there in the Titan IV area, and we intend to provide them, as well as our other customers, assured access in the late 2000s.

Mr. Rains: To Dr. Kuznetsov, there is a commercial launcher called Rocket. It is a cooperative arrangement between Germany and Russia. It has been successfully launched three times from Baikonur, I understand. Will it also be launched from Plesex?

Dr. Kuznetsov: What took place at Baikonur had nothing to do with Russian-German activities. That was just a test flight. Commercial launches will also be made from Plessetsk, however the existing launch pad will have to be modified so that the vehicle could be launched from the ground surface rather than from a silo.

Mr. Rains: Jim, I'm going to throw this one to you. There's an acronym in here I'm not familiar with, but it says, please discuss Boeing's experience with the IPT organizational structure adopted for the International Space Station program.

Mr. Noblitt: The term is Integrated Product Teams. I do know what it means. Basically, one of the real emphases in trying to downscale the program and fit within a cost cap of $2.1 billion was working together. That's one of the things that we have really stressed. We do what a lot of people call an Integrated Product Team approach, where all the specialists associated with one product area are located together and work together in a unified fashion to make sure the end product meets the requirements and expectations. It's a way to increase efficiency. We say that between the combination of centralizing the NASA structure at Johnson and bringing us in with an Integrated Product Team approach, we were able to cut the cost between 20 percent and 30 percent on the program. I think it really is proving true. Teams work very, very efficiently. We're big believers in them, as a lot of our partners are on Space Station, and it increases the communication, gets you a lot higher probability of taking into consideration the operational aspects, the manufacturing aspects when you design the original product and producing it right the first time at a lower cost. We're very much fans of Integrated Product Teams.

We do what a lot of people call an Integrated Product Team approach, where all the specialists associated with one product area are located together and work together in a unified fashion to make sure the end product meets the requirements and expectations.

Mr. Rains: For Dr. Kuznetsov, could you please discuss or explain the relationship between the Russian Space Agency and Energia?

Dr. Kuznetsov: The relation between Russian Space Agency and the Energia Corporation (Russian Space Corporation Energia) are similar to those between NASA and the Boeing. The only difference is that one of the board members of Energia is a representative of the Russian Space Agency and he has the right to vote based on the RSA's shares, i.e., Government shares, in Energia. We are Energia's main customer. Our relations are governed by the contracts that we mutually sign. We pay them for the products they develop for us.

Mr. Rains: To anyone who can answer the question, will the International Space Station use a common telemetry protocol? If so, will it use the NASA CCSDS telemetry protocol pocket processing system?

Mr. Noblitt: Not me. Can anyone out in the audience answer that question? I'm sorry.

Mr. Rains: OK, I have a question that I'd like each of our panelists to address, and that is, thinking about what Tom Rogers had to say, would each of you assess what you consider to be the near-term potential of space tourism, and is it a business opportunity?

Mr. Rogers: Are you asking me, Lon?

Mr. Rains: No. I already know what you think, Tom. You're excluded.

Mr. Wynne: Since Tom was so kind as to be excluded, I would say that when the era of reusable launch vehicles dawns out in the year 2010 to 2020, the concept of seating as you saw across the many Apollo capsules may actually come into being. Until we conquer that aspect of physics, the aspect of space tourism is very limited. So I would say the near term would be 2020, and perhaps if we can do the reusable launch sooner, that will be the foundation technology that would allow tickets to be sold.

Mr. Noblitt: I think I could subscribe to Tom's vision. I think, like Mike, it would probably be a question of when. What's the timing involved in it? There are a lot of technologies that have to be put in place. There are a lot of activities that have to be accomplished. There is some good news, however, in the whole idea, and that is that it is potentially a very large market that would provide a lot of revenue. And any business organization finds that attractive. The question is, what is it going to cost to develop the capability and when will you have the technology to do it? I have seen some of the presentations that were made by the Japanese companies. I know Shimizu was at one time talking about 2050 as a target when they would have a hotel in space, which is a little more ambitious than what Tom showed.

Mr. Evans: I don't pretend to be an expert on this matter. But I have given it some thought and I do believe that such a market exists. The question is when. I honestly believe that if someone were to invest in changing space hab or space lab or something like that into a personnel carrier, there are enough very rich people around the world who would pay the price to go.

Dr. Kuznetsov: We have some experience in the area of space tourism. Well, what I mean is the launch of a Japanese journalist in the Soyuz vehicle. We have not had any more applications since that flight.

Mr. Rains: I'd like to do a follow-up there and ask when your prices are going to come down.

Dr. Kuznetsov: The more launches, the lower the prices.

Prof. Vallerani: I believe, conservatively speaking, space tourism does have a great attraction because it brings men into the scene, and whenever this is possible, I believe that sooner or later mankind will just embark on these types of activities. I remember that already 10 years ago I was asked by an interpreter from the United States if it was possible to transform our space lab models that we were designing at that time to carry 20 people on board. We did a very brief, I won't say study, but a very brief survey of what was possible and we got our response: It was indeed possible and feasible. The only problem, of course, was the cost of the transportation and the overall policy of authorizing. So sooner or later, in my opinion, this will happen. And it's really a difficult guess when this is going to happen.

Mr. Rogers: I was addressing a seminar of young space students about six months or a year ago, and they must have been engineers. I started beating up on them, saying, "Let's go for it. Let's move it. Let's move it!" And finally they asked, "Gee, what are you beating on us so hard for, Mr. Rogers?" I said, "Think. At your age, you have a 50/50 chance of living two or three times my age. At my age, I have a 50/50 chance of living 10 percent more of my life. I'm in a hurry! That's the first thing. The second thing, more serious, I think we will see tourism begin with sub-orbital trips. I think we'll see people going up 30, 40, 50 miles, stay up there 10 minutes, and we'll gradually boot strap our way along. It will be some time before we have large hotels in orbit.

Mr. Rains: OK. I'd like to thank all of our speakers. And I'd also like to thank all of you for sticking it out with us this afternoon.

Space Technology Hall of Fame Dinner Presentation—New Strategic Vision for Space Policy and Programs

Introduction: **General James E. Hill**, USAF (Ret.)
Chairman of the Board
U.S. Space Foundation

Featured Speaker: **Joseph Gorman**
Chairman & CEO
TRW Inc.

Gen. Hill: Well, the man we're going to be introducing to you—who until just recently controlled what kind of credit card you could get, because of the TRW credit thing—is a person who heads up one of the quality enterprises in America. It is my pleasure to introduce this evening's distinguished speaker, Mr. Joseph T. Gorman.

Joe Gorman is chairman and chief executive officer of TRW Inc. He was elected to this position in December 1988 after serving as president and chief operating officer since 1985. TRW is a leading provider of automotive, space, and defense systems worldwide. The company is the world's largest independent supplier of occupant restraint systems, steering systems, engine components, and engineered fasteners and is a leading producer of automotive electronics. For space and defense markets, TRW is a leader in spacecraft and space systems, avionic surveillance systems and software based systems for defense and commercial markets. Mr. Gorman is a trustee of the Committee for Economic Development and is a member of The Business Roundtable's policy committee, the Council on Competitiveness, and the President's Export Council. In 1994 he received Japan's Prime Minister's Trade Award for his contributions to promoting improved U.S. trade relations. Mr. Gorman holds a Bachelor of Arts from Kent State University and a LL.B. from Yale Law School. A very warm welcome to Mr. Gorman as he comes up to the podium.

Mr. Gorman: Thank you very much. I appreciate that very gracious introduction.

This evening, I had the distinct pleasure of sitting next to Gen. Joseph Ashy's wife, better known as Sue. She said, "Joe, as you go up there tonight, remember the definition of a good speech. It has a good beginning, a good ending, and they are very close together." I'll try to live up to this at this late hour.

I am indeed honored to be with you this evening and to be asked to share some of my thoughts regarding a new strategic vision for our space policies and programs. The good news about this subject, of course, is that we have a rich and highly enviable record about which we can be enormously proud: all of our space accomplishments. The bad news is that we have absolutely nothing on the horizon that even remotely resembles a comprehensive, credible, affordable, strategic vision or plan designed to help the United States achieve its critical goals in a rapidly and vastly changing world.

Moreover, in the beginning stages of contemplating this task, we must be particularly mindful of one of H.L. Mencken's admonitions. He said that for every complex problem there is a simple solution—and it is wrong. For we naturally view space issues as part of a much larger set of interrelated issues that face this country and, indeed, the entire world. It is critically important at the outset to understand the massive and profound transformational changes that are taking place all around us and that indeed will drive much of what we do for the future. It is especially important to focus on the implications of those changes, the implications for the world, the implications for the United States, and, yes, the implications for space strategies and programs.

Now, in this dimension a lot of very good people, over many years, have missed the mark badly. Allow me a few illustrative quotes. "Heavier-than-air flying machines are impossible."—Lord Kelvin, President Royal Society, 1895. "Everything that can be invented has been invented."—Charles Duell, director of the U.S. Patent Office, 1899. "Sensible and responsible women do not want to vote."—Grover Cleveland, 1905. "There is no likelihood man can ever tap the power of the atom."—Robert Millikan, Nobel Prize winner in physics, 1923. "Who the hell wants to hear actors talk?"—Harry M. Warner, Warner Brothers Pictures, 1927. And finally, "Babe Ruth made a big mistake when he gave up pitching."—Tris Speaker, 1921.

What then would be some of the examples of the massive and profound changes that will drive much of what we do and will shape our thinking, our policies, our strategies, and our plans? One of the most pervasive and profound of our time is the globalization of markets that were once regional—this is little short of phenomenal—in a relatively short period of time. Whole industries have gone elsewhere; major portions of industries have been taken away or been added. Let me give you a statistic. In 1974, the Big Three controlled 85 percent of the automobiles sold in North America. By 1994, 20 years later, that number was 56 percent, when you take into account the automobiles sold through the Big Three that were built abroad. What a fantastic and astonishing change over such a short period of time. Now, that's the most dramatic, perhaps, but what we have experienced is only the tip of the iceberg. We will continue the globalization of markets at dramatic rates.

To me, the implications are clear. We must think globally, and we must act globally. It is clearly inexorable; there's no turning back. Indeed, we should see it as an opportunity, not a problem, and, of course, it means we must be globally competitive.

The second major transformational change—and, again, it is astonishing—is the rise of Asia. We all know Japan's story, a $120 billion favorable trade balance with the rest of the world. Of that, $65 billion was negative with the United States a year ago. Using the Department of Commerce's own standards of counting jobs per billion of dollars of exports or imports, that's 1.3 million jobs. And, by the way, our trade deficit with the Japanese is $600 billion over the past 10 years. We're now approaching a $40 billion trade deficit with China. And we use to squawk like crazy when we were at $40 billion with Japan. So we have a serious problem there. In China there are 1.2 billion people. By the way, 60 percent of the population of the world is in Asia, 40 percent in China and India alone. We cannot ignore Asia. If we ignore Asia, it is at our peril.

It was Alexis de Toqueville who said, "America is great because America is good, and America will cease being good when it ceases being great."

What again are some of the implications? China is likely to become the largest economic power in the world—sheer numbers dictate it. You don't have to have a very large GNP per person when you've got 1.2 billion growing to 1.5 billion perhaps over the next few years, which will exceed the economies of both the United States and Japan.

One startling statistic: If we were to imagine that someday—it may never happen—but if someday the per capita automobile population of China were to equal today's per capita automotive population of Germany, there would be 500 million vehicles in China. To put that in perspective, there are 500 million vehicles in the world operating today.

Imagine the implications militarily. If China is the strongest economic power on Earth, it is likely to be one of the strongest, if not the strongest, military power on Earth someday. Again, imagine what that tells us about what we ought to be doing by way of policy.

Now, to me several strategic imperatives stand out as a result of these changes. Economically and geopolitically we have to follow paths that create interdependence with China, not independence. It would be unthinkable not to have a situation where China needs us an ally, wants us as an ally, and where we want and need China as an ally. So imagine some of the geopolitical alliances that might result. I'll come back to that, particularly in connection with space implications.

Third, moving closer to our subject at hand today, what about defense, national security, and global security? We are kidding ourselves if we think there is any chance of succeeding in preventing high-tech weaponry proliferation. It is not a question of whether high-tech weaponry capability will proliferate, but rather when. I'm not smart enough to tell you exactly when and who will have it, but we estimate 12 to 17 countries that do not now have the capability will have ballistic missile capability within the next 10 to 15 years. Half of those, maybe five to seven only, will also have intercontinental ballistic missile capability and nuclear warhead capability. If you accept the premise of the inevitability of the proliferation of high-tech weaponry, it doesn't take very much logic to say that implies clearly and distinctly a global overhead system that will monitor and detect what's going on in the launch business, and a global system, not just systems aimed at the former Soviet Union, that has the capability of knocking out an unfriendly launch—and over the territory of the sender, not the receiver, so the nuclear fallout falls on the sender, not the receiver. And that is a deterrent to launch in the first place.

I believe there are clear implications for space. And even if you don't believe in the inevitability of proliferation, which I think is naive, you can't—we can't—for ourselves and for our grandchildren—afford to bet otherwise.

The fourth major change is that the U.S. increasingly will be, because it must be, to some significant degree, preoccupied with its problems at home. Why? In the aggregate, our social problems and our economic problems represent really and truly a crisis. And if they are not one, they certainly will do until a real crisis comes along.

It was Alexis de Toqueville who said, "America is great because America is good, and America will cease being good when it ceases being great." Ladies and gentlemen, I submit to you that we are in grave danger of losing both our greatness and our goodness. I know that's contrary to popular convention, but hear me out. On the social front, we have some of the most serious problems in the world. You're aware of them as well as I: drugs, crime, teenage pregnancy, housing, a huge and growing gap between the haves and the have-nots, education, lack of opportunity—and the list goes on. If we don't do something about our social problems, we'll have riots in the street to a far greater extent than we do today. Our quality of life will continue to decline, and decline dramatically. So we have to address, and with a sense of urgency, those problems. Economically, where do we stand? We have a $5 trillion budget deficit, roughly. What's not talked about very often is the $14 trillion unfunded liability that we have, liabilities we've promised each other—benefits, if you will, that we've promised each other but have yet to pay over and above the tax receipts that will come in. Of that $14 trillion, $12 trillion represents Social Security—or represents entitlements, half of which is Social Security and half of which is Medicaid and Medicare. We must address that because that's 50 percent of the budget, and it's moving to 60 percent. We have in education 20 percent, at best, illiteracy, 40 percent at worst. 88 percent of our 18 year olds can't consistently put fractions in the order of size. 80 percent can't write an understandable essay on an assigned subject.

We estimate that by the time our 18-year-olds graduate from high school, they have watched 22,000 hours of television and they have been in the classroom 11,000 hours. We've gone from the best educational system in the world to the worst among 17 industrialized countries. We're dead last among those 17 in math and science, and we're almost dead last in every other subject. You say, what about the top 10 percent of those kids? We're dead last, falling in behind Hungary, when we compare our top 10 percent with the top 10 percent of the rest of the countries. Don't let anybody tell you we don't have serious educational problems in this country.

I talked about the budget deficits. Our net savings rates are the lowest in the industrial world, one-third that of Germany, one-fifth that of Japan. And we all know the economic growth is a function of productivity growth. Productivity growth is a function of investment. Investment is a function of savings. So we must find ways to reward savings and penalize consumption. We have the perverse rules at this time that work in the opposite direction. It was Mark Twain who said, "Even if you're on the right track, you'll get run over if you're not moving fast enough." We know our problems, but we are not moving fast enough.

Fifth—and I'll try to condense some of these points—Europe is in much the same shape as we are, except worse. The Europeans are where we were eight to 10 years ago in terms of competitiveness, and they're worse off in terms of social costs. So we can't expect a whole lot of help from the Europeans in helping to lead the world because they also will be relatively preoccupied with getting their own house in order over the next several years.

Sixth, several countries in central and eastern Europe are on the razor's edge as they try to convert themselves to a full-blown democracy and to a market-driven economy. We must do more to help. We've got to ensure their success, but that will be yet another drain on our resources. And, of course, all of you will know about the implications of their failure.

Seventh, the environment. Dan Goldin talked a bit about that at lunch. Imagine the dire consequences that could befall our environment as the rest of the world industrializes as we did, and perhaps with far less stringent standards, and as literally hundreds of millions of vehicles sprout around the globe. This implies placing a high priority on developing a much better understanding of likely outcomes and of, course, there is a critical role for space to play there.

It was Mark Twain who said, "Even if you're on the right track, you'll get run over if you're not moving fast enough." We know our problems, but we are not moving fast enough.

Eighth, and finally, technology. It was Mark Twain who also said, "It's a good idea to look ahead, but not farther than the eye can see." Dan touched on this at lunch as well. Now, I think that's particularly good advice here, not farther than the eye can see, because it is probably impossible, not just unlikely, to foresee with any real specificity the mind-boggling pace or magnitude of the changes that will characterize technology over the next 10, 20, or 30 years. Perhaps it is sufficient to say simply we know we are short on specifics, but that we also can predict with relative certainty that technology changes will dramatically affect what we do, how we do it and how we think about what we do, and all with an unknown but enormous implication for space.

In summary and conclusion, that, of course, is not an exhaustive list of transformational changes, but it is a list that's highly illustrative and instructive of what we've got to do as we think through a new strategic vision for space. I've tried to weave in throughout the talk key implications for each of the identified changes, not because I know they are absolutely the right ones, but rather to illustrate the difficult but necessary process that is involved in crafting long-term strategic visions for the future. However, while difficult, it certainly is not impossible, and we do deserve better in the United States. And, indeed, it is an indictment against all of us, all of us in industry, the public sector, and the private sector, that we haven't together forged and developed a consensus on a long-term vision and key strategic goals. Now, before you become overly concerned about this failing, allow me to remind you that these criticisms may also be levied against visions, policies, strategies, and programs centered on technology in general, education, economic policies, trade competitiveness and, yes, even defense. And, in fact, most of what our government is doing. Sadly our policies, programs, and priorities tend to be short-term and firefighting in nature.

All of what we've talked about tonight virtually cries out for longer-term, comprehensive, integrated, affordable, strategic objectives, plans and programs—including, of course, space. We must decide our priorities in Earth observation, space sciences, planetary and lunar exploration, military space and, particularly, defense, launch capabilities, communications—the list could go on and on.

We must streamline and be certain we are employing the right organizing principles to achieve our goals. While we, of course, must find ways to do more with less, we still have to have adequate funding on a sustained basis. We can't succeed on the cheap. Paradigm shifts are required. You all know that as well, both in the public sector and the private sector.

Space must be an important integrated part of a well-defined national agenda, a national agenda that is comprehensive, overarching, integrated, coordinated, affordable, credible—something we've not had in my lifetime. If we've had one, I certainly have not been aware of it.

Now, why space? Space allows us to transcend humankind, to go beyond ourselves, as Dan said at lunch. It can help lead us, as the people in the TRW video said, to reach environmental harmony. Its communications potential could help unite the people of the world. Truly, its vast and magical mysteries stir the soul and spark boundless imagination, and we've got to do our part to keep the dream alive. Together I know we can make it happen, and together we will make it happen. For as I regularly remind our people at TRW, failure is not an option.

Thank you very much.

The Clinton Administration's View of Space

Introduction: **Steven P. Scott**
Program Development Manager
Rockwell Space System Division

Featured Speaker: **The Hon. Lionel S. Johns**
Associate Director for Technology
Office of Science and Technology Policy,
The White House

Mr. Scott: Today is the last day of the 12th National Space Symposium. We're going to start with the Clinton administration's view of space by Lionel "Skip" Johns. Mr. Johns is the associate director for technology in the White House Office of Science and Technology Policy, which incorporated the responsibilities of the National Space Council three years ago. He is also responsible for coordinating technology research and development between federal agencies. Ladies and gentlemen, please welcome The Honorable Skip Johns.

Mr. Johns: Thank you for that introduction. It's a pleasure to return this year and be a part of the U.S. Space Foundation's 12th Annual Symposium. It is a real tribute to the success of the Foundation—and to the efforts of Dick MacLeod and his staff—that we have here so many leaders in business and government to discuss our future in space. And, as Dick has said, it's the courteous and thoughtful volunteers who make it happen.

In preparing for this talk, I sifted through some of my past comments to this group and others around the nation, and I began to realize that we have done a lot over the past three years in many areas that rely on the nation's space science and technology knowledge and thus assure the future importance of space.

Within the space community, we sometimes tend to see any changes as unique or isolated occurrences. What I want to do today is connect the dots to show a larger picture. I'd like to talk a little about some of this administration's policies from a "big picture" perspective and tie them back into the space programs and policies we're discussing today.

I will take four of the administration's high-priority areas: reinventing government, investing in technology, promoting dual-use technologies, and promoting and protecting the environment. When this administration took office, the vice president was asked to take the lead in reinventing the way government works. Under Dan Goldin's leadership, NASA was at the vanguard of this movement, not only in terms of instituting organizational and management reforms, but also in terms of redesigning its largest program, the Space Station. You have to recall that when we took office, the Space Station was practically DOA—dead on arrival. Plagued with cost overruns and lack of focus, the program had a virtually zero chance of getting through to Congress. Even with a redesign, it carried by only one vote!

The easy way out would have been to walk away from the program and forego manned space flight for decades. We did not do that. The president decided that the Space Station was a crucial investment in our future, and he directed NASA to restructure the program and seek to expand international participation in the project. Today, the Space Station is on budget and on schedule and continues to be a symbol of what nations can do in the post-Cold War era through peaceful cooperation.

I'd like to turn to another theme that this administration has pursued very strongly—investments in science and technology. When we first took office, we published a technology policy to achieve economic growth. In that report, we made the observation that, in many ways, technology is the engine of economic growth. If you want economic growth, it only follows that you have to keep your engine running. Federal investments in science and technology fuel a competitive economy.

When we took office, the Space Station was practically DOA—dead on arrival. Plagued with cost overruns and lack of focus, the program had a virtually zero chance of getting through to Congress. Even with a redesign, it carried by only one vote!

We have stepped up to the plate, with industry's help, to defend these investments. And we've done so at a time in the budget process when proposing new initiatives in nondefense discretionary spending is practically impossible. Our efforts in space transportation are a good example.

I'll bet that if I were to ask 10 of you today, "What's our biggest problem in space today?" at least eight of you would say, "the cost of space transportation." If we are going to ever fully exploit the potential of space, we have to find a more economical way to access the space environment. It was for this reason that we developed a national space transportation policy, to chart a clear course toward lower costs, both on the reusable side and on the ELV side. The NASA funding going into the RLV program and the DOD funding going into the EELV program are not merely isolated funding choices of the agencies involved. They are part of a conscious strategy to select and invest in technology for the future. That's what we said we would do, and we are doing it.

What about on the satellite side of the equation? If you look at the satellite industry today, you will see that the United States leads the world in satellite communications with, I believe, 85 percent of the world market. Our space industry provides the vast majority of the on-orbit assets as well as the ground terminals in use today for communications. This leadership exists due to the technological advantage from continuing investment that the United States has in space systems and satellite technology.

Tomorrow's cars, trucks, trains, and ships will be guided by intelligent systems that will rely on GPS for timing, positioning, and navigation. And GPS is used in all sorts of recreational activities—from hiking and camping to fishing and sailing.

On Sept. 12, 1995, leaders of the satellite communications industry met with Vice President Gore and senior government officials from the administration, NASA, DOD, and the FCC to discuss their concerns about the future of their industry. This industry group represented 20 companies from satellite manufacturers to service providers.

Several issues were raised by industry. These issues included spectrum access, trade and security, access to markets, interoperability, and technology advancement. One of the clear messages of this meeting was a call for greater cooperation between the DOD, NASA, and industry in the investment in precompetitive technologies needed to continue the U.S. global leadership in satellites and their applications.

We are leading an effort to identify high priority R&D investments for satellite technologies. Working closely with DOD and NASA, we are reviewing each agency's road map for satellite R&D investment. In parallel, industry has embarked on an effort to identify its critical technology needs and to propose an industry-government-academia partnership model. Our hope is to identify critical technology areas that will enable the agencies to meet their crucial mission needs while providing the necessary long-term R&D that will promote U.S. technological leadership and industry's continued global competitiveness. We seriously support this effort.

On the space science side, NASA's New Millennium Program lays the groundwork for an age of exploration and achievement—by developing and flight-validating innovative technologies for future missions. In NASA's vision, future space exploration will be so extensive and comprehensive that a "virtual human presence" will extend throughout the solar system and beyond.

Investing in technology is crucial, however. Now we must also capitalize on technology we have already developed. Here I want to talk about a third theme we have pushed hard—dual-use.

In my view, one of our real success stories here is GPS. As we speak today, the U. S. leads the world in the development and use of global positioning systems and technologies. Originally designed by the Department of Defense to meet the navigation and positioning needs of U.S. military forces, GPS is now being integrated into virtually every facet of our military operations. It is critical to maintaining our national defense responsibilities.

But like another dual-use defense technology with which we are all familiar—the Internet—GPS is also finding its way into our everyday lives. Today's communications systems use GPS timing signals to control the flow of information—in fact, the flow of information on the Internet is controlled by GPS (precise time feature). Police cars, fire trucks, ambulances, and other emergency vehicles are using GPS to improve their response—saving time, and airlines are gearing up to use GPS to increase safety, enhance efficiency, and reduce costs. Tomorrow's cars, trucks, trains, and ships will be guided by intelligent systems that will rely on GPS for timing, positioning, and navigation. And GPS is used in all sorts of recreational activities—from hiking and camping to fishing and sailing. By some estimates, the commercial market for GPS equipment and services could exceed $8 billion by the year 2000, and the number of civil and commercial users will outnumber military users by more than 8-to-1.

On March 28, the president approved a comprehensive new U.S. GPS policy that seeks to support continued growth of commercial applications of this amazing dual-use technology, while, at the same time, protecting our vital national security interests.

GPS is not the only example of dual-use technology. Early on in the administration, the president directed consolidation of the DOD, DOC/NOAA, and NASA polar-orbiting weather satellite activities, eliminating duplication and saving taxpayers approximately $1.3 billion over 10 years with no degradation in service. Civil and national security agencies are working with the science and natural hazards communities to identify and use, as appropriate, valuable environmental data gathered by national security assets.

There's one last area I'd like to mention where administration priorities are driving significant achievements in space, and that is protecting and preserving the environment. The president is committed to the preservation of environmental quality. But we realize that it takes more than just laws and regulations to protect the environment; it takes knowledge and understanding so that we can make effective decisions. This is where science and technology and the space program have so much to offer.

Satellite measurements from space are a unique source of knowledge, permitting us to observe, monitor, and analyze the Earth's atmosphere, oceans, land surface, and their interactions on a global scale. They have vastly increased our understanding of such critical environmental issues as climate change, deforestation, and ozone depletion; reduced our vulnerability to natural hazards; and given us new resource management capabilities. Earth observations contribute to our national security and prosperity.

This is why we have taken significant steps to strengthen and improve the satellite programs of the National Oceanic and Atmospheric Administration (NOAA), the national security agencies, and NASA's Mission to Planet Earth.

In Mission to Planet Earth, we are integrating the Landsat series of satellites with the Earth Observation System (EOS), assuring that these critical land surface measurements will be continued into the future. EOS itself has been reshaped to save money and introduce new technologies, with no delay in launch dates and no reduction in measurement capability. We are also pursuing new and creative procurement and program management practices, including purchases of data from the commercial sector and an innovative, low-cost small satellite effort called Earth System Science Pathfinder.

I've outlined in this brief time just a few examples of how the promises we made three years ago—whether on reinventing government, investing in technology, ensuring that we get the most from dual-use technologies, or preserving and protecting the environment—are coming to fruition today.

Satellite measurements from space are a unique source of knowledge, permitting us to observe, monitor, and analyze the Earth's atmosphere, oceans, land surface, and their interactions on a global scale.

I am convinced that, with the able leadership we have in this room today, both on the government and industry sides, the same drive that brought us successfully to this point will propel us into a bright tomorrow. Thank you very much.

13th National Space Symposium

Better than ever!

April 1-4, 1997

The Broadmoor
Colorado Springs

"TechNation" National Public Radio/Voice of America Radio and TV Program—The Future of the Space Program

Master Moderator: **Steven P. Scott**
Program Development Manager
Rockwell Space System Division

Session Chair: **Dr. Moira Gunn**
Producer & Host
TechNation . . . Americans & Technology

Speakers: **The Hon. Robert Walker**
Chairman, Science Committee
U.S. House of Representatives

The Hon. Joel Hefley
National Security Committee
U.S. House of Representatives

The Hon. Lionel S. Johns
Associate Director for Technology
Office of Science and Technology Policy
The White House

Dr. Edward Stone
Director
Jet Propulsion Laboratory

Mr. Scott: Next up we have a real treat—a little point, counterpoint moderated by Dr. Moira Gunn. Dr. Gunn is the producer and host of "TechNation," which is a radio and TV program heard and seen on national and public broadcasting stations and armed forces radio and television. She will lead a discussion on the future of the space program, which will be recorded for an upcoming broadcast. As a reminder, there will be no photography during this session. Dr. Gunn is a former NASA engineer and scientist. As an engineering consultant, she specializes in engineering management, technology audits, systems testing, and robotics. Ladies and gentlemen, a warm welcome for Dr. Moira Gunn. (applause)

Editor's note: The TechNation National Public Radio/Voice of America Radio and TV Program was videotaped live at the Symposium and is available on tape through Dr. Gunn.

Dr. Gunn: Live from the 12th National Space Symposium in Colorado Springs, Colorado, I'm Moira Gunn, and this is "Tech Nation," Americans and Technology. Please welcome my guests today. First of all, Congressman Bob Walker, chairman of the Science Committee for the U.S. House of Representatives; Congressman Joel Hefley, chairman, Military Installations and Facilities Committee, U.S. House of Representatives; the Honorable Lionel Johns, associate director for technology, White House Office of Science and Technology Policy; and Dr. Ed Stone, director of NASA Jet Propulsion Laboratory. Thank you, gentlemen, for joining us. I have to tell you, last year many of you were here as well. We did a radio and television broadcast and on that broadcast we were fortunate to have Dr. Edward Teller, Dr. Buzz Aldrin, Dr. Hans Mark and Gen. Jay Kelly. And it was a wonderful, wonderful panel. The next day, I came through the front door of this building, and up came Dr. Teller with his big staff, and he said, "Now, tell me the truth. I am not embarrassed to ask. More or less, how was I yesterday?" And I said, "Well, Dr. Teller, you were magnificent. In fact, you stole the show." And Dr. Teller looked faintly pleased, and he said, "You know, but you were such a nice lady. I didn't want to say anything about that ridiculous idea that Buzz has about tourism in space!" And I said, "Well, Dr. Teller, what's the problem?" And he explained his problem, and I said, "Well you know, Dr. Teller, I don't think that's Buzz's idea. I think he had a slightly different intent." And I explained. And he said,"Oh, hmmmm." And he stood up a little higher with his staff, and he held his finger up to me, and he said, "You begin to have a point." And so while Dr. Teller could not be with us today, he shall be with us today in spirit, giving us the opportunity for you, gentlemen, to begin to have a point. And with that, I think some people do need some background on just exactly how, independent of your individual status, we all relate. Now, Representative Walker, if you would start by telling us about the Science Committee, and how it affects space legislation and policy.

Representative Walker: Largely, the Science Committee has jurisdiction over all civilian research and development activities within the federal government. That includes work at the Department of

Energy, it includes work at NOAA. But one of the largest jurisdictions is NASA. We have authorization authority for those programs, meaning that we are the committee that develops policy that relates to the space programs and other science-related efforts of the government.

Dr. Gunn: Skip, the White House Office of Science and Technology Policy. How does that relate here?

Mr. Johns: The White House Office of Science and Technology Policy is in the Executive Office of the president. It is one of the mechanisms that the president has to have policy coordinated and carried out in the agencies that are in keeping with the administration's policies. We are really a consensus-building organization that works as an honest broker to get agencies working together on common administration themes. It's challenging and it's exciting.

The high ground today is space, and the ability to communicate, to navigate, to predict, to do all kinds of things in space that are so important to defense.

Dr. Gunn: You bet. Representative Hefley, I realize I did not give the complete title of your committee. If you could say it for us and tell us what it does.

Representative Hefley: It's the Department of Defense, the Military Installation and Facilities Committee of the National Security Committee, and I'm here to represent military space efforts today. It's become so enormously important to the defense structure of this country. You know, it's not a new concept that in military engagements you try to take the high ground and hold it. At Gettysburg, all of us who studied our history, we know the secret of the Union forces. They had the high ground, the Confederate forces came on against them on that high ground time and time again and couldn't dislodge them. The high ground today is space, and the ability to communicate, to navigate, to predict, to do all kinds of things in space that are so important to defense, is why I'm here today. I was looking at our panel and I'm wondering which one of us is taking Dr. Teller's place. I'm certain it's not me.

Dr. Gunn: Make no mistake, both of these congressmen, Representative Hefley and Representative Walker, also represent their entire constituencies on all issues, not just these committee policy types of things. Now Dr. Stone, tell us how NASA Jet Propulsion Laboratory fits into this picture.

Dr. Stone: JPL is one of the NASA centers and our main area of responsibility is deep-space missions—the planetary missions. We also have a role in Earth Observing Systems and in astrophysics, and some work for non-NASA agencies as well.

Dr. Gunn: Skip, I was reading this week's edition of *Space News*, and Leonard David filed a story from Washington which begins, "A soon-to-be released White House space policy downplays the prospect of humans venturing beyond low-Earth orbit anytime soon." How soon is "soon to be released," and just what time frame does the White House envision for humans venturing beyond low-Earth orbit?

Mr. Johns: First of all, with regard to the space policy itself, we have a space policy in effect that was a presidential directive of some years back. And this is to update that to better reflect what it is that the nation's space agenda will contain for the future rather than for the past. This is again a process of consensus building and we would expect it within the next 30 days. Our largest problem is getting deputies who are scattered around the world in the same room at the same time. I think our next meeting is probably later this month, during the week of the 25th of April, 1996. It's going to take probably the better part of the next month to get the last few issues that we need to get resolved, settled.

Dr. Gunn: Was that a correct report—that we might expect a downplay in humans venturing beyond low-Earth orbit?

Mr. Johns: No, not at all. What it does is it puts the development of man's space exploration more in the perspective of the problems that we need to solve before we go further for long-term missions. A space station is a critical aspect in resolving problems we have of long-term manned space presence. There are problems with bone loss, there are problems with blood chemistry changes that we need to understand and solve before man can take long-term ventures into space. We are on a continuum of pursuing manned space exploration. We have to get our problems solved on the way. There's no point in misleading the American public that we are going to run off any time soon to Mars. That doesn't mean we're not going to explore in a manned way, but we'll do it when we get our problems solved and it's safe to do so.

Dr. Gunn: Recently, Dr. Stone, NASA published a strategic plan, and one of the objectives was to establish a human presence on the moon, in the Martian system, and elsewhere in the inner solar system. It seems to me at NASA, you just keep rolling along no matter what.

Dr. Stone: Well, we have to have a vision. I think it's very important to have a vision, and I think that the public really shares the vision of humans in space. But that's a long term vision, as Skip Johns said. What we need to do then, is set in place the milestones that will make it possible, eventually, for humans to venture again beyond low-Earth orbit.

Dr. Gunn: You know, people often say to me, "Are you talking about science or are you talking about technology?" I think I've said to you in the hallway, I defy you to separate science and technology. It can't be done. At the same time, when we focus on science, Representative Walker, where do you see the leading needs in science?

Representative Walker: I think that what you have to do as a society is decide where scientific investments are going to be made and how you go about doing that in a way that makes sense. From my perspective, the way that it makes sense to begin to apportion science spending is to have the federal government do a lot of the basic science funding. The work that goes on in the universities, the work that goes on in places like JPL, where we are really pushing the envelope, where we're developing the new knowledge on which the technology and the economy of the future will be based. There are very few corporations willing and capable of doing that now. So the government has to make its investments there. But then what we ought to be doing is setting the kind of policy climate in which businesses and universities and others will take the new knowledge and apply it to solutions. Develop the technologies based upon the knowledge we've built. And that means, you've got to integrate not only science policy in what goes on in the rest of the economy, you've got to look at the totality of your policy. For example, tax policy plays a role here. You ask any technology company what's the best thing that they could have—talking about small entrepreneurial companies—what's the best thing they could have in terms of getting up and going. They'll tell you a significant cut in capital gains taxes. When you're talking about how you have the kinds of things that blend science and technology, it involves the totality of your policies in government.

Dr. Gunn: Representative Hefley, I'm not sure that science plays a role in the military needs and directions in space. How does that factor in here?

Representative Hefley: With your earlier statement, I don't know quite how you separate them, particularly when you talk about space, but with a lot of things, I don't know how you separate science and technology. Is the GPS that Skip Johns talked about earlier, is that science or is that technology? Well, it's both, of course, and extremely important. You can go into Radio Shack to get those GPS receivers for your sailboat at under $300, $400 nowadays. I suppose that is technology, but it was science that developed that, so I don't know quite how you separate those. I think one of the problems we have in Congress with our space program, and we've talked about it a lot at these symposiums and elsewhere, is the perception of the American people as to whether or not either the science or technology of space is very important. I had a meeting with a group of constituents this week and one of the statements, and it's not an uncommon statement that I get, is, "Why are we wasting all that money in space? If you're going to do science, why don't you study the oceans more? But why are we studying space, we're never going to colonize space, so why are we studying space?" It seems like no matter how many times we repeat the benefits of studying space, or the necessity of it, the American people are not as excited about it right now as we would like for them to be, and somehow we have to change that.

It seems like no matter how many times we repeat the benefits of studying space, or the necessity of it, the American people are not as excited about it right now as we would like for them to be, and somehow we have to change that.

Dr. Gunn: What about your constituents, Representative Walker?

Representative Walker: I would say that there is a similar kind of attitude among some of them, although I was in a high school this week with a lot of high school students who are using weather satellites to develop information for the classroom. You have a mix of students in there all the way from very academically oriented students to students that would be classified as among the slow learners. All of them were very, very excited about the use of what we've created in space for their learning process, and it leads them to math and physics and a lot of other things. I think some of the attitude of the older generation is that they basically have come to the conclusion that space is never a place that they're going to go and so why should we spend any time there. The attitudes of the younger generation, who see it as a part of their future, are very, very different on this. I come down on the side of the young people. I think we ought to give them their chance.

Dr. Gunn: It's interesting. I've seen and heard a lot this week, and we keep talking about the education of the young people. Everyone was so excited 25 - 30 years ago about the space program, I feel like we've got a couple of lost generations in the middle. If we have to wait for all the young people to reach the age of majority and for them to vote in their representatives who support space, we could have a problem.

It's now possible for everyone to participate, to have the same sense of discovery as the science team has. I think that's one of the marvels of the communication age, which itself was created by the space program.

Representative Walker: We had a terrible down-period, particularly in the mid-70s. In fact, in the mid-70s I had to be begged to go on the Science Committee. When I came to Congress in 1976, the Science Committee was at a low ebb. There was not much happening in the space program, there was not much happening in the energy programs, and they literally had to recruit people to go on the Science Committee. I was one of the people who was recruited. I figured out in a matter of weeks that this is what I enjoy doing, and so I've been delighted to stay there, but I think that that low ebb really had an impact on us as a country and on a couple of generations of people, and we're still building back from some damage that we did at that time.

Representative Hefley: You know, Bob Walker, the group I was speaking to was an older group, a young at heart group is what it was called, so I think you make a very good point about the generational difference.

Mr. Johns: It's interesting to look at what Bob Walker just said about seeing school kids looking at weather maps. These kids were downloading these weather maps from the Internet, which was built by defense spending originally. It was called the ARPA-net. The weather maps that they were pulling down come from the Weather Bureau. There was actually a question on Capitol Hill a couple of weeks ago where someone said, "Why don't we shut down NOAA and the Weather Bureau because we can get all that off the weather channel?" Unfortunately, it's the other way around. No Weather Bureau, no weather channel. On the GPS, for example, it's very difficult to parse science and technology. In the GPS there are rubidium and cesium clocks that control this. The development of these are very much central to the science enterprise. The fact that they were needed was a technology need for worldwide navigational capability, and so there is this reinforcement process. With NASA you have the same thing. Astrophysics and astronomy at universities in this country is 80 percent funded by NASA. The value there is the feedback from the science community to NASA as a developing agency, which reinforces and keeps us very much in the lead around the world.

Dr. Gunn: And while your GPS system on your boat is clearly a leisuretime activity, the whole GPS system is kept in place and maintained and controlled by the U.S. Space Command, the military. To think that we don't need the military space, you have to think again. They are all so interconnected efforts here in the United States.

Mr. Johns: I'd like to get it straight, though. My boat is therapy.

Dr. Gunn: I see. A lot of those JPL pictures that you're downloading come right out of your lab.

Dr. Stone: That's right. I think another thing that makes it possible for everyone to participate is the World Wide Web. On the JPL home page we have millions of hits whenever there's a major event— like the Shoemaker-Levy 9 comet impacts on Jupiter, or last December when the Galileo probe dropped into Jupiter. This summer when we're flying by the moons of Jupiter we're going to be on-line so that anyone with a terminal can see the latest data coming back from space. It's now possible for everyone to participate, to have the same sense of discovery as the science team has. I think that's one of the marvels of the communication age, which itself was created by the space program.

Mr. Johns: And you can find that from the White House home page, which was created in my office.

Dr. Gunn: It's good to know you don't spend all your time on your boat.

Representative Walker: I think another interesting thing about student participation, though, is this most recent shuttle flight where we had on it a camera called Kidsat, put on a shuttle just for students' use, and the students actually determined what images that camera would take, where it would take them around the world. There were three high schools around the country that were running 24-hour shifts to program this camera, the data would come back to the students in their classroom. It was a wonderful learning experience. A fifth grader I was talking to at JPL explained to me where the various nations in the world were. She showed me a little fuzzy blob in one of the pictures of the desert and said, "That's a little town. The name of that little town was Garden, because it was a garden spot in the middle of the desert." She was just ecstatic about having discovered this place herself.

Dr. Gunn: Now let me make a point. We all know what it's like to go to the lecture and listen to someone telling you something. As you were saying earlier, Representative Hefley, no matter how many times we repeat the benefits of space it's like, are you not hearing? Are you not comprehending? We know that when you do it yourself, you get the picture. We have been talking, do we send humans out there or just unmanned probes. What your example is, is telerobotics. A student, who is perhaps 12-years old, understands that she can direct sensors from space and what she can do with them. Now this person gets it. Her parents may not get it, but they vote and pay taxes. I think that when we're talking about how does the American public get it, we've got to put some of that kinesthetic, that feel, into what they're doing so they can comprehend.

Representative Walker: That's one of the reasons that Buzz Aldrin's idea of space tourism becomes very, very important. The moment that people think they have a real opportunity to go into space at some point in the future you will change the dynamic of how we discuss space on Earth, and you'll change the political discussion in a very major way.

Dr. Gunn: Actually, that may have been what I told Dr. Teller, that he could go. I don't know if you gentlemen were here yesterday to hear Dan Goldin, the head administrator for NASA speak, but I know that you're all acquainted with him and his approach, so how do you feel about Tang and Velcro?

Representative Walker: Obviously the spinoff benefits into the economy are an important part of all of this. As you develop and as these missions go forward and you find unique things, the fact is they are very, very important. It's one of the things we've tried to describe to the public, and the public just says, "Well, it would have been done anyway." That's not something that has made a real difference except that at town meetings where the issue comes up of why are you involved in the space program and why you spend all your time doing that and why are we spending all that money. I will go down through and begin ticking off things that are in their everyday life. I say to them for example, "Do you like the idea that you are able to sit down at your TV set in the evening and get the news from around the world instantaneously?" When I was growing up as a kid, that was not possible. We had to wait for the film to be delivered, and sometimes it took days. And most people will say, "Yeah, that is a benefit, but that has nothing to do with the space program." And I say, "Where do you think the pictures are coming from?"

Dr. Gunn: I thought he made some very interesting points, including when you get the idea that there are products and services coming from space, when a new program comes up, it seems that you've got to predict what those products and services are going to be. I think what he was asking us, in part, to say, is we know now that the space program of the past has produced positively for us, without prediction as to what it was going to do. We ask that you support the space program in the future without a psychic view of what is actually going to happen. Do you feel with your constituents that that would be a tough sale and also from the White House perspective?

"Do you like the idea that you are able to sit down at your TV set in the evening and get the news from around the world instantaneously?" When I was growing up as a kid, that was not possible.

Representative Walker: Well, there's an old story and it fits with this. It's been true of basic research forever that politicians like to know what it is. There's a story about an Israeli visiting a scientist in his lab. The Israeli was making a point, "What is it you're producing here?" And basic science was being done. And basic science was not of course going to give him the answer that he wanted. Finally, the scientist became so frustrated with the Israeli's question, he said, "I don't know what it is we're going to get, but whatever it is, I'm sure you're going to tax it." You've always had that kind of byplay between scientists and politicians on these issues.

Representative Hefley: You know that the Persian Gulf War did a great deal for military space. It showed people a great deal about what can be done in space.

When I first went to Congress, when Bob Walker first went to Congress, the big debate was, oh, let's don't militarize space. The fact that you could probably make a case that the V2 rockets had something to do with space didn't mean anything. Let's don't militarize space. You don't hear that argument anymore. You hear the argument about what you ought to do in space. You don't hear anyone saying, well, we don't want military communications satellites in space anymore, or observation satellites, or those kinds of things. From that standpoint, the Persian Gulf War was an asset, I think, to our argument from a defense standpoint about the need for space.

Dr. Gunn: Representative Walker, you introduced HR-1953, the Space Business Incentive Act. Can you tell us about that legislation and the issues around it and what it's trying to accomplish?

Finally, the scientist became so frustrated with the Israeli's question, he said, "I don't know what it is we're going to get, but whatever it is, I'm sure you're going to tax it."

Representative Walker: What we're trying to do is get people more interested in putting investment dollars out of the private sector into space activities. I don't think anybody can analyze the space enterprise of the future and figure that the federal government is going to be able to make all the investments necessary. And so the more that you can attract investment from the private sector, the better off we are. What this bill is trying to do is to first of all begin to diminish some of the regulatory barriers that government has put in the way of investment. We have tried to get government out of competition with the private sector so that the private sector can flourish and not have a government-run program as a competitor. We are trying to make certain that we have appropriate tax incentives. For example, we say that if in fact you are manufacturing something in space, you will get 10 years of tax-free profits for that which you manufacture in space. It doesn't cost us anything because no one's doing manufacturing in space at the present time, but if you ever got there, just think of all the infrastructure that would be developed. It would be worth it to the country to provide those incentives to people. We're doing a number of things and trying to attract more in the way of the investment of the total GDP of our country into space than we get if you simply depend upon government budget strings.

Mr. Johns: I think one of the things that we can see in the immediate future is that communication is going to continue and expand considerably. The prospect of growing from 50 to 600 or even 700 of what we call LEO or MEO (low-Earth orbit or medium-Earth orbit) satellites put up in space by commercial operators is very likely. If that's the case, we're talking about doubling the number of commercial satellites that are put up relative to the number that the government puts up. The only way our companies are going to be able to have that launch business is to be competitive in a global market. The satellite folks who want those up are going to go for the lowest launch cost. We've already lost 50 percent of the launch market in the world on those communication satellites. We'd like to get that back. So we can see that there is a desirability in a partnership for lower cost access to space. It costs nominally $10,000 a pound. That would suggest that a person like me should lose a lot of weight before I plan to go spend a weekend in space. The ways that we get those costs down are in development programs that have to be joint efforts with industry. Industry alone can't afford the cost of those developments. The government represents some part of that market, but we want the companies not to be stuck with a U.S. government market that is not price-competitive with the rest of the world. The government gets a better price if it gets a world competitive price and our launch industry will be competitive with anyone in the world. We're striving to achieve that, and it's important to make those investments.

Dr. Gunn: I have to say that I see a lot of JPL things on NASA Select, which is wonderful, and I'm frequently engaged by others to discuss the pros and cons of NASA Select, NASA's own TV channel, and the issues mainly fall in two categories: that a good deal of the time is spent with cameras focused on sort of a near empty control room, and the joke is that there was more action when we let them smoke. People constantly ask me about that. Another is the fear that young people may not be watching. I've got some good news, and I've got some bad news. I have a 13-year old son, and every time he turns on the television he cycles through the major networks, MTV, and NASA Select. He's not alone. This is true of all his friends, without fail. Now we have the bad news. The other day, he was looking at an Apollo 13 documentary, it being the anniversary, and then they rolled right into Shannon Lucid's shuttle hooking up with MIR, and he said, "This is so great, she's up there right now." And then out of the clear blue sky he said to me, "We bought MIR, right?" I said, "No, no, no." He goes, "No, Mom, no, we bought the Space Station." I had to explain it to him. And when I explained it to him, he said, "What a good idea. This is really good." I said "Yeah, it is really good." Now with that introduction, I want to ask you, how do you gentlemen see the U.S. working with other national governments, and of course within that, however you want to discuss that, what areas should we be working in, and what share of the financial burden must the U.S. government expect to shoulder?

Mr. Johns: Ability to pay has to have something to do with it. The good news is we're a $6.7 trillion dollar economy and growing towards $7 trillion very rapidly. That would suggest that if a nation that has a $1 trillion economy is going to participate, they can't afford to participate at the level we do. The Space Station is a 14-nation endeavor which shares those activities. Not only is it an effort to pursue science, with the very companies that Bob Walker wants to see manufacture in space. What they're going to manufacture is what has been proven on the shuttle can be done. Once it has been established that something valuable can be produced in space, then you will go to the step to producing it and they will use those tax breaks to do that, or a tax holiday for a while. It's a complex process, but it's important that we have that station there, both for the human physiology things that I spoke of to enable us physically to go farther, but also as a science laboratory that is reliable. It will be there for a long period of time. You will be able to go back and do experiments the way the science community expects to do it. The industry from around the world is interested in pursuing those opportunities. That's how space is going to be further developed. Some of these things are quite long term—an industry, a company, can't afford to make these kinds of investments. There have to be in partnerships with other governments.

Dr. Gunn: Representative Walker, is this an idea that the Congress finds receptive, or is there some disparity there?

Representative Walker: I don't think so. I think Congress has come to the conclusion that if you are going to do very, very big engineering projects that are related to our science endeavor, in particular, if you're going to build the new machines that give you the basic science, whether they be a Space Station laboratory or whether they be a new fusion machine, those are going to have be done internationally. No one country can afford to foot the entire bill. Plus the fact that all of these projects become international in character anyway. You can't stop international scientists from participating in them, and so it's better from the outset to have the partnerships developed so that the entire world is involved in building the project as well as participating in the results from it. I believe that in Congress we are coming more and more to the conclusion that as you look at these big projects for the future, that going the international route makes an awful lot of sense.

Dr. Gunn: Representative Hefley, what we're talking about, though, is the science community. We're not talking about military corroboration in space.

Representative Hefley: No, we're really not. In spite of the fact that I think that you're going to see more shared satellites between military and NASA and NOAA and so forth, we're not going to see much shared activity with other nations when it comes to military satellites.

Dr. Gunn: At JPL, Dr. Stone, do you have affiliation with working outside the U.S.?

The whole world benefits from those scientific achievements. So it's perfectly natural that in space those science endeavors would be undertaken in a cooperative manner.

Dr. Stone: In the space science area, this is a long tradition. The Galileo spacecraft has a German-built main engine on it, the Cassini spacecraft that will be launched to Saturn at the end of 1997 carries the ESA-developed Huygens probe that will drop into the atmosphere of Titan. The probe carries both European and U.S. experiments. The main radio system which will be used to radar-map Titan and transfer data back is an Italian developed system. There has been a very strong tradition, and I think it will grow as we continue to open the space frontier.

Representative Hefley: It's important to recognize there is a long tradition that all nations and all scientists always share scientific development. The whole world benefits from those scientific achievements. So it's perfectly natural that in space those science endeavors would be undertaken in a cooperative manner. The Internet allows them to talk more easily across the globe in that process.

Representative Walker: An interesting piece of that was when we were in the midst of the Cold War. I was in Russia and was visiting one of the laboratories where they were building one of the Russian scientific satellites. They were very proudly showing me at that point an American experiment that was aboard that Russian satellite and, as I say, this was when we were in the depths of the Cold War, so that is a very, very long-standing tradition.

Dr. Gunn: Again, getting back to the point I keep bringing up with Representative Hefley, is that everybody knows about the Internet. Back when I started at NASA, it was the ARPA Net, the Advanced Research Project Agency net, the Defense Advanced Research Projects Agency network was a defense network, but then had civilian uses. So once again, we've seeded in the military and then proceed forward to a civilian use.

Representative Hefley: We really are. I think this raises an issue. We've had a tremendous drawdown in our defense budgets in recent years. If you're drawing down the defense budget, where is the emphasis going to go? Is it going to go on barracks and training facilities at Fort Carson? Or is it going to go into space? Of course, some is going to go both places, but when you're talking about readiness of troops, that's going to have to compete with space. I think we need to look at our defense budget and determine whether or not we're really doing the right thing with the level of drawdown that we're doing today. Of course we can draw down, the Cold War are over, but there are still a lot of very real threats out there, and as we draw down I think the military space effort, which has contributed to the civilian community as well as you indicate, also will suffer.

Dr. Gunn: I think what can affect military budgets is also the kind of thing that Dan Goldin was talking about affecting a NASA budget. Now you would expect the military to go in and ask for more money. You would expect everybody to go in and ask for more money, including NASA. And what he's saying is that when we have a very large program, that perhaps may be aging, or perhaps there's a new way to go, cancelling that program, pulling it back means losing jobs. And when you lose jobs, there can be a fight in Congress.

In an age when information is instantaneously transmitted globally, the nation that develops the base of new knowledge is going to succeed all the time.

Representative Walker: It has its ramifications well beyond that. When you draw down the defense R&D, it also has an impact on civilian research and development because as I go out to the university campuses right now, they are complaining about the fact that they are not getting R&D money, but when you figure out where it is that they have lost most, it's been lost from military research and development. We have maintained the National Science Foundation and a number of those agencies that fund the civilian research, but the drawdown of military research and development has had a significant impact, which means that researchers are not getting the kinds of money they need for a variety of activities going on across the country. So that has been a real problem for us.

Representative Hefley: It's important to recognize that the Department of Defense, when it found some years back that there just wasn't the talent base, started funding advanced degrees in engineering. DOD funds 65 percent of the advanced degrees in engineering in the United States, directly in universities, that's nearly $1.7 billion. The reason is, we need that talent, and it's not going to be funded somewhere else. If you cut that back, NSF couldn't begin to pick that up. NSF alone is roughly a $3 billion budget. So you can see to try and pick up an extra 1.7 would be very difficult indeed.

Representative Walker: The real danger here, I might say, to some of that military R&D is that it has been mission oriented. If you wonder why it is that the GPS, and a lot of these other things that we've cited today, are having the major spinoff benefits to the civilian economy, it's because they have been related to a mission. They had to actually accomplish something that came out for real in the end, which, oh by the way, can then be adapted to fairly easily into the civilian economy, such as the Internet or GPS. When you do a lot of other kinds of technology development in the government, it is not necessarily related directly to a mission, and therefore does not have the same practical impact into the economy.

Dr. Gunn: I'm going to ask Representative Walker and Dr. Stone, I'm going to ask you both, understanding that everybody always has lots of different opinions here, Representative Walker, from your point of view, what are the major areas in science that are a priority for the country?

Representative Walker: You have to have new knowledge in order to sustain the economy. In an age when information is instantaneously transmitted globally, the nation that develops the base of new knowledge is going to succeed all the time. Therefore, I think your first time investment has to be made in the underlying basic science that gives you the knowledge from which to build your economy. Beyond that, I think we have missions that we want to do as a nation, and we ought to be investing in those things which are mission oriented, that give us a chance to move ahead. And then I think we need to develop an interface that assures that the knowledge and the mission or work we do gets transmitted into our economy. We ought to build the kind of financial strength free from debt, free from deficits, so that you can in fact have a tax policy that makes sense and encourages investment over the broad base of the economy, so that R&D becomes a real practical help to people's lives and produces jobs.

Dr. Gunn: Dr. Stone, you are a rocket scientist. From your perspective, what are the priorities for science for the country?

Dr. Stone: Let me just focus on space science, because science is a very broad area, and there are very many important things to be done in science in general. In space science the focus of the future is in a general sense what it has been, that is, trying to understand how it all began, understand how things have evolved to what they are today, and therefore try to understand how they're going to continue to evolve. That's the case for the universe, for the solar system, and for Earth. I think another focus will be the origin and evolution of life. How did life begin? What were the conditions that led to the origin of life here on Earth. Did life begin anywhere else in the solar system? Is life anywhere else in the galaxy? I think these are the kinds of fundamental questions. In the process of developing the tools by which we can try to answer those questions, we get the technology investment that we've talking so much about this morning, technology that has many other implications and uses which are not even imagined when we're trying to answer these very fundamental questions.

Dr. Gunn: And if you could, so that people listening could hear, as a specific example, tell about the Mars program that's going on right now?

Dr. Stone: We have now a Mars program called the Mars Surveyor Program. We're going to Mars every 26 months, which is as often as you can go with the orbits of the planets. We know there was a lot of water on Mars 3.5 billion years ago, and we'd like to know if simple life actually evolved during that wet period on Mars? So we're beginning to explore the surface of Mars, and on July 4, 1997, we're planning to land a small micro-rover, about 12 kilogram mass, 8 watts average power, that will be able to image the surface, image the rocks, and analyze their composition. It's just the first step of what is hopefully a systematic exploration of a neighboring planet where life could well have originated some billions of years ago.

Dr. Gunn: Skip and Representative Hefley, I didn't mean to leave the White House and the state of Colorado out of this. Do you want to add anything about the priorities of science for the country?

Representative Hefley: I think that something Representative Walker said, tying in with what was just said, I am fascinated by the studies of the origin of the universe and that kind of thing, but that's kind of a subject for rocket scientists. The thing that really got the American people excited was what Representative Walker said, that defense is mission oriented. When NASA was mission oriented, America got excited. What was the mission? We're going to put a man on the moon in this decade and we're going to bring him home. Wow! This is a mission we can all get excited about. I'm sure we could all get excited about the Mars mission, as a matter of fact, too. That excites me when you start talking about that. Somehow or other the selling of that is something we need to do better.

How did life begin? What were the conditions that led to the origin of life here on Earth. Did life begin anywhere else in the solar system? Is life anywhere else in the galaxy?

Mr. Johns: In order not to have the rest of science set aside, we have to remember that in the late 1800s the average life expectancy of humans was 45. Today, it's 76 for women, and 72 for men—we're going to have to work on that in the men's department. It is the investment in life sciences that has made us understand things just a whole lot better. We know that the resources that our economies depend on are finite. There is a finite amount of oil in the world. If, as we heard last night, 50 million cars are driving around in Japan, they're going to have to burn something beside fossil fuels, both for environmental reasons and for energy availability reasons. We need the science to develop new energy, and these are not investments companies can make. Yet they are headed towards technology solutions to problems on life on Earth. We need to continue to make those kinds of investments.

Dr. Gunn: This has to do with what I call the business of science, the business of technology. Representative Hefley, you are right when we said, "Let's go. Let's send a guy to the moon, and let's get him back." Wow! I asked on a panel, and I think it must be two years ago, Skip and I were on the same panel, and Dr. Carolyn Huntoon, who was head of NASA's Johnson Space Center was there as well, as well as a number of other people, and I asked, "OK, first time we sent somebody to the moon and came back, it took 10 years. How about if we sent somebody there today, how long would it take?" The shortest estimate I got was 15 years. I said, "How could that be? That makes no sense." But Dr. Huntoon said, in a very quiet, even voice, "You have to understand. We had no idea what we were doing to Buzz when we sent him out there and had him come back. And it's the life sciences that teaches this. It's great for the movie of the week to send somebody to the moon and come back, but they're not going to tune in next week when all we're doing is monitoring those type of things. We have to say what it is that involves people and that gets that benefit, and that's a tough sell. In closing here, I'm going to ask each of you gentlemen to do something a little difficult. I'm going to ask each of you, just for one minute, to put aside the fact that you may be congressmen or a member of the White House staff or a NASA scientist, and put aside policies and budgets and elections and even the media, this can be difficult. Each of you are individuals and you're American citizens, just like every American listening today. From your personal beliefs, why space?

I think that we are at the unique point in history when we have a chance to step beyond ourselves and go where humankind will be going at some point in the future, and we've got to take advantage of that opportunity.

Dr. Stone: I think space represents a sense of a future of opportunity. It really is a sense of being able to learn something new, to be able to go somewhere no one has gone before. In a very general sense, space is a symbol of a future of new opportunities, which I think is crucial for our civilization.

Representative Hefley: I've always been very intrigued by the idea of pushing the envelope, pushing the frontiers of science. That somehow or other that's our destiny. We conquer diseases, there's not much smallpox in the world. There's very little polio, at least in this country, and there shouldn't be anywhere. That is kind of the mark of what we are in this country and many other countries, as a matter of fact. I get excited about any pushing of that envelope of science to try to discover what we didn't know before.

Mr. Johns: Suppose I said to you, "You have just elected me president, and I've decided we've sent somebody to the bottom of the ocean, so we're not going to do that anymore. We sent somebody to the moon so we're not going to do that anymore. We're just going to sort of make do with what we know today." What kind of world would that be? That's just not a place where I think any of us want to live. We've just got to keep looking for new challenges. That's what makes us all tick.

Representative Walker: I've often said to myself, "Do I believe that humankind will at some time explore and populate space?" And I believe that at some point we will. Then you say to yourself, "If we have the capability of beginning that mission today, shouldn't we do it?" Wouldn't it be a failure of our generation not to move ahead on that which we know future generations will do? I think that we are at the unique point in history when we have a chance to step beyond ourselves and go where humankind will be going at some point in the future, and we've got to take advantage of that opportunity.

Dr. Gunn: Thank you, gentlemen, thank you for joining me, and could we have a warm round of applause? First of all, Representative Bob Walker, chairman, Science Committee, U.S. House of Representatives; Representative Joel Hefley, chairman, Military Installations and Facilities Committee, U.S. House of Representatives; Skip Johns, Associate Director for Technology, White House Office of Science and Technology Policy; Dr. Edward Stone, director, Jet Propulsion Laboratory. I want to thank Dick MacLeod, president of the U.S. Space Foundation and the Foundation itself and its wonderful volunteers for inviting us today, and for their unflagging support of Tech Nation. Thank you, big round of applause for Dick MacLeod. I want to ask everyone listening to support the space program, today and in the future, based simply and solely on the knowledge that our past endeavors in space have positively benefitted every one of us... every part of our society, every nation on Earth, every member of the human race without fail, without exception. It is the space program of the past that enables Tech Nation to broadcast and to reach every person on this planet today. And to everyone listening to my voice now, ask yourself, "Why space?" And you will know, why we must go. For TechNation, I'm Moira Gunn.

The Emotional & Spiritual Aspects of *Space: Enhancing Life Here on Earth*

Moderator: **Steven P. Scott**
Program Development Manager
Rockwell Space Systems Division

Featured Speaker: **The Honorable Jake Garn**
Vice Chairman, Huntsman Chemical Corporation
Former U.S. Senator and Astronaut

Mr. Scott: Now we're ready for our closing address. We're very honored to have Jake Garn deliver it. Jake is currently the vice chairman of Huntsman Corp., and served in the United States Senate from Utah for 18 years. While senator, he flew aboard the Space Shuttle Discovery as a payload specialist. In 1992, he was the recipient of the very prestigious Wright Brothers Memorial Trophy. Ladies and gentlemen, please, a warm welcome for Sen. and Astronaut Jake Garn.

Sen. Garn: Thank you very much, and I'm certainly pleased to be with you today to take part in this symposium. I used to come to the symposium when I was still a member of the Senate. I never had the opportunity to stay very long—it was always come and appear and catch an airplane back to Washington—so I enjoyed the banquet very much last evening.

What I'd like to do today is take a little different tact than we normally talk about, and I certainly don't in any way mean to diminish the technological spinoffs that have occurred through space exploration and development. But I would not take your time to repeat them because all of you know them as well as I do. I'd like to talk more about the emotional and the spiritual aspects of enhancing life here on Earth as a result of flying in space, and to talk about the amazing speed of technological change. As a matter of fact, as I sit here looking at Buzz Aldrin, it reminds me of sitting with my father when Neil (Armstrong) and Buzz walked on the moon. My father was a real pioneer in aviation. He got his wings in April of 1917, and was a World War I aviator. I had to be a pilot or never come home. I had no choice whatsoever. "Don't ever darken my door again, kid, unless you become a military aviator." I'll never forget when my wings were pinned on, my wife stepped aside and let my father pin them on—and he was Utah's first Director of Aeronautics. He started to cry when he saw Neil and Buzz walking on the moon. I said, "Dad, why are you crying? This is not a sad event, this is an historic event." He said, "Oh, Jake, I'm not crying because I'm sad. I'm just overcome with emotion to think that here I am sitting with my son and watching a man walk on the surface of the moon, because when I was 10 years old your grandfather read me the story about the Wright Brothers' first flight." So when you think about that, my dad was 10 years old, and he lived long enough, from the Wright brothers' first flight, to see Buzz walking on the moon—in just a period of 66 years.

When I look at my own flying background, I'm sorry that I'm old enough to remember learning to fly with low frequency radio range stations. VORs did not exist. And the Morse code, di da's and da dit's, a's and n's and the bi signal zones, listening to hums in your ears and hoping it wasn't a thunderstorm. And I can remember being amazed when I'd shoot an instrument approach and break out of the overcast and there was a runway in front of me. It was always sort of a surprise. And now I've got a hand-held GPS which pinpoints every navigational fix in North, Central, and South America, and I could buy the rest of the world for $39.95. I'm not going to because my airplane is not going to cross any ocean so I don't need the rest of the world.

We live in a remarkable time and a remarkable age. When I hear that people are not excited about space, I dispute that. It's 11 years this morning since I had the opportunity to launch on Discovery, and I'm still doing a couple of schools a week after 11 years, talking to young people about space and the excitement of space. It's amazing how talented those young people are and how good their questions are. Much better in many cases than adults'. I wish Congress was as far-sighted as the grade school children of this country. They are not, and I can stand up here and criticize Congress because I spent 18 years there.

We live in a remarkable time and a remarkable age. When I hear that people are not excited about space, I dispute that.

I'm an insider so I can say it. Congress is not very far-sighted. They have a very good way of looking at what happens between now and the next election—but to look at something 10 or 15 or 20 years down the road, when they probably won't be there to take credit for it, is much more difficult to do. So we look at a space budget that continues to go down and down and down, and I can remember when I was a brand new freshman senator in January of 1975 and was assigned to the Space Committee in the Senate, which at that time was a separate full committee. I was chairman of NASA's Appropriations subcommittee for six years, and I can remember over and over again making the promise that we could keep NASA whole for inflation. We couldn't promise them any more, but at least their purchasing power would not decline. No administration, no Congress has kept that promise.

I am often asked this question, "Why do we waste money in space when there are so many problems here on Earth?" Let's put it in perspective. When I hear people say, "Why don't we cancel the Space Station?" I say, "Why don't we go further? Let's cancel NASA. We simply can't afford a civilian space program." Boy, that would save a lot of money, about 9/10ths of one percent of the whole budget. People are surprised when they hear that number. They're surprised when they hear that food stamps alone last year were double NASA's entire budget. We're hardly doing enough when we look to the future. We're eating our seed corn. We need a lot more vision. We need people in Congress and in administrations who can look to the future. I don't know, Bob, maybe term limitations would solve that problem, because the next closest thing to eternal life on this Earth is being a federal bureaucrat or member of Congress. Maybe term limitations would solve that and there would be a little more courage to look to the future.

If anybody had told me when I was a kid growing up in Utah that I would have the opportunity to fly in a reusable spacecraft and orbit the Earth 109 times, I would have smiled and said, "Uh huh, and what have you been smoking?"

We do have some serious problems on funding, and it's difficult to manage a NASA budget when Congress wants every program maintained: "Let's keep Mission to Planet Earth, let's build a Space Station, let's continue shuttle operations." Some people forget there's an aeronautical component of NASA as well as a space component. Super-critical wings, high bypass engines, all kinds of technology we use here on Earth in commercial airplanes that have nothing to do with space. We're spending 9/10ths of one percent of our whole budget on that entire effort, both in space and in aeronautics. A lot more needs to be done.

Again, to indicate that there is interest in space, I had an exciting evening last October. The Space Shuttle Discovery stopped in Salt Lake City. It wasn't just because it was a Space Shuttle, it was MY Space Shuttle. It took two or three days of delays. They had problems with the chase airplane, and so on. They were taking it to California for a year of rehabilitation. But it was MY Space Shuttle, Discovery, and it's lucky the people were looking at the shuttle when it taxied up to the ramp, because I started to cry. I got tears in my eyes. Do you know what happened? People say there's no interest in space? We didn't know what time the shuttle would show up. Finally it showed up on the third day at 8 o'clock at night and more than 100,000 people in Salt Lake City showed up just to look at it sitting on the back of a 747. They were going to close it down at midnight but they couldn't, and they kept it open all night with spotlights on it so that they could accommodate the crowds. We had traffic jams on the freeway, people couldn't get to the airport. They'd abandon their cars on the freeways and climb the fences and walk over to see it.

Somehow Congress has got to realize that these stories, these myths, that there isn't interest among the American people are wrong. Until both Republicans and Democrats recognize that you can't cut the one-third of a budget enough or raise taxes enough to solve the budget problems until you do something about the two-thirds that are entitlements programs and interest on the national debt, we're never going to solve the budget problem. In fact, there won't be any one-third left. I spent 16 years on the Senate Appropriations Committee, so I know something about the budget. You simply can't do it. You can't cut NASA, you can't cut defense, you can't cut national parks, you can't cut all the discretionary programs enough. You can eliminate the entire one-third and the budget still won't balance. Not until politicians have enough courage to say "no," no matter how unpleasant it may be with Medicare, Medicaid, Social Security, food stamps and all of those. We have got to restrain the growth of those programs. Maybe term limits would help that, too.

Now I've wandered far off what I started to say and I'm going to get back to it right now. I've said enough, and I'm sorry people like Bob Walker are leaving because he's one of those who understands what I'm talking about and has been a leader for many, many years. I consider him a friend who has fought for the future. Unfortunately, too many of the good people in both parties are the ones who are leaving, while the ones who are staying are those who will put up with any indignity from the press just for the power and glory of staying in the Congress of the United States. It's the good guys that leave, unfortunately. But let me talk about the other aspect of enhancing life on Earth. If anybody had told me when I was a kid growing up in Utah that I would have the opportunity to fly in a reusable spacecraft and orbit the Earth 109 times, I would have smiled and said, "Uh huh, and what have you been smoking?" Because when I was a kid, nothing had flown in space. As a matter of fact, Sputnik did not fly until three years after I had graduated from college. So if anybody had even told me when I was a senior at the University of Utah, "You'll fly in a reusable spacecraft," I would have said, "Sure, uh huh."

It's still the old Walter Mitty dream. I wake up many mornings and think, "Did I really get to do that? Did I really launch on Discovery 11 years ago this morning?" It still seems like sort of a wild, wild dream. I had a great crew that I still stay very close to. All of us on that crew had a lot of discussions while we were flying up there. First of all, I don't think anybody who's ever flown in space feels that they have the ability or the vocabulary or the intelligence to describe how magnificently beautiful this planet is from space. Or to describe how peaceful it looks. But of course having lived on the surface you recognize that it isn't very peaceful and that's why, while recognizing the great beauty of this Earth and the marvelous feeling of traveling at 25 times the speed of sound and being able to do things that Mary Lou Rhetten couldn't even think of doing in zero gravity, that we discussed how angry and frustrated we were with what was going on on the surface of the Earth. At the time we were flying, the Iran-Iraq war was going on, and Ayatollah Khomeini and Saddam Hussein were killing hundreds of thousands of each other's people. You obviously recognize where countries are from your geography lessons and you can identify them, but you certainly don't see national boundaries and stars for national capitals from space. So you look down at that situation and you can't fly in space without recognizing that we're all God's children on this planet, traveling on Spaceship Earth together and it doesn't matter where we live, it doesn't matter what the color of our skin, and it doesn't matter what language we speak—we are children of God traveling on Spaceship Earth together.

And the way we treat each other and the way we behave doesn't make any sense. I wish somebody could explain to this human being what is going on in Bosnia. I am not capable of understanding what ethnic cleansing is. Do these people think that killing each other and doing it in the name of God is pleasing to God? I have seven children. I like them to behave well. I can't imagine being pleased if they are arguing and fighting and killing each other. It doesn't make any sense whatsoever. I have often said that if I could take the Hitlers, the Stalins, the Ayatollahs, those type of people into space and let them see the perspective from this Earth that Buzz and I have seen, that I could turn them into nice people. But if I'm wrong, it wouldn't make any difference, we'd just leave them in orbit and that would solve the problem as well. There are a lot of those intangible benefits that don't come in the category of spinoffs and technology and eight or nine dollars back in the private sector for every dollar we spend.

As we were flying too, you'd look down and you'd look at countries such as Korea, and you'd say, "What's the difference between North and South Korea?" They're all Koreans, for the most part. They're not an ethnic mix like I am. I'm Scotch, Welsh, Dutch, Norwegian, Danish, English and German. I'm more NATO than the NATO organization. What's the difference? Why do you have a North Korea that's still a very sterile police state, compared to a South Korea that has shipyards and automobile factories and a dynamic, growing society? It's just like getting hit in the head with a two-by-four right between the eyes. You say, "The difference is freedom." The difference is freedom. Same experience flying over Europe and saying, "What's the difference between East and West Berlin?" The answer is freedom. You come to the conclusion that it's absolutely amazing, absolutely startling, how talented men and women are. How incredibly talented human beings are, how creative when they're free. So it's certainly enhanced my patriotism of this country, to think how fortunate we are to live in a country that gives us all of our free choices, to choose with whom we associate, where we go to school, what profession we follow. That's why we have produced so much, because we have been free. So I'm one of those who think we happen to have an obligation to our fellow citizens on planet Earth to help them be free. As critical as I am in many areas, as different as I am from President Clinton on a lot of issues, I am not critical of trying to help solve the Bosnian situation. I am critical when we say God's other children don't deserve to be free, too. They deserve to be able to use their talent and be creative and choose what they will do with their lives. So those kind of feelings come as well, as you orbit the Earth.

So you look down at that situation and you can't fly in space without recognizing that we're all God's children on this planet, traveling on Spaceship Earth together and it doesn't matter where we live, it doesn't matter what the color of our skin, and it doesn't matter what language we speak—we are children of God traveling on Spaceship Earth together.

As a matter of fact I was in Germany in November of 1989 with Sen. Bob Dole and some other senators, and I thought I was knowledgeable, but I guess I wasn't really prepared to see on the ground the difference between East and West Berlin. It was a few weeks before Christmas, and in West Berlin there were Mercedes and Beemers running around, women in fur coats, beautifully decorated storefronts. It didn't look too much different than an American city at that time of year until I walked through Checkpoint Charlie to see block after block of areas that had not been rebuilt since the end of World War II, to see a very drab, gray society—a few of those Trabant cars running around, spewing out pollution, very little street traffic. Our ambassador to East Germany invited our delegation to have dinner at the embassy and he invited members of the new forum, the dissident group that started the demonstrations, and he invited members of the Politburo. Hoenecker was still running the country. They were allowing daily visas to people to go to West Berlin. We saw lines three or four miles long, people waiting in line just to see what it was like on the other side of the border. I sat next to a young man and I asked him to tell me about his life. He said he was 42 years old, he had a doctorate degree in microbiology. I said, "What about your family situation?" He said, "When I was 17, my father made a very mild anti-government statement outside that Lutheran Church you visited this morning. The secret police took him away and we didn't see him for 13 years. They finally let him out when he was dying. He lived about six months, and we lost him. But, let me talk about the good news. The good news is we saw our 21-year-old daughter for the first time in seven years last week."

And I said, "Where has she been?" "Well, we were lucky enough to smuggle her out under the floorboards of a car so she could be free. Now maybe we'll be lucky. Maybe the wall will come down in four or five years and we can keep our other children home, because we're constantly looking for a way out for them."

Russian cosmonauts are human beings just like us and I value the friendships that I have with astronauts and cosmonauts from other countries with different backgrounds on this Earth.

He said, "You have children, Senator?" I said, "Yes I do. I have seven." He said, "Do you have any idea how hard it is to decide whether you give your children freedom or whether you keep them with you?" And I said, "No. I've never been faced with that kind of a choice, and I don't know what I would do. I don't know whether I could be unselfish enough to give up one of my children so they could be free." And he said, "Well it wasn't easy, Senator, it was not easy." And I said, "How do you explain that you're so anti-communist, you were born under communism, you've never lived under any other system." He got a little bit irritated with me and he said, "Senator don't you understand? Don't you understand? God gave us freedom. The communists have imprisoned my body for 40 years. They have not imprisoned my soul."

Well, I tell you, my wife and I came home, and got our teenage kids together, sat them down and told them some of these stories. We said that the next time you gripe because you haven't got the latest Reeboks or something from the Gap, or whatever it is, you're going to East Berlin. I don't think we realize how fortunate and blessed we are in this country. And that's a perspective I'm sure that Buzz would agree with me on—that you look back at this Earth and you have these emotional and these spiritual feelings and I don't know how you quantify that. I do sincerely believe that that is an enhancement of life on Earth to have that perspective and recognize we are traveling on Spaceship Earth together, and I happen to think there's a lot of solutions to our political problems on this planet as a result of having that experience. They're intangible. You can't quantify them like a heart pacemaker and an implantable insulin pump and satellites and communications and all of that. But maybe that aspect is even more valuable. I think it probably is. That's why if I sound a little irritated sometimes and why I spend so much time still trying to promote space, because I don't know where we can spend money any better than solving some of these social problems and political problems on this Earth.

I do sincerely believe that more people ought to fly in space. People can laugh when we talk about space tourism. I don't laugh at all. I think more people should fly in space, and I'm sorry that it's still such a relatively few, a few hundred, I don't know what the number is now. I'm telling you, even during the height of the Cold War, when we would hold our association of space explorers meetings, we didn't have any problems with the Russians. Russian cosmonauts are human beings just like us and I value the friendships that I have with astronauts and cosmonauts from other countries with different backgrounds on this Earth.

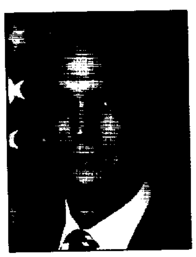
That's what I wanted to present to you today. Those feelings that are not often talked about. Technological spinoffs are valuable, they've improved and enhanced our lives. But the emotional and spiritual aspect of recognizing how insignificant the Earth is in the overall scheme of things, that there are 100 billion suns in our own galaxy alone, and galaxies billions of light years away—and I will upset some of the scientists here today by telling you there is no doubt in my mind whatsoever that there is life on other planets. And as a matter of fact, I happen to think they probably look just like you and I. They don't have green skin, pointed ears or anything else. I made that comment to a Senate prayer breakfast not long after I came back from my flight, and one of my good Southern Baptist senator friends said, "Jake, I don't believe that. God created the Earth and he created the universe and this is the only place he put his children. And I think it's silly that you would think he did it someplace else." And I said, "Oh, come on, even if you're an atheist mathematician, the law of large numbers ought to indicate to you that with billions of galaxies out there, billions of light years of away, that there might just happen to be a planet the right distance from its sun to have the proper temperature and humidity for life to evolve out of the sea." And he said, "I don't believe that evolution baloney. I believe that God created the Earth and the universe." And I said, "Well, you believe

God is intelligent?" And he said, "Yes." And I said, "Well then, wouldn't that be a lot of overkill out there? It's not really quite necessary to build all of that."

That's like me saying to all of you, I have built every house, every apartment building, every shopping center, every office building on this Earth just for this group. You'd say that's a little bit ridiculous. You're absolutely right, and that doesn't even begin to explain the disparity between planet Earth, this little speck of dust in this particular solar system, compared to the vastness of the universe. Yes, there are people out there. No doubt in my mind about it. That's why they called me E.T. Garn when I was in the Senate and kept trying to fund SETI (Search for Extraterrestrial Intelligence project). I'm still trying to help fund SETI privately because government didn't have enough money to do that. Just remember, the technological spinoffs are there. But these other values enhance life here on Earth. And travel in space for men and women can provide solutions to a lot of the social and political and domestic problems we have on this planet. I appreciate very much the opportunity of being with you this morning. Thank you very much.

FEATURED SPEAKERS

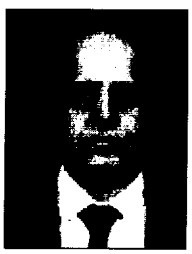
Gen. Joseph W. Ashy, USAF, commander-in-chief, NORAD, and the unified United States Space Command, and commander of the Air Force Space Command at Peterson Air Force Base, Colorado Springs, Colorado. Ashy entered the Air Force in 1962 through the Air Force Reserve Officer Training Corps upon graduation from Texas A & M University. He earned his pilot wings in 1964 and began his flying career in the F-100. His military career includes assignments in England, South Vietnam, Washington D.C., Arizona, Texas, South Korea, Utah, Alabama, California, Nevada, and Virginia. Some of his military decorations include the Defense Distinguished Service Medal, Distinguished Service Medal, Silver Star, Legion of Merit with oak leaf cluster, the Distinguished Flying Cross with oak leaf cluster, and the Air Force Commendation Medal.



The Honorable Robert V. Davis, Deputy Under Secretary of Defense for Space, U.S. Department of Defense. Davis is responsible for all DoD policy, strategy and plans for DoD space and space intelligence systems, their acquisition and employment, space control, space cooperation with foreign governments and the integration of space capabilities into DoD force structure. DoD space activities involve the annual expenditure of over $13 billion and employ a total of 30,000 military and civilian DoD personnel. Prior to his appointment, Davis was a senior professional staff member of the Committee on Appropriations of the United States House of Representatives. Davis received his B.S. in Political Science from Massachusetts Institute of Technology and his Master's of Public Administration degree from American University.

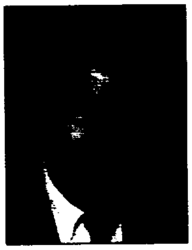
The Honorable Daniel S. Goldin, NASA Administrator. He was appointed in 1992 to his post after 30 years in the aerospace industry. Prior to his appointment he served as vice president and general manager of the TRW Space and Technology Group in Redondo Beach, Calif. Goldin served 25 years with TRW managing the development and production of advanced spacecraft, technologies and space science instruments. Under his leadership at TRW, the group won the 1990 Goddard Award for Quality and Productivity and was a finalist in 1991 for NASA s highest quality award, the George M. Low Trophy. He earned his bachelor's of science in mechanical engineering from the City College of New York.

Joseph T. Gorman, chairman and chief executive officer, TRW Inc. He was elected to this position in December 1988 after serving as president and chief operating officer since 1985. TRW is a leading provider of automotive and space and defense systems worldwide. The company is the world's largest supplier of occupant restraint systems, steering systems, engine components, and engineered fasteners, and is a leading producer of automotive electronics. For space and defense markets, TRW is a leader in spacecraft and space systems, avionics and surveillance systems, and software-based systems for defense and commercial markets. Mr. Gorman is a trustee of the Committee for Economic Development and is a member of the Business Roundtable's Policy Committee, the Council on Competitiveness, and the President's Export Council. In 1994 he received Japan's Prime Minister's Trade Award for his contributions to promoting improved U.S.-Japanese trade relations. Mr. Gorman holds a Bachelor of Arts from Kent State University and an LL.B. from Yale Law School.

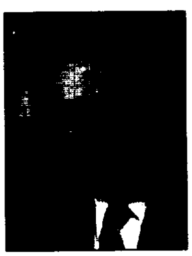


Dr. Krishnaswamy Kasturirangan, chairman, Space Commission/Secretary, Department of Space, Govt. of India, and chairman, Indian Space Research Organization. He is the project director for India's first two experimental Earth observation satellites. He also oversaw the development of the second generation INSAT spacecrafts launched in 1992 and 1993 respectfully. He is a Fellow of the Indian National Science Academy, Indian Academy of Sciences, National Academy of Sciences of India and Indian National Academy of Engineering and Telecommunication Engineers and the Astronomical Society of India, life member of the Indian Physics Association, Fellow of the Astronautical Society of India and the National Telematics Forum.

Alexander Nikolayevich Kuznetsov, the department head for launch and space support systems at the Russian Space Agency. He graduated from the military academy in 1977. From 1977 to 1995 he remained in the service and worked at the Institute for Quality Control. Mr. Kuznetsov conducted experiments and implemented the Meteor-1 and Meteor-2 meteorological space satellites, and participated in the preliminary testing of the Meteor-3 and Electro satellites. From 1985 to 1992 Mr. Kuznetsov worked in the central power structure of the military-space sector, and was tasked with the creation of advanced aerospace technologies. The Russian Space Agency is responsible for the development of rocket engines, boosters, and upper stage motors, the maintenance of launch infrastructure for the federal space program, and the day-to-day maintenance and upgrade of launch facilities. This organization also maintains test stands for the development of space technologies at ground level.

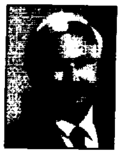


Capt. James A. Lovell, USN (Ret.), commander of Apollo XIII and the first man to journey to the moon twice. He also commanded the Gemini 12 mission with pilot Buzz Aldrin and has logged more than 6,500 hours of flying time, 4,000 of that in jet aircraft. After retiring from the Navy and the space program he joined the Bay-Houston Towing company which is involved in harbor and coast wide towing, mining, and marketing of peat products for the lawn and garden industry, and ranching. He then served as chief executive officer of Fisk Telephone Systems until it was acquired by the Central Corporation where he became an executive vice president and a member of the board of directors before his retirement in 1991. He holds a bachelor's of science degree from the U.S. Naval Academy and eight honorary doctorates from such schools as Blackburn University, Rockhurst College, and Milwaukee School of Engineering. He is a Fellow of the Society of Experimental Test Pilots and the American Astronautical Society. His honors include the Presidential Medal of Freedom; the NASA Distinguished Service Medal, twice; and two Navy Distinguished Flying Crosses. He is the Chairman of the National Eagle Scouts Association and is an Eagle Scout himself. Captain Lovell is Chairman of the Advisory Board of Mission Home.



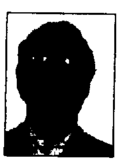
The Hon. Robert S. Walker, (R-PA), chairman, Committee on Science, U.S. House of Representatives. Walker was first elected in 1976. Prior to his congressional service he was a congressional assistant to U.S. Representative Edwin Washleman. Walker began his career as a high school Social Studies teacher in Pennsylvania and while he taught school he was a member of the Pennsylvania National Guard. He is an author and co-author of several books and articles. Some of his key legislative accomplishments include: the Drug-Free Workplace Act; Growth Management Study, Omnibus Space Commercialization Act; and he is a strong advocate of research and development into hydrogen as an alternative fuel source. Walker earned his Bachelor's of Science in Education from Millersville University and his Master's degree in Political Science from the University of Delaware.

PROGRAM PARTICIPANTS



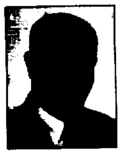
The Hon. Edward C. "Pete" Aldridge, Jr. is the President and CEO of The Aerospace Corporation. From June of 1986 to December 1988, Pete Aldridge was Secretary of the Air Force. Prior to that, he served as Under Secretary of the Air Force. In 1977 he was named Vice President, National Policy and Strategic Systems Group for System Planning Corporation. Pete Aldridge served as Deputy Assistant Secretary of Defense for Strategic Programs from February 1974 until March 1976 when he was selected to be the Director, Planning and Evaluation, and principal adviser to the Secretary of Defense in the planning and program evaluation of U.S. military forces and support structure. Prior to his service in DoD, he was a senior manager with LTV Aerospace Corp. in Dallas for a year until he was named senior management associate in the Office of Management and Budget, Executive office of the President, Washington, D.C. in 1973. From 1967 to 1972, he was with the staff of the Assistant Secretary of Defense for systems analysis as an operations research analyst and then served as Director of the Strategic Defensive Division. He also served as an adviser to the Strategic Arms Limitation Talks in Helsinki and Vienna. From 1967 and back, Mr. Aldridge held various staff and management positions with the Douglas Aircraft. Co., Missile and Space Division, in Santa Monica, CA and in Washington, D.C. He received a bachelor of science degree in Aeronautical Engineering from Texas A&M and a Master of Science degree, also in aeronautical engineering, from Georgia Institute of Technology.

Maj. Gen. Robert S. Dickman, USAF, Department of Defense Space Architect, Washington D.C. Dickman is responsible to the Under Secretary of Defense (Acquisition and Technology) for space missions and system architecture development. He entered the Air Force in June 1966 as a distinguished graduate of the Reserve Officer Training Corps program at Union College, N.Y. He has had a varied career in space operations, acquisition, and planning, including headquarters assignments at the Pentagon, NORAD, U.S. Space Command and Air Force Space Command. Dickman earned his bachelor s degree in physics from Union College, N.Y., and his master's degree in space physics from the Air Force Institute of Technology. He also has a master's degree in management from Salve Regina College, Newport R.I. Some of his military decorations include the Distinguished Service Medal, Legion of Merit, Defense Meritorious Service Medal, Meritorious Service Medal with oak leaf cluster, and the Air Force Commendation Medal with oak leaf cluster.



David T. Edwards, executive vice president and chief operating officer of Earth Observation Satellite Co. (EOSAT). He is responsible for all EOSAT domestic and international operations, including marketing, satellite mission management, and follow-on satellite development. Before joining EOSAT, he served as director of Financial Planning and Decision Support Systems at Hughes Aircraft Corporate Headquarters in Los Angeles, Calif. He also held the position of Chief Financial Officer at the Santa Barbara Research Center, a subsidiary of Hughes Aircraft where he developed the initial business plans in support of Landsat commercialization. Before joining Hughes Aircraft, he worked six years at Grumman Aerospace where he performed a number of duties in program business management and corporate planning. He earned both his B.A. and M.S. in finance and accounting from Adelphi University in Garden City, N.Y.

Mac Evans, president of the Canadian Space Agency. Mr. Evans has worked more than 22 years in the Canadian Space Program where his career has included extensive experience in research, project management, policy development, international relations, and senior management in a number of federal departments. With the formation of the Canadian Space Agency in 1989, Mr. Evans became vice president of Operations with responsibility for all of the Agency's major space programs. These included Canada's contribution to Space Station, the Radarsat Program which is Canada s first remote sensing satellite, and the Canadian Astronaut Program. His major accomplishments include: Development of the 1985 and 1994 Space Plans that defined and obtained approval for the Canadian Space Program for the period from 1985 to 2004; negotiation of the arrangement for Canada's participation in the Space Station Program; and preparation of the proposal for the creation of the Canadian Space Agency. Mr. Evans is a member of the Canadian Aeronautics and Space Institute and Fellow of the Canadian Academy of Engineering. He holds a Bachelor's of Science degree in Electrical Engineering from Queen's University and a Master's of Science degree in Electrical Engineering from the University of Birmingham in England which he attended as an Athlone Fellow.



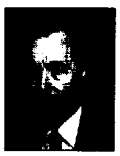
Dr. Murray Felsher, president of Associated Technical Consultants (ATC) and director of North American Remote Sensing Industries Association. He began his career in remote sensing as a graduate research and teaching assistant in photogeology at the University of Massachusetts in Amherst in 1959 while pursuing a master's degree. He joined the Geology Department faculty at Syracuse University before moving to Washington D.C. to become associate director of a National Science Foundation-funded program at the American Geological Institute. With the formation of the U.S. Environmental Protection Agency, he joined the EPA as a senior staff geologist. He transferred to NASA where he served in various capacities including the originator and first program manager of NASA s Regional Remote Sensing Applications Program. He left in 1980 to form ATC whose clients have included the FBI, Orbital Sciences Corporation, and the Eastman Kodak Company where he was hired in a permanent consulting capacity as director of Special Projects. As a consultant to the Department of Defense s Landsat Program Office, he was responsible for establishing a civilian gateway to DOD's Landsat-7 imagery. He is the publisher of Washington Remote Sensing Letter, the oldest and largest subscription newsletter devoted to remote sensing/GIS. He is a Fellow of the Geological Society of America and a senior member of the American Astronautical Society.

Dr. Brenda Forman, has spent over a decade in the private sector first with the Lockheed Corporation in Calabasas, California, and currently as Director, Federal Planning & Analysis, for Lockheed Martin corporation in Bethesda, Maryland. Prior to this she spent twelve years in the federal government, first as a Senior Policy Analyst in the Office of the Secretary of Defense and later as a Senior Technology Policy Advisor in the Commerce Department. At the University of Southern California's School of Engineering, she taught a graduate level course that she originated, entitled "The Political Process in Systems Architecture Design," which some of her students have dubbed "Survival Skills for the 90's Aerospace Engineer." She took her Ph.D. in political science at the City University of New York. She is a member of Phi Beta Kappa and a recipient of the Defense Department's Distinguished Civilian service Award. She was also an Honorable Mention Honoree at the 27th Annual Wright Brothers Banquet, "The Wright Women," in 1989. She is well known in the space community for her monthly column, now in its ninth year, for the United States Space Foundation. She also contributes frequently to Space News, OMNI, Vertiflite, Program Manager, Acquisition Review Quarterly and other national publications.

E.J. Jake Garn, vice chairman, Huntsman Chemical Corporation, Salt Lake City, UT. Former Utah Senator Garn served in the United States Senate for 18 years. He served as Chairman for both the Senate Committee on Banking, Housing, and Urban Affairs; and the VA, HUD, and Independent Agencies subcommittees. He flew aboard shuttle Discovery flight 51-D as a payload specialist. Senator Garn currently serves on the boards of Dean Witter Funds (New York City), John Alden Life Insurance Company (Miami), The Aerospace Corporation, American Association for the Advancement of Science, and the United States Space Foundation (Colorado Springs). In December of 1992, Senator Garn received the very prestigious aviation award, The Wright Brothers Memorial Trophy. Senator Garn received his bachelor's of science degree in Banking and Finance at the University of Utah, Salt Lake City, UT.

Lt. Gen. Jay M. Garner, USA, commander of the U.S. Army Space and Strategic Defense Command headquartered in Arlington, Va. He began his military service in the Florida National Guard. He then enlisted as a Marine and was commissioned a second lieutenant in the Army. His military career has included assignments in Kentucky, Texas, Europe, northern Iraq, Frankfurt, Germany and Vietnam. Before his current assignment he served as assistant deputy chief of staff for Force Development, ODCSOPS, Washington D.C. He has attended the U.S. Army War College, the U.S. Marine Corps Command and General Staff College, the U.S. Army Air Defense Artillery Advance and Basic Officer Courses, and numerous other military schools. He holds a bachelor's degree in history from Florida State University. His awards include the Distinguished Service Medal, the Defense Superior Service Medal, the Legion of Merit with four oak leaf clusters and the Bronze Star.

Michael J. Gianelli is responsible for government operations including business development and programs at Hughes Space and Communications Company (HSC).Gianelli was named group vice president in May 1993. He had joined the Office of the President in September the previous year, leaving a position as interim division manager of the systems engineering and operation division.During the bulk of his 23-year career at Hughes, Gianelli has worked on government programs, rising to the position of assistant manager of the systems applications division in 1988. In 1989, Gianelli moved to the space vehicle electronics division where he was responsible for control system, software and technology development. In 1991, Ginanelli managed a comprehensive program aimed at reducing the length of time needed to build spacecraft.Gianelli began his collegiate career at Notre Dame University where he earned a BS in aerospace engineering in 1969. He went on to the University of Southern California, receiving his MS in mechanical engineering in 1971 and an engineering degree in the same discipline just two years later. In 1982, he received an MA in business from Pepperdine University, and in 1989, completed the UCLA Executive Program. He has received both the Hughes Masters and Engineering fellowships.



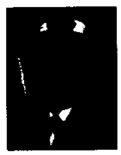
Roy Gibson, special advisor to Director General of INMARSAT, and past president and vice-president of the International Astronautical Federation. Prior to his current position, Mr. Gibson was the DG of the European Space Agency and the British National Space Centre. He addition to his present position, he is a vice-president of the International Astronautics Academy. He is a Fellow of the Royal Aeronautical Society, a member of the British Interplanetary Society, and the American Astronautical Society, American Institute of Aeronautics and Astronautics.

Jeffrey D. Grant joined the Central Intelligence Agency in 1976 and worked as an analyst in the Office of Scientific Intelligence. He joined the Office of SIGINT Operations in 1978, developing and installing collection systems. In 1980, he began work in the Office of Development and engineering, (OD&E) C Program Group, and worked until 1986, developing a series of new collection capabilities. In 1986, Mr. Grant joined the S Program Group as Chief of their Systems Analysis Staff. In March 1988, he became the Program Manager for a major collection system in another group. Mr. Grant Rejoined C Program Group as Chief of the Systems Analysis Staff in March 1991, and in September 1991 moved within OD&E to become Chief of the Imaging Technology Division. He worked in the Community Management Staff as Director, Systems and Architecture Office from July 1993 to June 1994 when he returned to the National Reconnaissance Office as Director, Office of Plans and Analysis. Mr. Grant holds a Bachelors degree in Ocean Engineering from the Florida Institute of Technology, and has enhanced his education with numerous Agency-sponsored training courses. His engineering skills and technical leadership have been recognized by the presentation of the Agency Certificate of Distinction, the Meritorious Officer Award, the Intelligence Commendation Medal, the CIA's 1988 Engineer of the Year Award, and the Intelligence Medal of Merit.

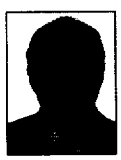
Dr. Moira Gunn, producer and host of *Tech Nation...Americans & Technology* and an adjunct professor at the University of San Francisco. A former NASA engineer and scientist, she is an engineering consultant, specializing in engineering management, technology audits, systems testing and robotics systems. Her robotics systems are in operation today at such diverse sites as IBM Corporation, Lockheed Missiles & Space, Morton Thiokol, and the U.S. Navy. She holds a patent, along with USDA nutrition scientists, on a computerized food intake measurement system. While at NASA's Institute for Advanced Computation, she managed the software development of large scientific applications including; global weather and climate models, satellite image processing, earthquake modeling and prediction, and real-time satellite tracking on supercomputers. She holds a Ph.D. in mechanical engineering and a Master of Science in computer science from Purdue University.

The Hon. Joel Hefley, U.S. House of Representatives, Fifth District, Colorado since 1987; House National Security Committee, Chairman, Subcommittee on Military Installations and Facilities, Subcommittee on Military Research and Development. He is also currently in the House Resource Committee serving on the subcommittee on National Parks, Forests, and Lands as well as the Subcommittee on Energy and Mineral Resources. Hefley also serves on the House Small Business Committee in the subcommittee on Government Programs. Joel Hefley has held the leadership positions of President of the Class (1987 - present), Theme team Member, and Assistant Minority Whip (1989-1994). He holds a B.A. from Oklahoma Baptist University, a M.S. from Oklahoma State University and a Gates Fellow from Harvard University Summer Program. He has had the honor of receiving the Watchdogs of the Treasury "Golden Bulldog" award, National Federation of Independent Business "Guardian of Small Business" award, National Taxpayers' Union "Taxpayer's Hero" award, American Security Council Foundation "National Security Leadership" award and the U.S. Chamber of Commerce "Spirit of Enterprise" award. He has also received the Common Sense "Sound Dollar" award, the Christian Coalition Friend of the Family Award and the Theme team's outstanding Speaker award.

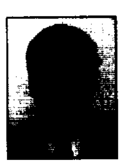
The Hon. Lionel S. Johns, Associate Director for Technology, Office of Science and Technology Policy, The White House. "Skip" Johns is responsible for technology R&D policy coordination between federal agencies. This work is coordinated through the National Science and Technology Council, including space and aeronautics, industrial R&D, defense conversion, information and communications and education and training technologies. He serves as co-chair of three NSTC committees: Information and Communication R&D, Civilian Industrial Technology R&D, and Transportation R&D. Johns reports to Dr. John Gibbons, Director of OSTP and Assistant to the President for Science and Technology. Prior to this position, Johns has 16 years of management experience in high technology industries and served as an officer in the United States Navy as a carrier-based naval aviator.



Rear Adm. Katharine L. Laughton, USN, commander, Naval Space Command, Dahlgren, Va. Rear Admiral Laughton was commissioned as an Ensign in the United States Naval Reserve, June 1964. A specialist in information systems technology and transportation management, Rear Admiral Laughton has had a variety of tours in both disciplines. In 1979, she assumed command of the Military Sealift Command, Port Canaveral, where she was the first woman to have operational control of ships. Her responsibilities as commanding officer included support for the Space Shuttle and the Trident programs. She had several automated data processing assignments including two tours as a program manager for ADP systems, on the staff of the Chief of Naval Education and Training and of the commander, Naval Data Automation Command. She assumed her present position in April 1995. Admiral Laughton's awards include the Legion of Merit (two awards), the Defense Meritorious Service Medal, Meritorious Service Medal (four awards), and the Navy Commendation Medal (two awards). In addition, she is a recipient of the William F. Parsons Award for Scientific & Technical Progress, the AFCEA Medal of Merit and Technical Excellence Award. She received a baccalaureate in Political Science from the University of California, Riverside, Ca. She is also a graduate of the Naval War College.



Dr. John S. MacDonald, chairman of the board, MacDonald Dettwiler and Associates Ltd. His professional interests lie in the areas of advanced digital systems engineering, remote sensing, image processing, and machine vision. He led the design team for the first LANDSAT ground processing system produced by the company, was involved in the early development of synthetic aperture radar processing at MacDonald Dettwiler. More recently, Dr. MacDonald's technical activities have been in the areas of handling techniques, especially the use of integrated data sets as a means of increasing our ability to extract useful information from remotely sensed data. As a former assistant professor of Electrical Engineering at M.I.T., Dr. MacDonald was extensively involved in teaching at both the undergraduate and graduate levels. In the industrial sector, Dr. MacDonald is a Director of the Geosat Committee in the U.S., Analytical Spectral Devices Inc., of Boulder, Colorado, ST Systems of San Mateo, California, Radarsat International Inc., of Richmond, B.C., and Kinetic Sciences, Inc., Vancouver, B.C. He is a registered Professional Engineer, a Fellow of the Institute of Electrical and Electronic Engineers, a Founding Fellow of the Canadian Academy of Engineering and a Fellow of the Canadian Aeronautics and Space Institute. Dr. MacDonald earned his B.S. in Electrical Engineering from the University of British Columbia, and his Master's degree in Electrical Engineering at M.I.T.



Hon. Dr. Hans Mark, professor, department of Aerospace Engineering and Engineering Mechanics, University of Texas, Austin, TX. Prior to serving in his current position, Mark was Chancellor of the University of Texas System. Mark also served as deputy administrator of NASA, and was the Secretary of the Air Force. He is the author and co-author of more than one-hundred-fifty scholarly articles as well as numerous books, including most recently: The Space Station: A Personal Journey, The Management of Research Institutions, and In Search of the Fulcrum. He is a member of the National Academy of Engineering, a fellow of the American Physical Society, the American Institute of Aeronautics and Astronautics and the American Association for the Advancement of Science. He obtained a B.A. degree in physics from the University of California at Berkeley, and a Ph.D. in physics from the Massachusetts Institute of Technology. Mark is the recipient of two honorary degrees, the honorary Doctor of Science degree from Florida Institute of Technology, and the honorary Doctor of Engineering degree from Polytechnic Institute of New York.

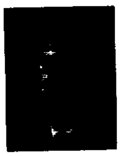
Robert G. Minor, president of Rockwell International's Space Systems Division. He directs the design, development, test, evaluation, and production of Space Shuttle orbiters. He is responsible for all orbiter logistics operations, integration support of the Space Shuttle vehicles, and Space Shuttle mission flight operations support. He directs extensive aerospace independent research and development projects and is responsible for significant advanced technology programs. Mr. Minor was appointed to his present position in 1988. Before his present assignment, Mr. Minor served as vice president and general manager of Rockwell's Houston Operations and as president of Rockwell Shuttle Operations Company. He also has served as orbiter engineering leader in the Mission Evaluation Room at NASA's Johnson Space Center, playing a key role in significant technical achievements of the early Shuttle missions. Mr. Minor has received several honors to include NASA's Distinguished Public Service Award, the NASA Medal for Exceptional Engineering Achievement, and NASA's Public Service Award. He is a member of the American Institute of Electrical Engineers and a Fellow of the American Institute of Aeronautics and Astronautics. Mr. Minor received his bachelor of science degree in electrical engineering from Southern Methodist University and continued his studies at UCLA's graduate School of Engineering.

Brig. Gen. Willie B. Nance, Jr., USA, deputy commanding general, U.S. Army Space and Strategic Defense Command (SSDC). Nance shares the responsibility for SSDC's role as the Army's Advocate for Space, Theater Missile Defense, and National Missile Defense. He entered the Army in 1968 and served 13 years as an infantry officer with assignments in Germany; Fort Benning, Georgia; and Korea. Nance has also served as a project officer for many of the Army's missile projects conducted at the Redstone Arsenal in Alabama. Nance earned his undergraduate and graduate degrees from the University of Southern Mississippi and Florida Institute of Technology. He is a graduate of the Army Command and General Staff College and the Industrial College of the Armed Forces. Some of his decorations include the Legion of Merit, Defense Meritorious Service Medal with three oak leaf clusters and the Army Commendation Medal with two oak leaf clusters.

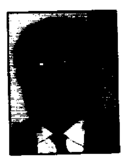
James P. Noblitt, vice president and general manager for the Boeing Defense and Space Group, Missile and Space Division. He is responsible for Boeing's work as prime contractor on NASA's International Space Station program. During the Apollo program, he worked on the integration team for the giant Saturn V rockets which took American astronauts to the moon. After a stint designing commercial jetliners, he was put in charge of preliminary design activities for air-launched cruise missiles. He directed the design and proposal efforts on advanced versions of the Short Range Attack Missile and the Air Launched Cruise Missile. In 1989 he was named vice president for Space Systems, then vice president and assistant general manager of Missiles and Space Division in 1992 and general manager in 1993. He is an aeronautical engineering graduate of Purdue University and an active member of national organizations including the American Institute of Aeronautics and Astronautics and the National Space Society.

The Honorable Jaime Oaxaca, vice chairman of Coronado Communications Corporation, Los Angeles, Calif., in charge of public relations, marketing, and research. He has 37 years of experience in the fields of engineering, engineering management, and program management. He held various administrative positions including director of international and domestic marketing and long range planning; vice president of missile programs and vice president and assistant general manager of the Northrop Corporation, Electromechanical Division; and president of Northrop-Wilcox Electric, Inc. He holds a bachelor's of science in electrical engineering from the University of Texas, El Paso, and is a graduate of the School of Business at Stanford University. He is a Distinguished Fellow of the Institute for the Advancement of Engineering. He was the first recipient of the Jaime Oaxaca award for excellence in engineering and dedication to the community from the Society of Hispanic Professional Engineers, the Business and Industry Award from the Mexican-American Opportunities Foundation, and the Outstanding Engineer Merit Award from the Institute for the Advancement of Engineering.

Lon Rains, Editor, *Space News*. Rains is responsible for all of the newspaper's news and editorial coverage. He joined Space News in October, 1989, as the Advanced Technology and Soviet Space Program reporter. He was responsible for covering the Soviet Union's military and civilian space programs and a number of civil and military space programs in the United States, including the National Aerospace Plane (NASP) program and the work of the research labs of NASA, the Department of Energy and the Department of Defense. He holds a bachelor's degree in political science from the University of Maryland.

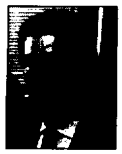


Vice Adm. William E. Ramsey, USN (Ret.), Vice President, Corporate Business Development, CTA Incorporated, a leading aerospace company with corporate headquarters in Rockville, MD. Admiral Ramsey entered active duty in June 1953 with a commission as an ensign after graduating from the U.S. Naval Academy. He completed flight training in 1965 and has logged more than 4,700 flying hours in tactical aircraft, 912 carrier landings, with 258 at night. Admiral Ramsey was the first commanding officer of the nuclear carrier USS Dwight D. Eisenhower. He also was the commander, Carrier Group One, embarked on the carrier USS Constellation. He became the first director, Navy Space Systems, Office of the Chief Naval Operations in 1981. Some of Admiral Ramsey's awards include, the Defense Distinguished Service Medal, the Legion of Merit with gold star, the Bronze Star with combat V device, the Air Medal with two gold stars (8 awards), and the Navy Commendation Medal with combat V device. Admiral Ramsey was also awarded the 1986 Military Astronautics Trophy by the American Astronautical Society. He earned a Bachelor's of Science degree in naval science from the U.S. Naval Academy, Annapolis, Md., is a graduate of the Royal Air Force Staff College, Bracknell, Berkshire, England; the Naval Test Pilot School, the Nuclear Power School, and the Nuclear Power Training Unit.

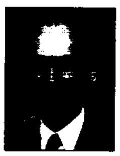


Thomas F. Rogers, president of the Space Transportation Association which is interested in using space more by expanding and increasing efficiency in space transportation. He is also a physicist, a communications engineer, a private investor, and the president of his family's private operating foundation, the Sophron Foundation which is emphasizing low-earth-orbit life sciences and biomedical research. His experience in research and development is extensive and has included serving as deputy director of Defense Research and Engineering in the Office of the Secretary of Defense where he was responsible for research and development supporting the command and control of our nuclear strike forces. Rogers did research and development work during World War II at the radio Research Laboratory of Harvard University and, later, at the Bell and Howell Company and the Air Force Cambridge Research Center. He has held senior federal government positions, and professional positions with university , industrial, and non-profit organizations. He was a member of the National Academy of Sciences/Institute of Medicine/Robert Wood Johnson Foundation group that created early emergency medical systems including the 911 emergency number in over forty locations across the U.S. Rogers holds a bachelor s of science from Providence College and a master's degree in physics from Boston University and is a Fellow of the Institute of Electrical and Electronic Engineers.

Steven P. Scott, currently directs business development activities for Rockwell's Space System Division's DoD space programs. This includes responsibility for strategic planning in the areas of satellites and space defense, and program development on pursuits such as the Global Positioning System Block IIF and follow-on programs to the P91-1 ARGOS Space Test Program satellite. Past assignments have involved business development activities with Air Force Space Command, Space & Missile Systems Center, Phillips Laboratory, Goddard Space Flight Center, and the Jet Propulsion Laboratory on both earth-orbiting systems and interplanetary probes. Prior to joining Rockwell, he was the Business Development Manager at Logicon/Ultrasystems for the satellite command and control and simulation and training program areas, and site manager for Contel Federal Systems Division in Los Angeles. While on active duty as a captain in the Air Force, Scott was responsible for the site activation and initial operation of the remote ground stations for the GPS Operation Control Segment. He received his undergraduate degree in electrical engineering from the University of Texas, and holds a M.S. in Engineering from Northrop University and a M.B.A. degree from Pepperdine University. Scott is on the board of directors of the National Space Club's West Coast Committee, and is a member of the Southern California Association of Professional Representatives.

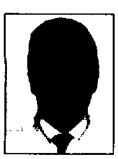


Dr. Arturo Silvestrini, president and chief executive officer, EOSAT. Dr. Silvestrini has more than 40 years of professional experience, including more than 35 years in aerospace-related industries. Most of Silvestrini's career has involved managing large business operations. He joined EOSAT in 1991 after electing to take early retirement from Computer Sciences Corporation (CSC), where he spent more than 25 years of his professional career. Before his retirement, he was assigned to coordinate the commercial CSC initiative of acquisitions and rapid expansion in Europe. Before CSC, Silvestrini served at various technical, consulting, and managerial levels in companies such as Page Communications and Cubic Corporation, in both the U.S. and Europe. Silvestrini has authored textbooks and numerous technical and scientific publications. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics and a Fellow of the American Astronautical Society. He serves on the board of directors of CTA, Inc. , of Rockville, Md, and is President of Teleos, a joint venture between EOSAT and Telespazio of Italy. Silvestrini received his doctorate degree in electrical engineering from the University of Rome.



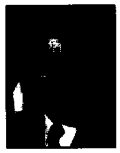
Dr. Edward Stone, Director, Jet Propulsion Laboratory, Vice President and David Morrisroe Professor of Physics at the California Institute of Technology. Stone is the current chairman of the Board of Directors of the California Association for Research in Astronomy. Since 1961, Stone has been a principal investigator on nine NASA spacecraft missions and a co-investigator on five other NASA missions. He is a member of the National Academy of Sciences and the International Academy of Astronautics. He is a Fellow of the American Physical Society, the American Geophysical Union, and the American Institute of Aeronautics and Astronautics. Stone also is a member of the American Astronomical Union, the American Philosophical Society, an honorary member of the Astronomical Society of the Pacific and a member of the California Council on Science and Technology. He received his Ph.D from the University of Chicago as well as honorary degrees from Washington University at St. Louis, Harvard University, and the University of Chicago.

Akiyoshi Takada, Deputy Director-General, Communications Policy Bureau, Ministry of Posts and Telecommunications, Japan. In 1968 Mr. Takada entered the Ministry of Posts and Telecommunications. He then became Director of the Postal Savings Department, Kinki Bureau of Postal Services (Osaka Prefecture), in 1982. Between 1983 and 1985 Mr. Takada was the senior advisor of General Coordination Division, Minister's Secretariat and in 1985 he became the director of Computer Communications Division in Telecommunications Business Department. Until 1992 Mr. Takada was the Director of Policy Division in the Communications Policy Bureau and Director of International Policy Division. Prior to his current position as Deputy Director-General in the Communication Policy Bureau he was Director-General for Sinetsu Bureau of Postal Services (Nagano Prefecture). Mr. Takada graduated from Tokyo University Law School in 1968.



W. David Thompson, founder and president of Spectrum Astro, Inc. The company builds small satellites and advanced technology components and subsystems for such diverse space applications as ballistic missile defense, planetary exploration, technology demonstration and validation, communications, and research instruments aboard the space station. Prior to starting Spectrum Astro, Thompson was assigned to HQ USAF SMC in a wide range of capacities over a 10-year period, including positions in launch, six different spacecraft development programs, technology and advanced system design and development, Space Shuttle payload integration and training as DoD Manned Spaceflight Engineer/Payload Specialist. His last position was as chief of the Advanced Plans Branch for a major office where he was responsible for the conceptualization and development of a number of small and low-cost but sophisticated quick reaction space payloads. He is a senior member of the American Institute of Aeronautics and Astronautics, and a member of the Institute of Electrical and Electronics Engineers.

Prof. Ernesto Vallerani, chairman, Alenia Spazio, S.P.A. Prior to his current position, Vallerani lectured on advanced Gasdynamics at Turin Polytechnic. He was the local project manager and later the technical director for the Spacelab program for Aeritalia. He became the general director of the Space Sector of Aeritalia in 1980 and was appointed to his current position in 1991. He is a Fellow of the American Institute of Aeronautics and Astronautics, and a member of the International Astronautical Federation. He is currently a member of the board of trustees for the International Academy of Astronautics. Vallerani graduated in Aeronautical Engineering (propulsion) from Milan Polytechnic.



Maj. Gen. David L. Vesely, USAF commander, 14th Air Force, Vandenberg AFB, Calif. General Vesely commands the only space force conducting military operations and supporting global civil and commercial activities. The 14th AF supports warfighting worldwide with ballistic missile warning, command and control of DoD and NATO satellites, spacelift generation and range operations, global space surveillance/warning, and ballistic missile test operations. The general entered the Air Force in March 1966 as a graduate of the Michigan Technological University Reserve Officer Training Corps program. He is a command pilot and has flown more than 4,200 flight hours. He also is a Vietnam veteran, he flew more than 200 combat hours in the Republic of Vietnam. The general has experience in special operations, strategic missiles, tactical fighters, electronic combat, intelligence, training and space operations. He has also held key staff positions at Headquarters, U.S. Air Force, the staff of the Secretary of the Air Force, the Joint Staff, and at North Atlantic Treaty Organization (NATO) headquarters. His military decorations include the Legion of Merit, Distinguished Flying Cross, Purple Heart, Defense Meritorious Service Medal, Meritorious Service Medal, Air Medal, Air Force Commendation, Vietnam Service Medal, and the Republic of Vietnam Gallantry Cross with Palm. General Vesely received his Bachelor of Science degree in Electrical Engineering at Michigan Technological University, and a Master's degree in Business Administration from Auburn University, Ala. He's completed Squadron Officer School, Air Command and Staff College, and the Air War College.

Peter G. Wilheim, director, Naval Center for Space Technology. The Center's mission is to preserve and enhance a strong space technology base and provide expert assistance in the development and acquisition of space systems which support naval missions. The Center is the only Defense Department facility that has its own in-house capability to design, fabricate, and fully qualify spacecraft. Mr. Wilheim is credited with contributions in the design, development, and operation of 82 scientific and Fleet-support satellites. He has been awarded five patents. His previous experience includes satellite system design, equipment development, environmental testing, launch operations and orbital data handling. Mr. Wilheim s awards include the Navy's Meritorious Civilian Service Award, the Distinguished Civilian Service Award, the Presidential Meritorious Executive Award, and the Institute of Electrical and Electronics Engineers Aerospace and Electronic Systems Group Man of the Year Award. Mr. Wilheim is a Fellow of the Washington Academy of Sciences and a Fellow of the American Institute of Aeronautics and Astronautics. He earned a B.S.E.E. from Purdue University, and has completed all course work for an M.S.E.E. from George Washington University.

Michael W. Wynne, Michael W. Wynne is vice president and general manager of Lockheed Martin Space Systems, a business unit of Lockheed Martin Astronautics located in Denver, CO. In 1991 he became Corporate vice president and general manager of General Dynamics' Space Systems Division and in 1992 was named vice president of the Space Systems Division and in 1992 was named president of the Space Systems Division. In 1982, he joined the Land Systems Division in the President's office and was subsequently promoted to vice president of contracts and estimating. Wynne was then named vice president of business development, where he directed strategic and business planning functions, as well as domestic and international marketing. Wynne joined General Dynamics' Fort Worth Division in 1975 in the estimating department. He was promoted to corporate manager of pricing at corporate headquarters. Wynne graduated from the U.S. Military Academy at West Point. He has a master's degree in electrical engineering (MSEE) from the Air Force Institute of Technology and a master's in business administration (MBA) from the University of Colorado.

SPACE TECHNOLOGY HALL OF FAME

SPACE SPINOFFS are materials and products originally developed for space program application which have made significant contributions to benefit all people. Spinoffs are nominated each year for induction into the Space Technology Hall of Fame.

Sponsored by NASA and the U.S. Space Foundation since 1988, the Space Technology Hall of Fame honors individuals and companies responsible for these remarkable products. Though the number of inductees is limited, each nominee is truly a winner in its innovation and practical benefit to humankind.

THE 1996 INDUCTEES:

ANTI-SHOCK TROUSERS

(Health Care Products Category)

A problem that has confronted aviators and astronauts alike is protection from the g-forces that occur during periods of rapid acceleration. Anti-g suits have been developed to help to control the shifting of body fluids during changing gravity conditions. At the beginning of the 20th century a physician observed that the use of controlled pressure could help reduce internal bleeding. Subsequently, others made similar observations and began to modify pressure suits for medical purposes. In 1969, a surgeon who was aware of NASA's work in this area requested their assistance in treating a patient. A special suit was developed and was successful in controlling bleeding in the patient. Subsequently, other patients also received treatment using the novel anti-g suit system. A similar effort was also occurring at a U.S. Army Post. That work led to patent and the first commercial Medical Anti-Shock Trouser. These garments can now be found in most trauma centers and ambulances and have been credited with helping save the lives of many seriously injured individuals.

RADIANT BARRIER

(Consumer Products Category)

Space voyagers are subject to temperature extremes that range from 400° F above zero to 400° F below zero. Protecting equipment and astronauts from these extremes was an early requirement for NASA. Based on pioneering research, that continues today, a class of materials called Multi-Layer Insulation was developed. A key component of this insulation is a radiant barrier made from "metallized" plastics. These materials have been incorporated into virtually every item, for example, satellites, the lunar module, space suit, etc, that is exposed to space temperature extremes.

Temperature extremes are not limited to space. They also occur on earth, although not over such a broad temperature range. Radiant barriers and multi-layer insulation are being used extensively on cryogenic tanks, food wrap, plus home and office insulation to name just a few applications.

FIRE RESISTANT AIRCRAFT SEATS

(Industrial Products/Processes Category)

One of the early tragedies of the space program was a fire in an Apollo module that was undergoing flight preparations. Investigation of all aspects of the fire indicated that many of the materials used in the module were highly flammable. One solution to this problem was development and use of a novel fire resistant encapsulation technology that protected materials from direct ignition.

It was found that this technology had another important application. It was for seats and fabrics in aircraft. Application of the fire-blocking material decreased seat flammability substantially, and also retarded smoke and toxic emissions sufficiently to allow passengers to safely exit the aircraft in emergency circumstances. All commercial airlines now utilize this technology in seats and some other applications in aircraft.

ANTI-SHOCK TROUSERS
(health care products category)

Developed through the cooperative efforts of:
NASA Ames Research Center
David Clark Co.
George Baldes (deceased)
Alan Chambers (deceased)
Burt Kaplan, M.D.
Don Peeler
Ralph Pelligra, M.D.
Forrest Poole (deceased)
Eugene Sandberg, M.D.
Hubert Vykukal
Bruce Webbon

RADIANT BARRIER
(consumer products category)

Developed through the cooperative efforts of:
NASA Jet Propulsion Laboratory
NASA Lyndon B. Johnson Space Center
NASA Marshall Space Flight Center
Radient Technologies, Inc.
Clark E. Beck, Sr.
Robert Brown
Peter E. Glaser, Ph.D.
Eric Hyde
Arthur D. Little
David B. Shea
Preston E. Smith
James M. Stuckey, P.h.D.
Hugh von Delden

FIRE RESISTANT AIRCRAFT SEATS
(Industrial products/ processes category)

Developed through the cooperative efforts of:
NASA Ames Research Center
NASA Lyndon B. Johnson Space Center
Federal Aviation Administration
Mosites Company
John Bailey
Richard W. Bricker
James Burnett
Fred E. Duskin
John Gagliani, Ph.D.
J. Lynn Helms
Richard G. Hill
Joseph D. Keating
Demetrius Kourtides, Ph.D.
Jack Owens
John Parker (deceased)
Matthew I. Radnofsky, Ph.D. (deceased)
Constantine P. Sarkos
David A. Stivers
Daniel E. Supkis, Ph.D.
Edward L. Trabold

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SPACE TECHNOLOGY HALL OF FAME

THE OTHER 1996 NOMINEES

Advanced Communication Technology Satellite has permitted on-demand allocation of satellite channels, re-use of bandwidth, and the opportunity for small user earth stations for direct interconnectivity. The petroleum industry, banks, and the Mayo Clinic have adapted the technology to develop new and improved services.

Advanced Wire Resistance Strain Gauge is a technology critical to the design and development of advanced gas turbine engines and hypersonic aerospace vehicles. Using the technology, companies developed the capability to manufacture a free-filament, weldable strain gauge for the commercial market.

Automated Hydrogen Gas Leak Detection System produced a comprehensive approach that monitored leaks in hydrogen propulsion systems. In addition to its aerospace application, the system can be used to include safety monitoring of hydrogen facilities and hydrogen build-up in nuclear waste depositories.

Bioreactor for Cell Culture Systems was created to study the effects of cell interaction, metabolism, and other cellular functions in microgravity, and to protect cultures from high shear forces present during space shuttle launch and landing. The commercial Bioreactor design can reduce the effects of shear and gravity while in an earth gravity environment, thus providing for the growth of such things as cancer tumors outside the human body for study — a vital step in the search for cancer cures.

Ceramics Analysis & Reliability Evaluation Software is an enabling software technology that predicts the failure of ceramics parts which responds to a national need for developing more reliable ceramic parts.

Database Management System allows for a system that could run on a small computer, permitting the manipulation of data and enabling users to write miniprograms simply and easily using basic commands. Many database products and millions of copies of software based upon this system are now in use throughout the world.

Low Vision Enhancement System was designed to capture minute information by satellite camera by zooming in on the image and enhancing it with computer software. It is used today to enhance the vision of over three million visually impaired Americans who cannot readily discern low-contrast or who experience blind spots, tunnel vision, or suffer from macular degeneration.

Ocular Screening System is a digital-imaging process designed to interpret Landsat satellite observations of Earth. It is now used to examine the human eye by photographically recording the eye's reflective properties. When analyzed, these properties provide details about the quality of the eye.

Ground Processing Scheduling System is an artificial intelligence-based software program that models the temporal configuration and the resource constraints while performing schedule conflict resolution.

Robotic Ultrahigh-Pressure Waterjet Stripping is a robotic-precision-controlled, high-speed waterjet cleaning system first developed for the space shuttles' external tanks and is now being used for several industrial cleaning applications such as paint removal from aircraft, railroad cars, tank farms, and shipyards.

Telemetry Acquisition & Processing System is a technology that produced a ground station capability to receive and process data 10 times faster than existing systems and fulfilled the requirements of lower system's cost and high reliability.

Underwater Location Aid (The "Pinger") is a system that can precisely locate submerged space objects (space payloads, spacecraft booster, etc.) and is now used by airlines and others to assist with location identification in the event of an accident.

Water Purification is a small, lightweight water purifier that recycles and purifies water using minimal resources, processed in shorter periods of time, while being less costly than traditional methods.

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Abbreviations & Acronyms Glossary

ADC	ARGOS Data Communicator
AEC	Atomic Energy Commission
AFCEA	Armed Forces Communications and Electronics Association
AFPM	Autonomous Fluid Physics Module
AFSCN	Air Force Satellite Control Network
AIAA	American Institute of Aeronautics & Astronautics
ALE	Automatic Link Establishment
ALTEC	ASI Logistic Technological Engineering Center
APL	Aerospace Propulsion Laboratory
ARGOS	Space based Data Acquisition Systems, France
ARPA	Advance Research Programs Agency
ASPRS	American Society for Photogrammetry and Remote Sensing
ASW	Anti-Submarine Warfare
BDPU	Bubble, Drop & Particle Unit
BSIDS	Border Surveillance & Intrusion Detection
BWIS	Battlefield Weather Information Station
CAOC	CombinedAir Operations Center
CBM	Common Berthing Mechanism
CCSDS	NASA's telemetry protocol pocket processing system
CEAS	Confederation of European Aerospace Society
CEOS	Committee of Earth Observation Satellites
CINC	Commander In Chief
CIS	Combat Identification System
CMG	Control Moment Gyros
CNES	Centre Nationale D'Etudes Spatiales (National Center for Space Studies)
COF	Columbus Orbiting Facility
COO	Chief Operations Officer
CSEL	Combat Survivor Locator
DASA	Defense Atomic Support Agency
DoD	Department of Defense
DOC	Department of Commerce
DSCS	Defense Satellite Communications Systems
DTED-5	Digital Terrain Elevation Data, Version 5
EELV	Evolved Expendable Launch Vehicle
ELF	Extremely Low Frequency
ELINT/SIGINT	Electronic Intelligence System / Signal Intelligence
EOB	End of Battle
EOS	Earth Observation System
EOSAT	Earth Observation Satellite
ERS	European Remote Sensing (Satellite)
ESA	European Space Agency
ESRIN	European Space Records Information
EUMETSAT	European Organization for Meteorological Satellites
FBM	Fleet Ballistic Missles
FCC	Federal Communications Commission
FSL	Fluid Science Laboratory
GBS	Global Broadcast Service
GPS	Global Positioning System
GSO	Geo-Synchronous Orbit
GTO	Geostationary Transfer Orbit
HELSTF	High Energy Laser Systems Test Facility
IDR	Interim Design Review
IEA	Integrated Electronics Assembly
IFOR	International Forces
IG	Inspector General
INMILSAT	International Military Satellite
IPT	Integrated Product Teams
IOC	Initial Operational Capability
IRS	Indian Remote Sensing
ISA	Italian Space Agency
ISRO	Indian Space Research Organization
ISSA	International Space Station Alpha
JERS	Japan Earth Remote Sensing
JPL	Jet Propulsion Laboratory
JROC	Joint Requirements Oversight Council
JSMB	Joint Space Management Board
JTGS	Joint Tactical Ground Stations
LEO	Low Earth Orbit
LISS	Laser Illuminator Subsystem
LMLV	Lockheed Martin Launch Vehicles
MBS	Mobile Base System
MEO	Medium Earth Orbit
MIGOSC	Miniature Global One-Way Satellite Communicator
MILSATCOM	Military Satellite Communications

MoD	Ministry of Defense
MOS	Marine Observation Satellite
MPLM	Mini Pressurized Logistic Modules
MSS	Mission planning system of a tactical Air Force
NARSIA	North American Remote Sensing Industries Association
NASA	National Aeronautics and Space Administration
NEO	Near Earth Orbit
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Organization
NTF	National Test Facility
NTS	National Technical Systems
ORI	Operational Readiness Inspection
ORU	Orbital Replacement Unit
OSE	Operational Support Equipment
OSO	Operation Support Organization
PCS	Personal Communications Systems
PMA	Pressurized Mating Adapter
PQE	Path Quality Evaluation
R&D	Research and Development
REV	Revised or Revision
RLV	Reusable Launch Vehicle
RMS	Remote Manipulator System
RSA	Russian Space Agency
SAC	Strategic Air Command
SBIRS	Space-Based Infrared System
SCUDTSOC	Theater Support Operations Cell
SEAL	United States Navy special forces team
SETI	Search for Extraterrestrial Intelligence
SES	Societe Europeene des Satellites
SPOT	Satellite Positioning and Tracking
SSRMS	Space Station Remote Manipulator System
STEP	Space Technology Experimental Program
STS	Space Transport System
SWC	Space Warfare Center
TAD	TIROS Arctic Drifter
TENCAP	Tactical Exploitation of National Capabilities
TIROS	Television Infrared Observation Satellite
TOGA	Tropical Ocean Global Atmosphere (Ocean Buoy)
TSIDS	Tactical Surveillance & Intrusion Detection System
UAV	Unmanned Aerial Vehicle
UCP	Unified Command Plan
ULF	Ultra Low Frequency
USGS	U.S. Geological Survey
VHF	Very High Frequency
VOR	Visual Omni Range
WGS-84	World Geodesy Standard, v.1984
WiFS	Wide Field Sensor
WSD	Wind Speed & Direction


Top to bottom, left to right:
San Juan, Argentina– Landsat 5 (U.S.A.); Sacramento, California– ERS-1 (European Space Agency); Alamosa, Colorado– IRS-1B (India); Lake Ponchartrain, Louisiana– JERS-1 (Japan); Cairo, Egypt– KVR-1000 (Russia)