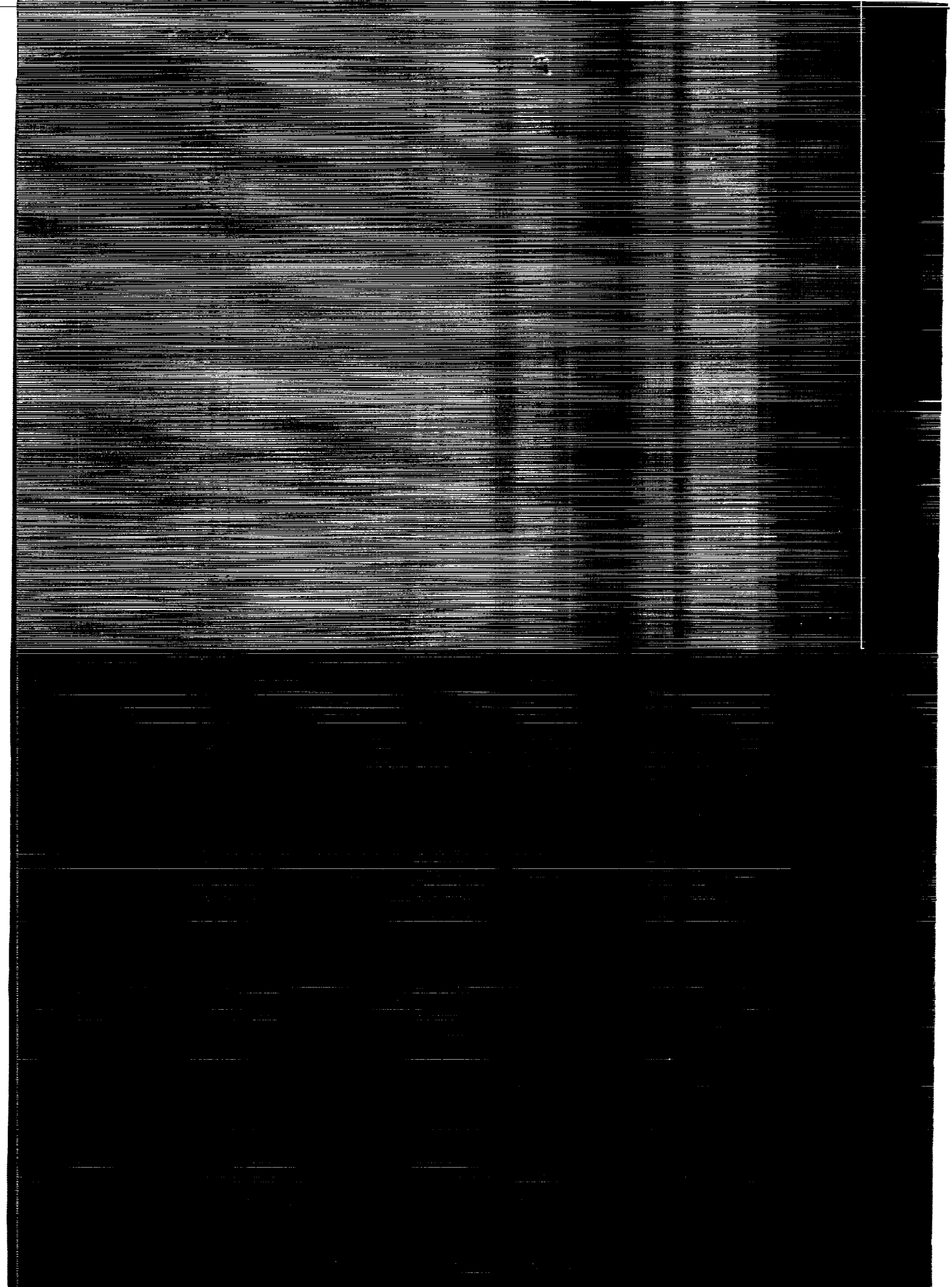


NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

tn of: RS

April 20, 1992

Dear Colleague,

Improving the effectiveness with which the results of U.S. government research and technology (R&T) investments are applied is a topic of great importance to many in government, industry and academia. Because technological advancement has been one of the traditional hallmarks of U.S. civil space efforts, it is important to assure that U.S. civil space R&T developments are soundly planned and transferred effectively. In 1991, NASA's Office of Aeronautics and Space Technology (OAST) developed an *Integrated Technology Plan* (ITP) for the civil space program in response to Recommendation 8 of the Advisory Committee on the Future of the U.S. Space Program, chaired by Mr. Norman Augustine. The ITP provides both a strategic plan for NASA's advanced space R&T programs. It also represents a strategic planning framework for other technology development agencies and potential users of space technology. Providing such as strategic framework is an important step in establishing long-term success in technology transfer, but it is not enough.

Enclosed are the minutes from a OAST-hosted workshop on Technology Transfer and the Civil Space Program, held on March 17, 18 and 19, 1992, in McLean, Virginia. This workshop provided an initial forum for discussions among participants from across NASA, other U.S. government agencies and laboratories, the U.S. private sector, and universities. The meeting was kept deliberately small and discussion focused not on specific technology areas, but rather on process (including a variety of potential mechanisms for enhancing transfer of various types, as well as related structural issues). These minutes provide both presented materials and the results of working panel and plenary discussions from the workshop.

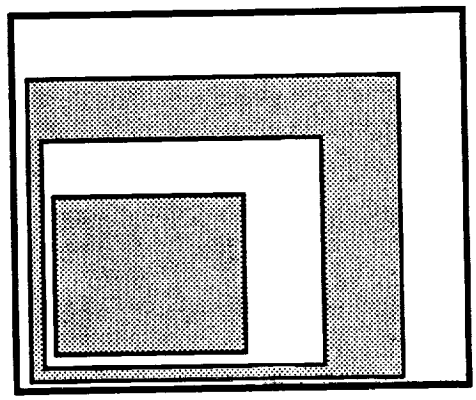
I hope that you find this volume (and the accompanying *Workshop Results Summary* volume) to be both thought provoking and useful as references.

Sincerely,

John C. Mankins
Manager, Program Integration Office
OAST Space Technology Directorate

VOLUME II
WORKSHOP PROCEEDINGS

Technology Transfer
AND THE CIVIL SPACE PROGRAM



A WORKSHOP TO ASSESS ISSUES AND STRATEGIES

McLean, Virginia
March 17, 18 and 19, 1992

NASA
National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, D.C. 20546

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

March 17-19, 1992 Workshop
McLean, Virginia

Volume II. Workshop Proceedings

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Part V: March 19th

Part VI: Additional Material

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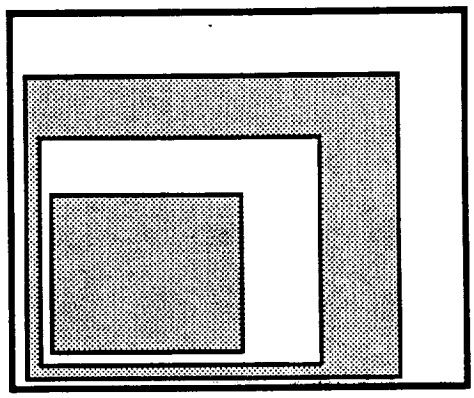
TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM



A WORKSHOP TO ASSESS ISSUES AND STRATEGIES

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Washington, D.C. 20546

CONTENTS

SECTION 1

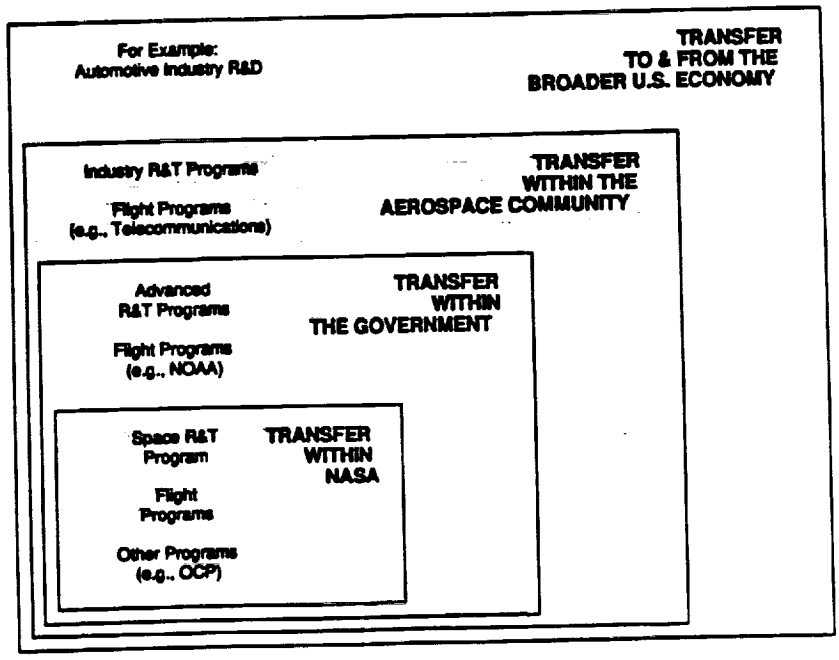
INTRODUCTION

The following section provides an introduction to this workshop, including a brief background discussion, the general approach to assessing technology transfer of which this workshop is an intended part, and the specific purposes for which this workshop is being held.

BACKGROUND

■ In response to Recommendation 8 of the Advisory Committee on the Future of the U.S. Space Program, NASA's Office of Aeronautics and Space Technology has developed an *Integrated Technology Plan* (ITP) for the civil space program.

Three particular aspects in the process of creating new technologies are crucial to the success of the ITP: (1) the determination of what technologies should be developed (i.e., identification of technology needs and priorities); (2) development and demonstration of the technology; and, (3) successful transfer of the technology to users. The latter issue — successful technology transfer — is the subject of this workshop.



In the 1991 edition of the ITP, four distinct arenas were identified, within which civil space-related technology transfer needs to be both understood and facilitated (these are shown in the figure above): (a) transfer within NASA, (b) transfer within the U.S. government, (c) transfer between the government and the aerospace industry, and (d) transfer with the general (non-aerospace) economy.

APPROACH

■ The general approach that is being pursued to enhance civil space technology transfer is four-fold: (a) *conduct a workshop to share and assess experiences on the issues and to develop an informal framework to consider the problem, encompassing NASA, other U.S. government, industry and universities*; (b) based on the issues identified in the initial workshop, develop white papers with proposed solutions in specific areas; (c) review the white papers and propose specific actions to facilitate transfer; and, (d) incorporate, as appropriate, proposed technology transfer actions/mechanisms into the ITP and OAST space R&T implementation.

WORKSHOP PURPOSE[1]

■ Confirm the strategic value of U.S. government investments in space research and technology — and in particular of the ITP — to NASA, the aerospace industry, and the broader U.S. economy.

■ Enhance the value of the Integrated Technology Plan through proactive definition of technology transfer strategies that can meet current and emerging needs of potential civil space technology users, including NASA, other U.S. government, aerospace industry, academia and non-aerospace industry.

WORKSHOP SCOPE/GROUNDRULES

■ By assumption, this workshop will not deal with the following topics:

1. Transfer either to or from non-U.S. technology developers and/or programs (i.e., international technology transfer issues).

2. Transfer from U.S. government programs that are "black" — i.e., subject to National Security related constraints on information dissemination.

Although these areas are legitimate topics associated with the general subject of technology transfer, they are beyond the scope of the intended effort and will not be dealt with in this discussion.

[1] Note: this workshop is envisioned as a "TQM-type" meeting with strong participation by all participants, not purely presentations.

SECTION 2

WORKSHOP PLAN

The following section provides the "order of march" for this workshop, including workshop objectives, the strategy that was used to develop the list of participants that were invited, and the general processes by which the meeting will accomplish its goals.

WORKSHOP OBJECTIVES

- Review. Top-level review of the ITP and current civil space technology plans, including planning processes and technologies.

- Assessment. Discussion and assessment of technology transfer experiences across a wide range of participants (NASA, other U.S. government and private sector).

- Transfer Alternatives. Identify alternate categories/strategies for technology transfer and define the objectives of transfer processes in each case; areas of technology transfer include:

  — from NASA researchers[2] to NASA flight programs/projects
  — between NASA and other U.S. government agencies/laboratories
  — Between NASA/U.S. government and the aerospace industry
  — Between NASA/U.S. government (and between the aerospace industry) and the broader U.S. economy.

- Roles. Identify the roles of various Government 'stakeholders', aerospace industry, industries at large, and universities in civil space technology research, development, demonstration and transfer.

- Barriers/Opportunities. Identify potential barriers and/or opportunities to successful civil space technology transfer: what needs must be met to achieve successful transfer.

[2] For this purpose, university researchers/technologists are included in this category.

■ Innovation. Identify specific needs for innovations in policy, programs and/or procedures to facilitate technology transfer.

■ Issues. Exchange ideas and experience regarding the key issues (see above).

■ Commitment. Develop a plan of attack for the development of a workshop report; secure commitment at the management and researcher level to participate in preparation for follow-on activities, if any. Goal: Sharing and assessment of technology transfer experience and strategies.

PARTICIPANTS STRATEGY

■ Strategy. Participation would be by invitation only, targeted on a group of approximately 60 people to ensure substantive exchanges of ideas. The specific individuals have been invited on the basis of various objectives and the overall approach discussed above.

■ Invitation List. Individuals have been invited from NASA, other Federal Agencies, academia, and private corporations. These individuals include: (1) senior management (to ensure the credibility of the results of the process), (2) R&T management and planning personnel (to support follow-on activities); and (3) specialists in technology transfer to provide a base of data on lessons learned and to catalyze discussion.[3]

WORKSHOP METHODOLOGY

■ The planned methodology by which the workshop will accomplish its objectives has several components. These include:

(1) Use of the Integrated Technology Plan (ITP) as an "initializing" framework for the discussion at the workshop.

(2) A mix of presentations, discussion and analysis during the meeting, including plenary sessions to provide overviews and background material, and separate working panel sessions to focus attention on individual aspects of the overall questions of technology transfer.

[3] The full list of participants (as of the first week in March 13, 1992) is provided as an appendix to this workshop overview.

(3) A set of specific, pre-defined "tools" that will be used to frame the conduct and capture the results of the individual working panel discussions. These include:

(a) Technology Transfer "strategic areas" taxonomy
(b) "Issues To Be Considered" (ITBC) form
(c) Process evaluation/assessment charts

(4) Development of a formal workshop report. It will: (a) provide a record of the results of this workshop; (b) create a working forum for continuing discussion and planning; and (c) establish a "body of knowledge" on this subject.

WORKSHOP LOGISTICS

Location	HILTON HOTEL McLean, Virginia
Dates	MARCH 17-19, 1992 (Tuesday, Wednesday and Thursday)
Services	During the meeting, a variety of support services will be provided, including: photocopying, access to word processors, limited support for the creation of graphics, etc.

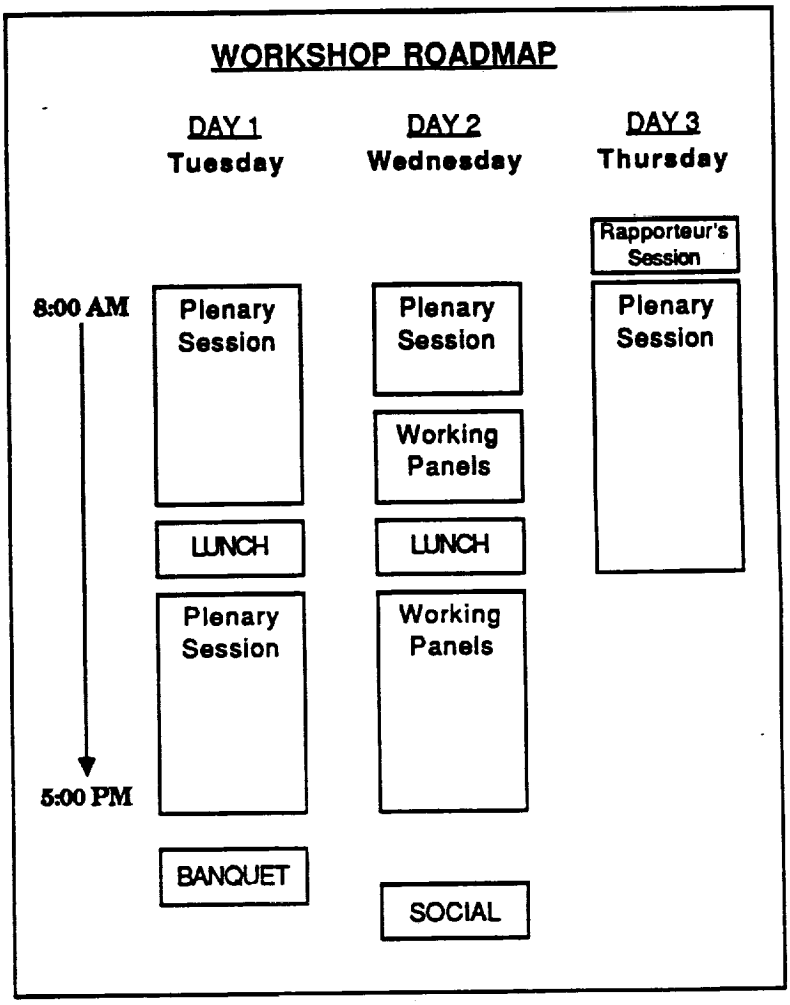
Information regarding costs and hotel accommodations are provided separately.

SECTION 3

WORKSHOP AGENDA

The following section provides the agenda for the workshop, including an example of the path that the discussion in one of the working panel sessions should follow. (Specific times for starting/stopping the discussion for each of the panel sessions subtopics are not provided.)

■ The figure at right provides an overall "roadmap" for the workshop. This includes (a) a plenary session on the first day, culminating in a panel discussion among members of the workshop's steering committee; (b) a brief plenary session on the morning of the second day to set the stage for separate working panel sessions; (c) a set of concurrent working panel discussions in the late morning and afternoon on the second day of the meeting; and (d) a closing plenary session on the last day, with reports from the working panel rapporteurs, and a discussion of options for future action.



PLENARY SESSION — DAY 1

Tuesday, March 17 — *Overview Briefings*

8:00 AM	Welcome; Workshop Agenda and Expectations	J. Mankins (Manager, NASA/ OAST Program Integration Office)
8:30 AM	NASA Space Research and Technology Overview	G. Reck (Director for Space Technology, NASA/OAST)
10:15 AM	**BREAK**	
10:30 AM	Department of Commerce Overview	D. Wince-Smith (Assistant Secretary for Technology Policy, DOC)
11:00 AM	Department of Energy Overview	R. Lewis (Deputy Director, Office of Technology Analysis, DOE)
11:30 AM	Department of Transportation Overview	S. Myers (Director, Office of Commercial Space Transportation)
NOON	**LUNCH**	
1:00 PM	DOC/Office of Space Commerce Perspective on Technology Transfer	S. Pace (Deputy Director, Office of Space Commerce, DOC)
1:30 PM	White House/OSTP Perspective	D. Pryor (Senior Policy Analyst, OSTP)
2:00 PM	Congressional Perspective	D. Moore (Principal Analyst, Congressional Budget Office)
2:30 PM	Aerospace Industry View	G. Millburn (National Center for Advanced Technology, AIA)
3:15 PM	**BREAK**	
3:30 PM	Panel Discussion: Workshop Steering Committee	Moderator: R. Rosen (Deputy Associate Administrator, OAST)
4:45 PM	Re-Cap/Overview of Next Day	J. Mankins (Manager, NASA/ OAST Program Integration Office)
5:00 PM	**BREAK**	
6:00 PM	**BANQUET DINNER**	Speaker - J. Mannix (Assistant Administrator, NASA/OCP)

PLENARY SESSION/WORKING SESSIONS — DAY 2

Wednesday, March 18 — *Plenary Wrap-up and Working Discussions*

Plenary Session: Technology Transfer Challenges

8:00 AM	Intro & Re-cap of First Day	
8:15 AM	Technology Transfer "Needs and Experiences"	F. Penaranda (Deputy Assistant Administrator (Pgms.), NASA OCP)
	— NASA Research Center View	A. Gross (ARC)
	— NASA Flight Program View	G. L. Dyer (MMC)
	— National Laboratory View	L. Gilliom (SNLA)
	— NASA OCP/NTTC View	L. Rivers (NTTC)
10:00 AM	Charge to the Working Panels	J. Mankins
10:30 AM	**BREAK**	

Working Panel Sessions

11:00 AM	Parallel Working Panel Sessions
	— NASA: Internal Transfer
	— Government: Interagency Transfer
	— Government-Aerospace Industry Transfer
	— Beyond Aerospace Transfer
	— Strategies and Mechanisms
12:30 PM	**LUNCH**
1:30 PM	Working Panel Meetings (continued)
3:15 PM	**BREAK**
3:30 PM	Working Panel Meetings (continued)
5:00 PM	**BREAK**
7:00 PM	**SOCIAL**

PLENARY SESSION — DAY 3

Thursday, March 19 — *Consensus and Actions*

7:00 AM	Rapporteur's Coordination Session	
	Plenary Session: Workshop Results Summary	
8:00 AM	OAST Perspective on Technology Transfer and the Civil Space Program	R. Petersen (NASA/OAST Associate Administrator)
8:15 AM	Reports from Technology Transfer Working Panels/Sub-Panels	
	— NASA Internal Transfer — Government: Interagency Transfer — Government-Aerospace Industry Transfer — Transfer Beyond Aerospace — Strategies and Mechanisms	
10:15 AM	BREAK	
10:30 AM	General Discussion	
11:30 AM	Plans for Future Action	
	— Plans for potential follow-on actions (white papers: topics, writing assignments, review process)	
1:00 PM	ADJOURN	

TECHNOLOGY TRANSFER WORKING PANEL

Synthesis Discussion Format

The following is the general "flow" suggested for working panel discussions.

General

First — Organization of the Panel.
Review of panel participants. Review of proposed sub-topics for the panel, possible identification of any additional sub-topics that should be addressed by the panel. Identification of panel sub-topic rapporteurs.

Second — "Pilot Presentations."

Invited, or offered presentations (formal or informal) by several members of the panel that address the key issues from that person's perspective.

For Each Sub-Topic

First — Working Discussion.
General discussion of the subject, working toward the development of "targeted assessments" and creation of any "Issues To Be Considered" (ITBC) inputs

Second — Conclusions.
Development of a summary "report" for overhead projection charts from the working panel. This is the responsibility of the Rapporteur for the sub-topic. Contents should include: (1) review of the material presented, (2) summary of the discussion, (3) identification of any key ITBC's, and (3) recommendations on potential courses of action related to the topic area.

Third — Repeat process for any subtopics

General — Closing Position.
Develop a closing position for the group as a whole and choose a spokesman for the Thursday plenary session; contents should include (a) major issues, (b) major recommendations for future action, etc.

SECTION 4

WORKING PANEL START-UP MATERIALS

The following section provides a series of materials that are intended to help with "start-up" of the discussion in each of the individual working panels. Four topics are discussed below: (a) a general, idealized model for civil space research and technology development; (b) a strategic framework for technology transfer (created specifically to support this workshop discussion); (c) detailed definitions of the objectives of the five working panels (and the topics to be discussed within each); and (d) explanation of the "tool kit" that will be provided to each panel to facilitate capturing the products of their discussions and thoughts.

TECHNOLOGY TRANSFER "STRATEGIES"

To assist in discussing and evaluating various potential mechanisms that bear on the question of technology transfer, a taxonomy of such mechanisms has been devised. This taxonomy divides potential transfer mechanisms into a set of "strategies" which includes:

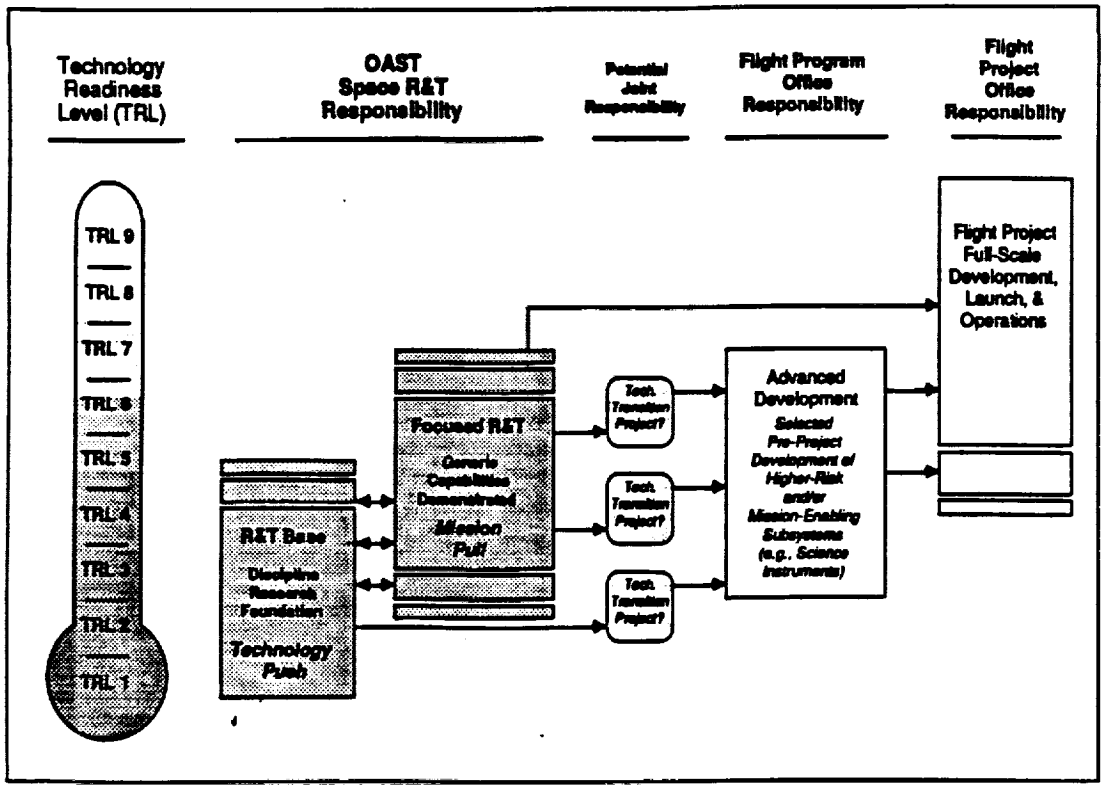
- Communication and Information
- Coordinated and/or Cooperative Research (and Research Interchanges)
- Directed Investments
- Institutional Plans and Actions
- Procedural and Structural Factors: Impediments and Enhancers

Clearly, no one of these strategies is truly independent; each has a larger or smaller "overlap" with the others. Nevertheless, the categorization is intended to facilitate our ability during the workshop to abstract from particular examples of technology transfer to general issues, assessments, and proposals. (Appendix B provides an initial listing of some of specific technology transfer mechanisms that falls within each "strategy.")

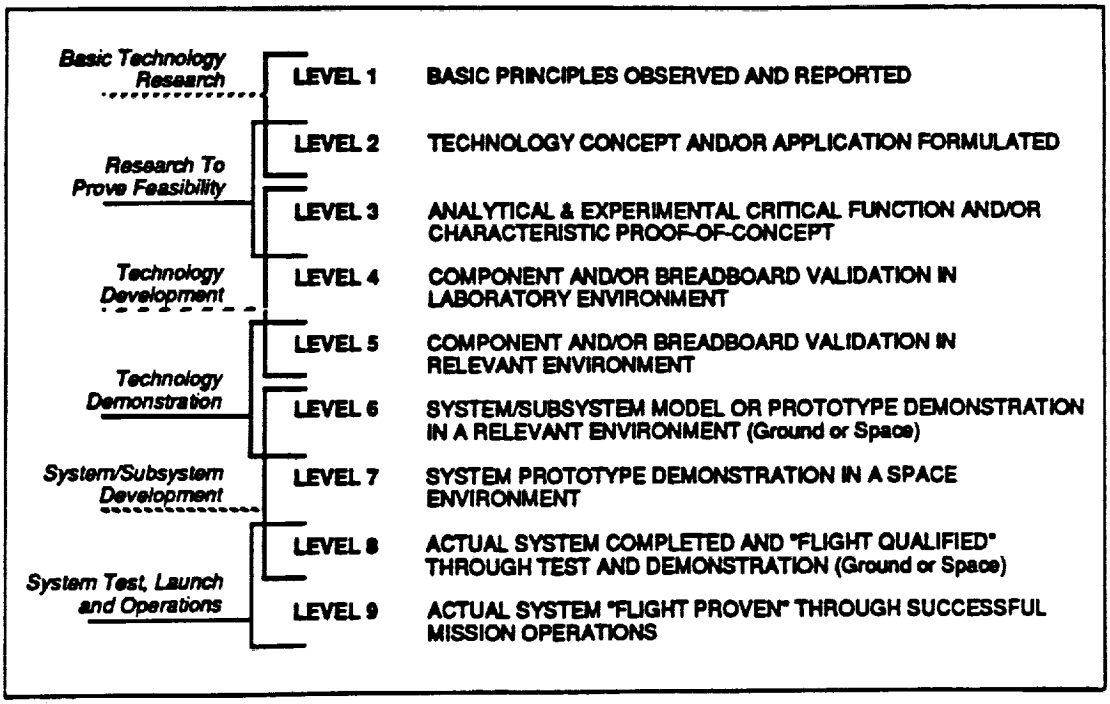
TECHNOLOGY MATURATION MODEL

In order to aid the working panel in assessing where different types of technology transfer mechanisms come into play in the process of technology maturation and

system (or product) development, a preliminary generic model of the civil space technology maturation has been provided. (This model is derived from the technology maturation model used in the development of the Integrated Technology Plan in 1991.) The figures below illustrate this generic technology model as well as providing the standard "technology readiness levels" that are used within NASA.



NASA Civil Space Technology Maturation Strategy



NASA Civil Space Technology Readiness Levels

WORKING PANEL "TOOL KIT" EXPLANATION

In addition to flip-charts, overhead projectors, etc., several "tools" are provided to facilitate working panel discussion.

Working Chair

■ A "working chair" will be designated for among the participants for each of the working panels. This individual will provide overall guidance to the discussion, assigning and working with the rapporteur's for each subtopic, and being assisted by the coordinator/facilitator. This person will introduce and provide an overview for the panel's report to the Thursday morning plenary.

Sub-Topic Rapporteur

■ Working panels/working chairs are requested to designate an individual to serve as the "Rapporteur" for each of the sub-topics assigned to that panel. These individuals are to be chosen by consensus from among the members of the working panel and are responsible for reporting the results of the panel's discussion of their particular sub-topic at the plenary session on Thursday.

Coordinator/Facilitator

■ Each panel has been provided with a "coordinator/facilitator." The role of this individual is to support the working chair and the several rapporteurs, and to serve as "timekeeper" to assure that the working panel covers the appropriate scope of material during the discussion (i.e., all of the sub-topics).

"Issues To Be Considered"

■ The panels are provided with a standardized form which should be used to capture key ideas/issues as they are raised by the panel. The "Issues To Be Considered" (ITBC's) will be provided to the rapporteurs to aid in their preparation of summary reports, as well as being transcribed for incorporation into the workshop's report.

"Transfer Assessment Worksheets"

■ A second form is provided which is intended to facilitate the panel's assessment of the particulars of each sub-topic/area. These forms allow easy reference to the overall Technology Transfer Strategies framework for evaluation of each proposed solution to a technology transfer challenge. (The idea is for each/most of the members to fill one or more "Transfer Assessment Worksheets" for each of the sub-topics discussed (and for each proposed "solution").

WORKING PANEL GUIDELINES

WORKING PANEL 1— TRANSFER WITHIN NASA

■ The objective of this working panel is to review the question of technology transfer within a large organization that includes both research and technology development units and separate system development or project implementation units. For example, technology transfer within NASA represents this type of transfer.

SUB-TOPIC A
THE "CLASSICAL" PROBLEM: TECHNOLOGY TRANSFER WITHIN AN ORGANIZATION (E.G., FROM NASA TECHNOLOGIST TO NASA FLIGHT PROJECT)

SUB-TOPIC B
SPACE SCIENCE INSTRUMENT TECHNOLOGY & THE ROLE OF UNIVERSITIES IN THE TECHNOLOGY DEVELOPMENT PROCESS

WORKING PANEL 2 — TRANSFER WITHIN THE GOVERNMENT

■ The objective of this working panel is to examine issues and opportunities related to the question of technology transfer within the U.S. Government. For example, technology transfer between DoE and NASA represents this type of transfer.

SUB-TOPIC A
TRANSFER FROM NON-NASA U.S. GOVERNMENT TECHNOLOGY DEVELOPERS TO NASA SPACE MISSIONS/PROGRAMS

SUB-TOPIC B
TRANSFER FROM NASA TO OTHER U.S. GOVERNMENT CIVIL SPACE MISSION PROGRAMS

WORKING PANEL 3 — TRANSFER BETWEEN NASA AND THE AEROSPACE INDUSTRY

■ The objective of this working panel is to review questions pertaining to technology transfer between NASA and the aerospace industry. For example, application of a particular new technology by an aerospace company to NASA for use in a NASA flight program represents this type of transfer.

SUB-TOPIC A
TECHNOLOGY TRANSFER ASSOCIATED WITH A PROJECTED GOVERNMENT APPLICATION

SUB-TOPIC B
TECHNOLOGY TRANSFER ASSOCIATED WITH A COMMERCIAL SPACE SECTOR APPLICATION[4]

WORKING PANEL 4 — TRANSFER WITH THE BROADER ECONOMY

■ The objective of this working panel are three-fold: (1) transfer from NASA to the broader economy; (2) transfer from the broader economy into the Government; and, (3) transfer of technology between the aerospace community (including government and industry) and the broader economy.

SUB-TOPIC A
HARVESTING COMMERCIALLY-DEVELOPED TECHNOLOGIES FOR CIVIL SPACE MISSION APPLICATIONS

SUB-TOPIC B
COMMERCIAL APPLICATIONS OF NASA/GOVERNMENT-DEVELOPED CIVIL SPACE TECHNOLOGY

SUB-TOPIC C
COMMERCIAL APPLICATIONS OF NON-GOVERNMENT DEVELOPED CIVIL SPACE TECHNOLOGY

[4] Note: Technology transfer associated with non-aerospace commercial sector applications are grouped under Working Panel 4.

WORKING PANEL 5 —STRATEGIC DIRECTIONS AND MECHANISMS FOR CIVIL SPACE TECHNOLOGY TRANSFER

■ The objective of this working panel is to review the overall strategic directions and mechanisms for technology transfer as it pertains to the civil space program.

SUB-TOPIC A
OVERVIEW OF TECHNOLOGY TRANSFER APPROACHES

SUB-TOPIC B
CATEGORIZATION AND ASSESSMENT OF EXISTING MECHANISMS

SUB-TOPIC C
SPECIFIC NEEDS AND OPPORTUNITIES FOR POLICY/LEGAL INNOVATIONS TO ENHANCE THE EFFICACY OF THE TECHNOLOGY TRANSFER PROCESS

SUB-TOPIC D
THE VALUE OF STRATEGIC PLANNING AND SYSTEMS ANALYSES TO EFFECTIVE TECHNOLOGY TRANSFER

SUB-TOPIC E
ISSUES INVOLVED IN DEALING WITH EXCLUDED SUBJECTS: TRANSFER OF TECHNOLOGY FROM NATIONAL SECURITY-RESTRICTED PROGRAMS, AND INTERNATIONAL TECHNOLOGY TRANSFER QUESTIONS

SUB-TOPIC F
POTENTIAL OPPORTUNITIES FOR FUTURE ACTION

SECTION 5

PRELIMINARY WORKSHOP REPORT OUTLINE

The following section provides current thinking regarding the outline and contents of the report that will be developed as a result of this workshop.

- Chapter 1 — Executive Summary

An overview into the process, the workshop, the summary findings of the meeting, and options for future activities.

- Chapter 2 — Transfer Strategies and Mechanisms

Strategic definition of approaches to facilitate the transfer of space technologies (plus preliminary evaluation of mechanisms in terms of their relative importance in achieving success).

- Chapter 3 — Transfer within NASA

A preliminary assessment of civil space technology transfer issues and improvement strategies regarding transfer from NASA technology research programs to NASA flight programs/projects.

- Chapter 4 — Transfer within the Government

A preliminary assessment of civil space technology transfer issues and strategies for transfer *between* NASA and other U.S. Government Agencies/Laboratories.

- Chapter 5 — Transfer between Government and the Aerospace Industry

A preliminary assessment of civil space technology transfer issues and improvement strategies for transfer *to and from* Government and the aerospace industry. (This may include distinct strategies for transfers related to (a) aerospace industry supporting a NASA flight program, or (b) aerospace industry pursuing a commercial space sector objective.)

- Chapter 6 — Transfer between Government and the Broader Economy

A preliminary assessment of civil space technology transfer issues and improvement strategies for transfer *to and from* the Government and the broader economy.

- Chapter 7 — Transfer between Aerospace and the Broader Economy

A preliminary assessment of civil space technology transfer issues and improvement strategies for transfer *to and from* the Aerospace community and the broader economy.

- Chapter 8 — Government Technology Research Assessment

List specific research areas to be addressed and technologies to be developed as part of the space R&T program under the ITP, and related other Government R&T related to meeting the needs of the civil space program.

- Chapter 9 — Private Sector Technology Needs Assessment

List specific generic research areas and technologies in government civil space R&T efforts that might be of greatest potential use to the aerospace sector and private industry in the broader economy.

- Chapter 10 — Summary Review of Options

Discussion of the primary options for actions to enhance the transfer of technology (strategies, mechanisms, innovations, policy-related questions, modes of implementation). Projections of efficacy/priority for options.

- Appendices — Workshop Presentations

APPENDIX A

WORKSHOP STEERING COMMITTEE

- General Chairman — NASA Code R — R. Petersen
- Member — NASA Code RS — G. Reck
- Member — NASA Code C — J. Mannix
- Member — Department of Transportation —S. Myers
- Member — Department of Energy — F. Carey
- Member — Private Sector — G. Kozmetsky (IC^2)
- Member — Private Sector — B. Edelson (GWU)
- Member — Private Sector — J. Preston (MIT)
- Executive Secretary — NASA Code RS — J. Mankins

APPENDIX B

TECHNOLOGY TRANSFER STRATEGIC AREAS — MECHANISMS AND ISSUES —

The following appendix provides a detailed (albeit preliminary) listing of potential technology transfer mechanisms and issues within an overall framework encompassing five strategic areas.

Communications and Information

Advisory Groups
Workshops/Seminars/ Conferences
Strategic Plans
Intra–government Liaison
Mailings
Technical Reports
Technical Databases
Popular Media
News Releases and Publications
Articles in Trade Journals and Magazines
Fact Sheets
Videotapes
Decision Tools
Electronic Bulletin Boards
Education Programs

Institutional Plans and Actions

Information Dissemination Centers
Government/Industry/Univ. Consortia
Broker Organizations
Industry Research Labs

Coordinated and/or Cooperative of Research and Research Interchanges

Contracting R&D to Industry
Cooperative Research Projects

Access to Government Facilities
Conducting Work for Others (Gov't., Industry, Academia)
Private Consulting by Government Staff
Working with Trade Organizations
Industry Guest Researchers
Government Staff Transfers
Participation in Research Consortia

Directed Investment

Licensing
Privatization
Demonstration Projects
Spinoff Companies
Royalty Arrangements
Incubators
Government–Sponsored Research Opportunities
Corporate Acquisitions

Structural Factors: Impediments and Enhancers

Technology Transfer to Foreign Entities
Technology Transfer to Partially Foreign–Owned U.S. Firms
Use of Federal Infrastructure
Federal Procurement Policies (e.g. Service–Oriented Procurement Policies)
Tax Credits and Other Tax Incentives
Industrial Policy
Standards Development and Distribution
Effect of Agency Mission/Organization on Technology Transfer Programs and Mechanisms Used
Patent Law and Other Intellectual Property Laws and Regulations
Anti–Trust Legislation and Policies (e.g. R&D Limited Partnerships)
Personnel Policies
Federal Budget Constraints

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

March 17-19, 1992 Workshop
McLean, Virginia

List of Attendees

Name	Organization	Location
Acuna, Dr. Mario	Goddard Space Flight Center	Greenbelt, MD
Adelson, Dr. Harold	TRW	Redondo Beach, CA
Alario, Joseph	Grumman	Bethpage, NY
Anderson, Robert	Rockwell International	Arlington, VA
Anyos, Dr. Thomas	Electric Power Research Inst.	Palo Alto, CA
Bajpai, Dr. Shyam	NOAA	Washington, DC
Bartine, David	Oak Ridge National Lab.	Oak Ridge, TN
Bertin, John	Department of Energy	Washington, DC
Bott, Robert	McDonnell Douglas	Arlington, VA
Bowles, Norman	Department of Transportation	Washington, DC
Carey, Dr. Fenton	Department of Energy	Washington, DC
Carlson, Dr. Curt	David Sarnoff Research Center	Princeton, NJ
Christensen, Carissa	Princeton Synergetics Inc.	Princeton, NJ
Clark, Robert	National Media Lab.	St. Paul, MN
Connolly, Denis	Lewis Research Center	Cleveland, OH
Culpepper, Dr. Ronald	Office of Naval Technology	Arlington, VA
Cykoski, Russ	General Research Corporation	Vienna, VA
Dula, Alex	Johnson Space Center	Houston, TX
Dunbar, Dennis	General Dynamics	San Diego, CA
Dyer, Gordon	Martin Marietta	New Orleans, LA
Edelson, Dr. Burton	George Washington University	Washington, DC
Edgerly, David	National Inst. of Sci. & Tech.	Gaithersburg, MD
Etenberg, Dr. Michael	David Sarnoff Research Center	Princeton, NJ
Freese, Dr. Kenneth	Los Alamos National Lab.	Los Alamos, NM
Fuller, Joseph	Futron Corporation	Bethesda, MD
Gernand, Joseph	Rockwell International	Downey, CA
Gilliom, Dr. Laura	Department of Energy	Washington, DC
Gold, Dr. Robert	Johns Hopkins University	Laurel, MD
Greenberg, Joel	Princeton Synergetics Inc.	Princeton, NJ
Gross, Dr. Anthony	Ames Research Center	Moffett Field, CA
Handley, Thomas	Jet Propulsion Lab.	Pasadena, CA
Hartman, Steven	NASA Headquarters	Washington, DC
Helm, Neil	George Washington University	Washington, Dc
Hodge, Ronald	General Electric	Schenectady, NY
Holcomb, Lee	NASA Headquarters	Washington, DC
Hops, Larry	Idaho National Engr. Lab.	Idaho Falls, ID

Name	Organization	Location
Jennings, John	NASA Headquarters	Washington, DC
Kozmetsky, Dr. George	IC Squared Institute	Austin, TX
Kravitz, Dr. Larry	Allied Signal	Arlington, VA
Lewis, Roger	Department of Energy	Washington, DC
Mackin, Dr. Robert	Jet Propulsion Lab.	Pasadena, CA
Mankins, John C.	NASA Headquarters	Washington, DC
Mannix, John	NASA Headquarters	Washington, DC
Marinzel, Ronald	BDM International Inc.	Washington, DC
Martinell, John	Department of Energy	Washington, DC
Marzwell, Dr. Neville	Jet Propulsion Lab.	Pasadena, CA
Matthews, Bruce	Department of Energy	Washington, DC
McGovern, Dr. Dennis	McDonnell Douglas	Huntington Beach, CA
Millburn, George	Nat. Ctr. for Adv. Technologies	Washington, DC
Montanarelli, Nick	Department of Defense	Arlington, VA
Moore, David	Congressional Budget Office	Washington, DC
Morrison, James	BDM International Inc.	Washington, DC
Mosakowski, George	Kennedy Space Center	Cape Canaveral, FL
Myers, Stephanie	Department of Transportation	Washington, DC
Neeland, Dr. Roger	General Electric	Colorado Springs, CO
Norwood, Dr. Robert	NASA Headquarters	Washington, DC
Olstad, Dr. Walter	Lockheed	Palo Alto, CA
Pace, Dr. Scott	Department of Commerce	Washington, DC
Palmer, Dr. Larry	Hughes Network Systems	Germantown, MD
Paugh, Jon	Department of Commerce	Washington, DC
Penaranda, Frank	NASA Headquarters	Washington, DC
Petersen, Richard	NASA Headquarters	Washington, DC
Plotkin, Dr. Henry	Goddard Space Flight Center	Washington, DC
Preston, John	MIT	Cambridge, MA
Pryor, Donald	OSTP/White House	Washington, DC
Ray, Dr. Joseph	Great Lakes Tech. Transfer Ctr.	Cleveland, OH
Reck, Gregory	NASA Headquarters	Washington, DC
Rivers, Lee	Nat. Tech. Transfer Center	Wheeling, WV
Root, Jonathan	NASA Headquarters	Washington, DC
Rosen, Dr. Robert	NASA Headquarters	Washington, DC
Russell, Col. John	Phillips Laboratory	Kirtland AFB, NM
Rydalch, Ann	Idaho Nat. Engr. Lab.	Idaho Falls, ID
Sackheim, Robert	TRW	Redondo Beach, CA
Sadin, Stanley	NASA Headquarters	Washington, DC
St. Cyr, Dr. William	Stennis Space Center	Mississippi
Schneider, Stanley	NOAA	Washington, DC
Sevin, Dr. Eugene	Department of Defense	Arlington, VA
Shariq, Dr. Syed	American Technology Initiative	Menlo Park, CA
Simpson, Theodore	General Research Corporation	Vienna, VA
Sokoloski, Dr. Martin	NASA Headquarters	Washington, DC

Name	Organization	Location
Spann, Robert	Johnson Space Center	Houston, TX
Steen, Robert	Princeton Synergetics Inc.	Princeton, NJ
Steer, Randolph	OMB/White House	Washington, DC
Sutey, Dr. Anthony	Boeing	Seattle, WA
Thornton, Ronald	Southern Tech. Application Ctr.	Alachua, FL
Thurman, Don	Marshall Space Flight Center	Huntsville, AL
Vander Velde, Dr. George	Chemical Waste Mgmt. Inc.	Oak Brook, IL
Weaver, Willard	Langley Research Center	Hampton, VA
Weingarten, Michael	NASA Headquarters	Washington, DC
Wells, Damon	Department of Transportation	Washington, DC
Zombeck, Dr. Martin	Harvard/Smithsonian Center for Astrophysics	Cambridge, MA

Office of
Aeronautics,
Exploration and
Technology

Workshop Introduction and Overview

Technology Transfer and the Civil Space Program

John C. Mankins
OAST Space Technology Directorate
Program Integration Office

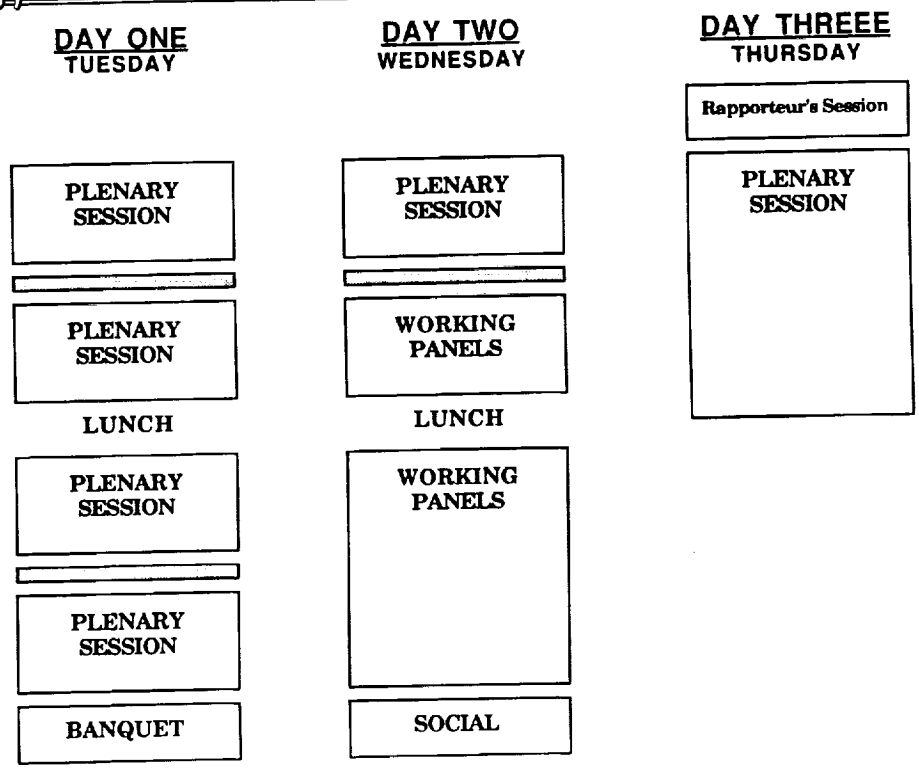
March 17, 1992

NASA
National Aeronautics and
Space Administration

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Workshop Roadmap

OAST



MARCH 17, 1992
JCM 7959

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

EXTERNAL RECOMMENDATIONS

OAST

- **ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM ("AUGUSTINE COMMITTEE" — 1990)**
  - "The serious technological challenge for NASA at the present time does not relate to issues of invention or creativity, but rather to the difficult sequence of taking an invention and turning it into an engineered component, testing its suitability in space; and then incorporating it into a spacecraft system."
  - "There is a widely-held opinion that although NASA continues to do excellent research, both in its centers and its affiliated universities, the results of this work are not being efficiently transferred into applications — a fault, it must be said, that is shared with U.S. industry at large."
  - "A prime responsibility of the NASA technology development activity must be to bridge the gap between technology concepts and application to space practice."
- **SSTAC, et al, REVIEW OF THE INTEGRATED TECHNOLOGY PLAN (1991)**
  - "... the review team (recommends that NASA) ... improve Technology Transfer. (NASA should) focus management attention on developing clear, widely accepted criteria for adopting new technologies for future civil space flight programs."

MARCH 17, 1992
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TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

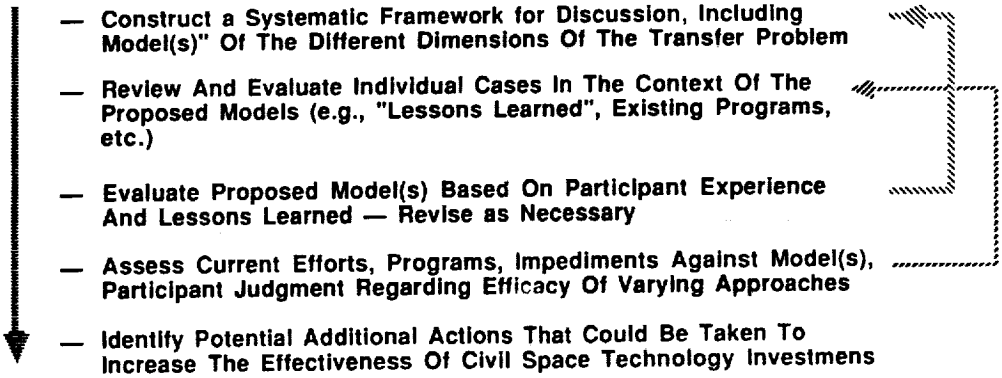
WORKSHOP CONCEPTUAL FRAMEWORK

OAST

- **TECHNOLOGY TRANSFER IS A COMPLEX, MULTIDIMENSIONAL PROBLEM**

  WORKING HYPOTHESIS:
  - CORRECT SOLUTIONS WILL VARY SIGNIFICANTLY WITH SUBTLE CHANGES IN THE STATEMENT OF THE PROBLEM (I.E. CHARACTER OF THE SITUATION)
- **SYSTEMS APPROACH PROPOSED TO ANALYZE THE PROBLEM**

  APPROACH:
  - Construct a Systematic Framework for Discussion, Including Model(s)" Of The Different Dimensions Of The Transfer Problem
  - Review And Evaluate Individual Cases In The Context Of The Proposed Models (e.g., "Lessons Learned", Existing Programs, etc.)
  - Evaluate Proposed Model(s) Based On Participant Experience And Lessons Learned — Revise as Necessary
  - Assess Current Efforts, Programs, Impediments Against Model(s), Participant Judgment Regarding Efficacy Of Varying Approaches
  - Identify Potential Additional Actions That Could Be Taken To Increase The Effectiveness Of Civil Space Technology Investmens

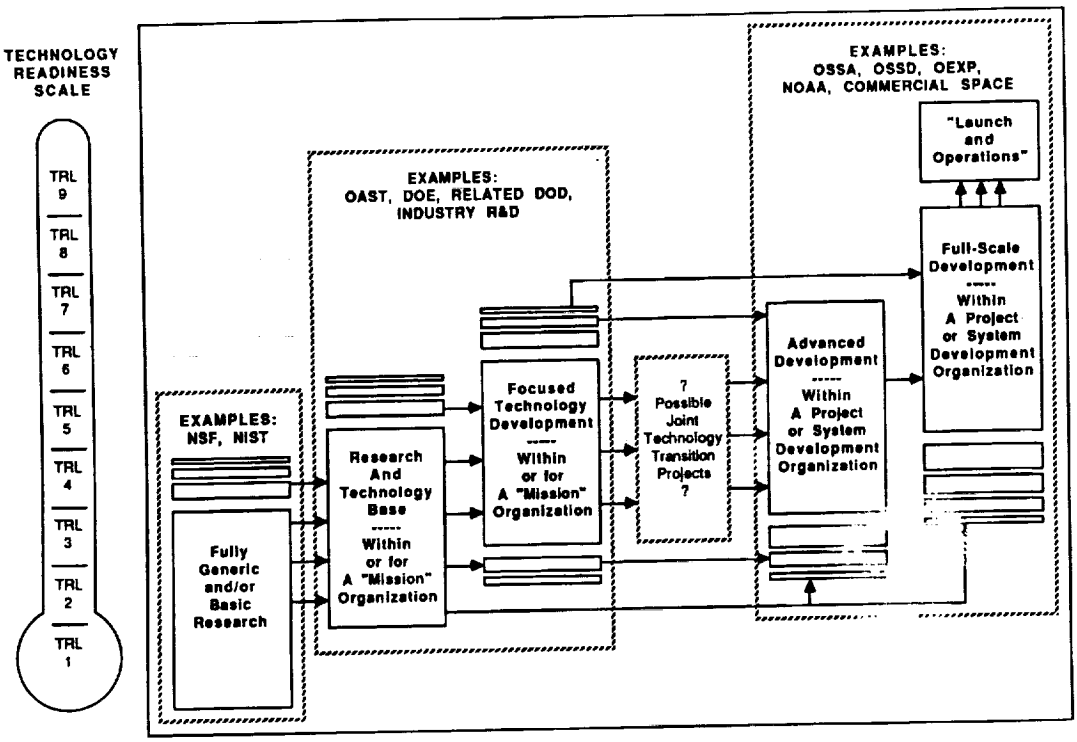


MARCH 17, 1992
JCM 7964

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Generic Technology Maturation Model

OAST



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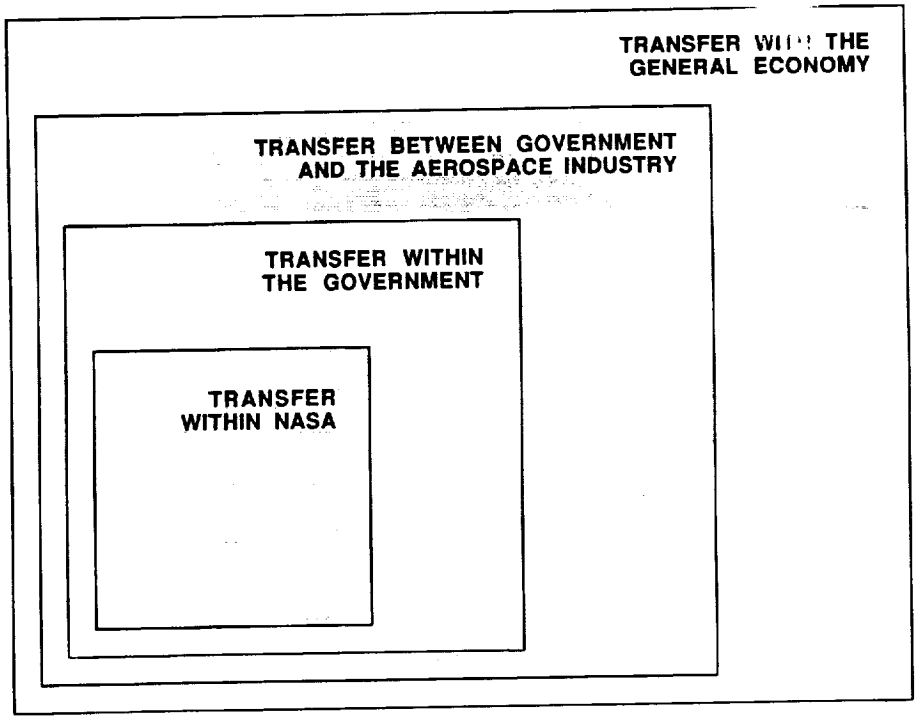
TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Technology Transfer Arenas

OAST



MARCH 17, 1992
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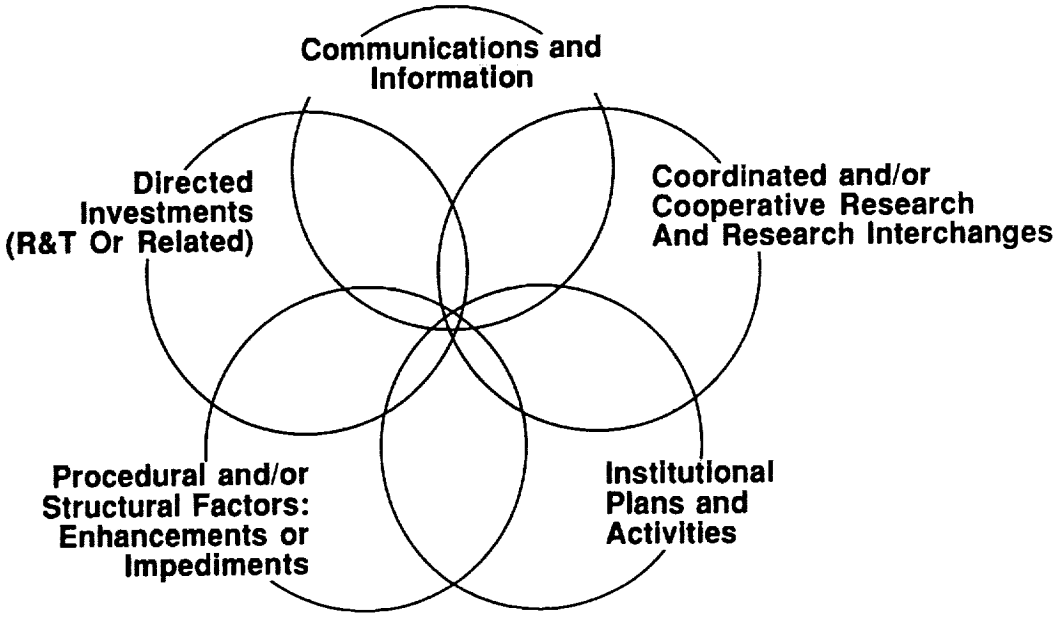
TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Technology Transfer Strategic Areas

OAST

Proposed Framework

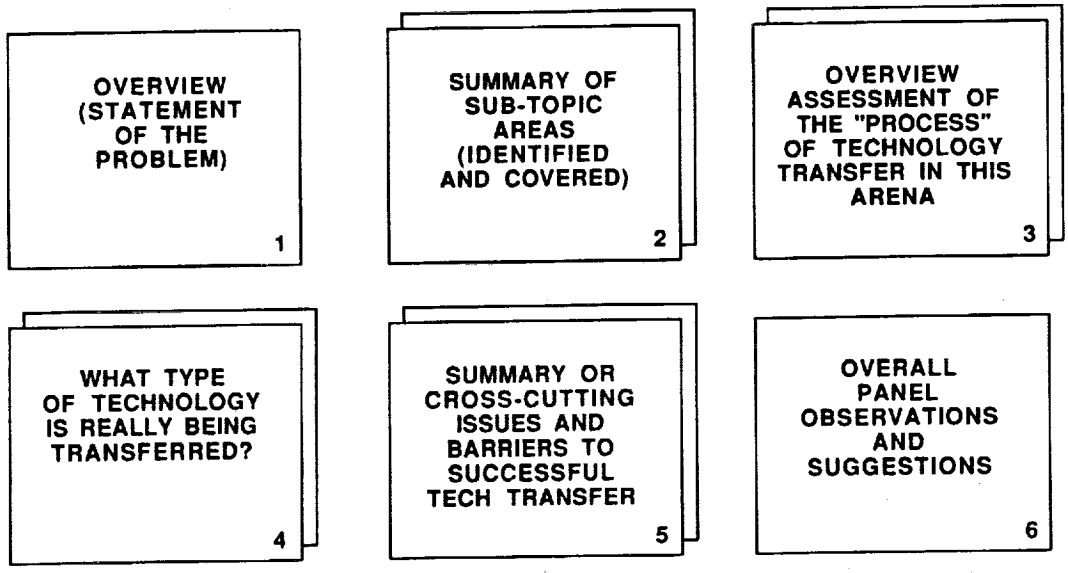


MARCH 17, 1992
JCM-7970

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

"Panel Chair" Report Suggested Format

OAST



MARCH 17, 1992
JCM-7954.1

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Working Panel "Sub-Topic Rapporteur" Role

OAST

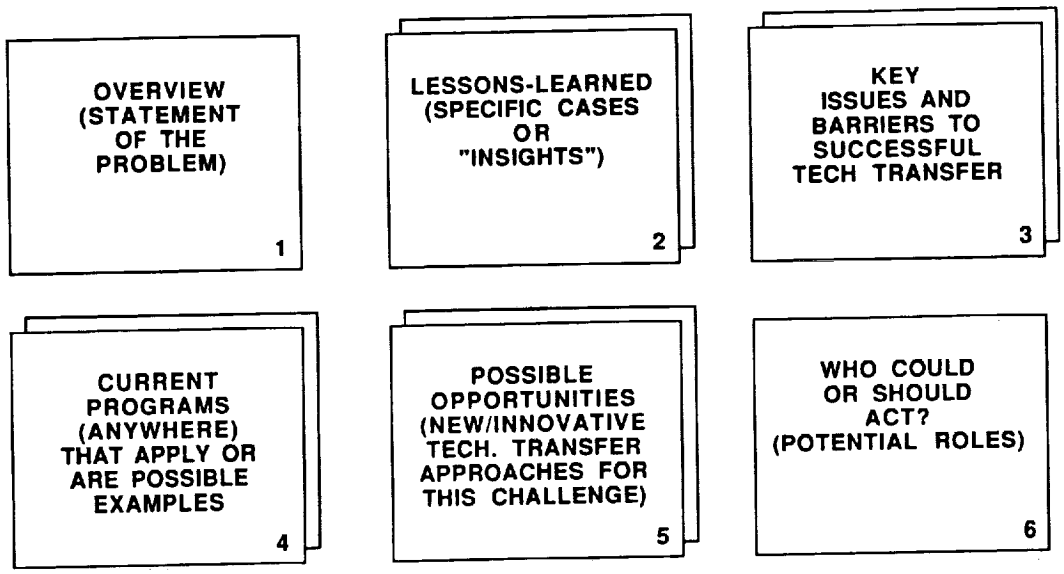
- SUPPORT THE WORKING PANEL CHAIR AS REQUIRED IN ASSEMBLING THE OVERALL REPORT FROM THE PANEL
- GUIDE WORKING PANEL DISCUSSION OF ONE OF THE SUB-TOPICS (AS ASSIGNED)
  - E.G., ASSURE KEY ISSUES AS WELL AS CURRENT TECHNOLOGY TRANSFER PROGRAMS ARE IDENTIFIED
- IDENTIFY TOPICS/ISSUES THAT MAY ARISE IN THE DISCUSSION OF OTHER SUB-TOPICS THAT BEAR HIS/HER SUBJECT
  - E.G., LOOK FOR CORRELATIONS ACROSS THE FULL COURSE OF THE WORKING PANEL DISCUSSION
- RECORD WORKING PANEL DISCUSSION AND CONCLUSIONS FOR THE SUB-TOPIC
  - I.E., PULL TOGETHER MATERIAL FOR WORKSHOP REPORT (WHICH ARE PROVIDED TO THE COORDINATOR) AND PREPARE CHARTS FOR USE IN CLOSING PLENARY SESSION PRESENTATION
- PRESENT WORKING PANEL RESULTS ON A PARTICULAR SUB-TOPIC DURING THE THURSDAY MORNING PLENARY SESSION

MARCH 17, 1992
JCM-7968

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

"Sub-Topic Rapporteur" Report Suggested Format

OAST



MARCH 17, 1992
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TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Working Panel Coordinator Role

OAST

- **SUPPORT THE WORKING PANEL CHAIR, SUB-TOPIC RAPPORTEURS, AND MEMBERS AS REQUIRED**
- **MAINTAIN WORKING PANEL ATTENDANCE RECORDS**
- **COLLECT ALL WORKING GROUP MATERIALS**
  - **E.G., PREPARED PRESENTATIONS, MATERIALS PREPARED DURING THE PANEL DISCUSSION**
- **TIMEKEEPER FOR THE WORKING PANEL DISCUSSION**
  - **E.G., BASED ON SUBTOPICS AGREED-TO AT BEGINNING OF PANEL, ASSURE EACH SUBJECT IS GIVEN SOME TIME IN DISCUSSION**
- **MANAGE "ISSUES TO BE CONSIDERED", ETC.**
  - **E.G., DISTRIBUTE AND COLLECT ITBC'S (OR OTHER FORMS) DURING THE COURSE OF THE PANEL DISCUSSION**
- **ASSURE WORKING PANEL DISCUSSION DOESN'T "STALL"**
  - **E.G., SEEK ASSISTANCE FOR A QUESTION OF PROTOCOL, OR USE "ITBC'S" TO FACILITATE TRANSITION TO NEW SUBJECT**

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TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Technology Transfer Approach Assessment

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Technology Transfer Arena: _____ AUTHOR: _____

Technology Transfer Sub-topic

	ELEMENT IN QUESTION	SPECIFIC EFFORTS (CURRENT/PROPOSED)	OVERALL ASSESSMENT
Information and Communications			☐ Key Factor In Transfer? ☐ Minor Factor? ☐ Not a Factor in Transfer?
R&T Coordination and/or Cooperation			☐ Key Factor In Transfer? ☐ Minor Factor? ☐ Not a Factor in Transfer?
Directed Investments (R&T or Related)			☐ Key Factor In Transfer? ☐ Minor Factor? ☐ Not a Factor in Transfer?
Institutional Plans and/or Activities			☐ Key Factor In Transfer? ☐ Minor Factor? ☐ Not a Factor in Transfer?
Procedural and/or Structural Enhancements or Impediments			☐ Key Factor In Transfer? ☐ Minor Factor? ☐ Not a Factor in Transfer?

MARCH 17, 1992
JCM-7955

OAST SPACE RESEARCH & TECHNOLOGY APPLICATIONS

-Technology Transfer Successes

Gregory M. Reck
Director for Space Technology
Office of Aeronautics and Space Technology

OAST

February 1992

INTRODUCTION

OAST

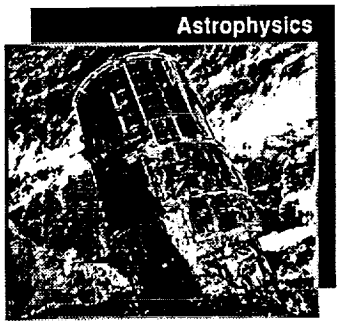
The ultimate measure of success in the Space R&T program is the incorporation of a technology into an operational mission. These charts describe technology products which OAST has helped support that (1) have been used in a space mission, (2) have been incorporated into the baseline design of a flight system in the development phase, or (3) have been picked up by a commercial or other non-NASA user. We hope that these examples will demonstrate the value of investment in technology. Pictured on each of the following charts are illustrations of the technology product, the mission or user which has incorporated the technology, and where appropriate, results from the mission itself.

Future U.S. competetiveness in the world economy will increasingly depend upon the speed and effectiveness with which new technologies and new, high quality products can be brought to maturity and the marketplace. A strong investment in advanced space research and technology, including focused programs directed at rapidly developed breadboards and demonstrations can make a significant contribution to national competetiveness across a wide range of critical technologies. Many of these technologies will also be applicable to private U.S. civil space users, will indirectly support future DOD space mission needs, and will have numerous spinoff uses in the private sector. In this way, all our future national space endeavors will be enhanced by an investment in NASA Space R&T.

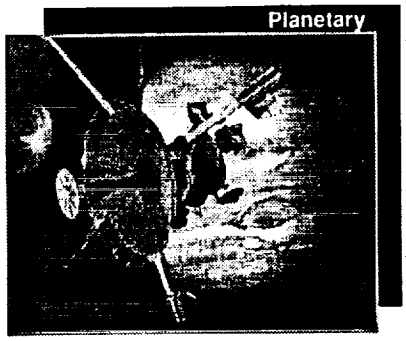
The evolution of a technology from proof-of-concept, through validation in successively more realistic environments, and eventually to development can be a complex and time-consuming process. In many of the examples selected, the technology efforts were completed a number of years ago and the time required to complete the development phase is evident. An objective of the NASA technology program is to facilitate this process and minimize the time required.

We believe that involving the technology "users" as early as possible in this process is critical to achieving this goal. OAST has developed a strategic planning process which is focused on involving the user community at the critical phases of technology development. Concurrent participation by technologists and mission developers in the selection and maturation of technologies should lead to a level of understanding and a sense of ownership that will improve all aspects of technology development and transition.

TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

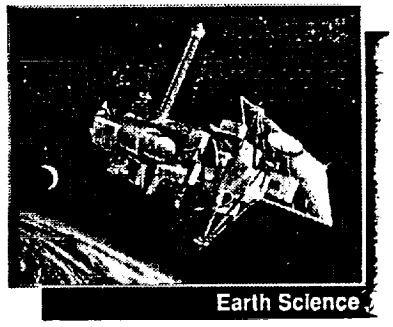


- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration



- Galileo (& Hubble) - CCD Array
- Voyager - Spacecraft Health Monitoring
- Magellan - Radar Ground Processor

- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging



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92 801

SYNTHETIC APERTURE RADAR PROCESSOR

OAST

The Magellan spacecraft launched onboard the Space Shuttle in April of 1989 uses a radar-based high resolution imaging technique to carry out its mapping of the Venus surface. Many real aperture radar echos are computer processed to create a large synthetic aperture image through a Synthetic Aperture Radar (SAR) technique. Multiple swaths are combined to produce image mosaics. The creation of synthetic aperture images must account for the relative geometry and movement between the target and spacecraft radar and for multiple surface images of different amplitudes and phases. For Magellan an advanced SAR technique is responsible for the highly detailed, nearly seamless photographs of the surface of Venus - but it is computationally intensive.

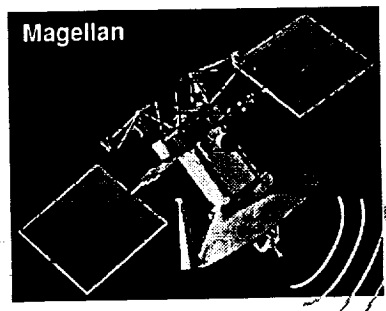
The Advanced Digital SAR Processor (ADSP) technology developed by OAST has been adapted and used for the ground processing of the radar data returned by Magellan. This processor integrates algorithm elements into a programmable pipeline architecture with great speed.

This ADSP provides a peak compute rate of 6 gigaflops, more than that of a Cray 2 computer. The significance is that this compute rate permits processing four times faster than real-time acquisition rates. It is the Input/Output computer system that limits the actual processing rate to approximately real time.

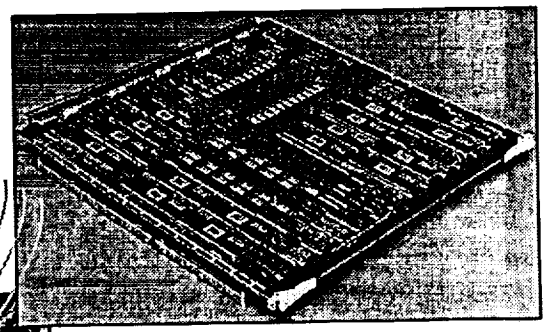
Work was initiated in 1980 to provide an engineering technology demonstration of (ADSP) to support late 1980's missions. In 1983 it was decided that the ADSP technology development would be focused on Magellan requirements. In 1985 the Magellan Project decided to modify and use the engineering model of ADSP as the prime mission operations processor for SAR data.

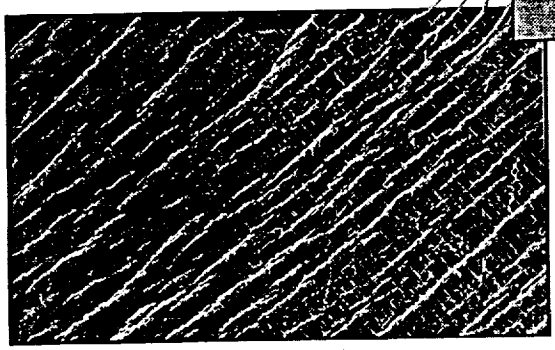
OAST completed work on this technology with the delivery of the ADSP engineering model to the Magellan Project in 1986. Magellan demonstrated the success of the ADSP technology which now provides a a flexible architecture that can serve many missions. For more information please contact: Paul Smith, NASA Headquarters, Code RC, Washington, D.C. 20546. Phone: (202) 453-2753.

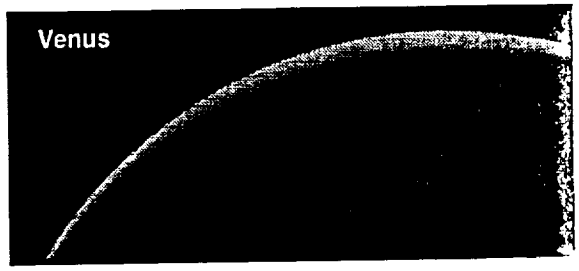
SYNTHETIC APERTURE RADAR PROCESSOR



SAR Processor







Venus Surface Characteristics

BATTERY TECHNOLOGY (HUBBLE SPACE TELESCOPE)

OAST

The nickel-hydrogen battery design has resulted in the most advanced, long-life, rechargeable battery technology developed over the last 50 years. The dramatic advances in capabilities of this technology are opening a whole range of possibilities for both NASA and the commercial space sector. During periods of darkness, rechargeable batteries supply the power needs of the spacecraft. Recently, breakthroughs have been achieved in the low-Earth-orbit (LEO) cycle life of individual pressure vessel nickel-hydrogen battery cells. The cycle life was improved by more than a factor of 10 over state-of-the art cells. Ground-test cells containing 26 percent potassium hydroxide (KOH) electrolyte were cycled for 40,000 stressful accelerated LEO cycles at a deep depth of discharge (80%). Cells containing 31% KOH had achieved only 3500 cycles.

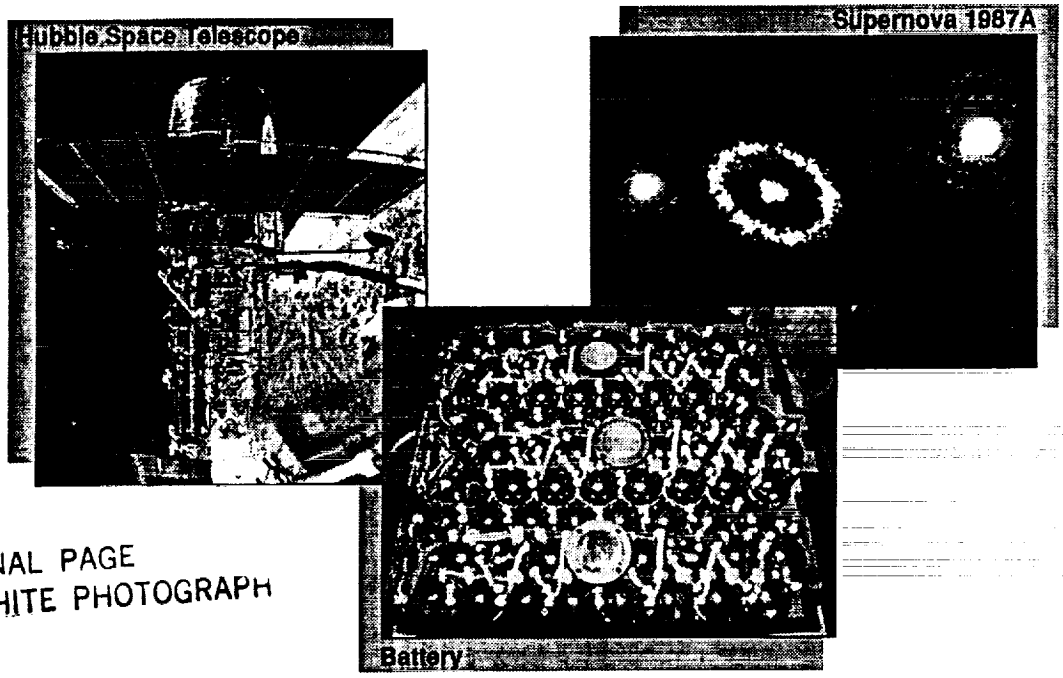
The significance of this breakthrough is that long term LEO missions can now rely on a greater than 5 year life span for advanced nickel hydrogen batteries. This advance will result in a significant reduction in life cycle cost. In addition, nickel-hydrogen batteries provide the capability of operating at a deep depth of discharge which could enable reductions in the mass devoted to batteries and increases in payload capability.

The dramatic benefits of this technology led directly to the Office of Space Science Application's (OSSA) decision to utilize nickel hydrogen batteries for the Hubble Space Telescope. Technologists at the Lewis Research Center participated in the review task team to assess battery options for Hubble and provided technology support to OSSA on the use of nickel hydrogen batteries for the actual mission. The batteries are performing very well in their first nonexperimental use in LEO. In addition, the Earth Observing System has chosen to use OAST's nickel-hydrogen battery technology. Technologists at Lewis are working closely with OSSA to meet this mission's power needs. This program is based on a close working relationship with not only NASA mission offices, but also the military, and industry. The Air Force is using Lewis's advanced nickel hydrogen cell technology for military flights. The aerospace industry, meanwhile, has adopted a scaled-up version of the Lewis design which is currently undergoing cell testing at Loral Corporation.

As we look to the future, nickel-hydrogen is fast replacing nickel-cadmium as the standard satellite storage system. It is projected that nickel-hydrogen will be the major rechargeable battery system for future aerospace applications. The ongoing technology development efforts at Lewis are aimed at increasing the life, power density, and reliability and at reducing the mass and lowering the cost of the nickel-hydrogen battery system.

Sponsored under the auspices of OAST, work was initiated on nickel-hydrogen battery technology at Lewis in the early 1980's. For additional information, contact: Gary Bennett, NASA Headquarters, Code RP, Washington, D.C., 20546. Phone: (202) 453-2856.

BATTERY TECHNOLOGY



ASTROS STAR TRACKER
(CCD SENSOR TECHNOLOGY)

OAST

Star sensors are used to determine a spacecraft's attitude relative to a star, or a group of stars, and to point science instruments at selected targets. Star trackers are a special class of star sensors that image an area of the sky to provide precision star position data relative to a fixed line of sight. Technology provided by OAST was critical to the development of the Star Tracker used on the recent Astro-1 mission on STS-35 in December 1990 and was also a crucial element in Astro-1's successful outcome.

As initially conceived, the Astro Star Tracker (AST) was designed to assist Astro's Image Motion Compensation System in stabilizing the pointing of the Ultraviolet Imaging Telescope and the Wisconsin Ultra Photo-Polarimeter Experiment. The AST acquired the three brightest stars in its field of view and then provided star position information to the IMCS for in-flight correction of gyro drift parameters. Based on Charge Coupled Device (CCD) sensor technology, the AST tracks objects over a 10,000:1 brightness range and allows very accurate and stable position determination at any point within their field of view.

The AST took on a vital role early in the mission when problems with the prime star trackers prevented Astro's automated Instrument Pointing System from locking onto the operational guide stars. AST then became the primary means of target acquisition. The Shuttle crew was able to compare star positions acquired with the AST with on-board small field of view star maps and manually point the instruments to the science target with a joystick. Problems for the mission were compounded when the Shuttle's second onboard Digital Display Unit failed. AST star positions could then no longer be displayed to the crew. Ground support crews were able to resolve this glitch by identifying each star field acquired by the AST in real-time and issuing instructions to the astronauts who then manually repointed the telescopes. The MSFC mission manager stated that this capability "saved the mission."

Astro Star Tracker technology and expertise will provide the base for future space science missions such as the CRAF/CASSINI target and star tracker function, and the the Space Infrared Telescope Facility (SIRTF) fine guidance sensor.

OAST sponsored the initial critical phases of CCD based star tracker research at JPL beginning in 1973. Several years of research effort achieved technology transfer to flight hardware development in the 1980's. For more information, please contact: Fred Hadaegh, Guidance and Control Section 343, Mail Stop 198-326, Jet Propulsion Laboratory, Pasadena, CA 91109. Phone (818) 354-8777.

STARTRACKER

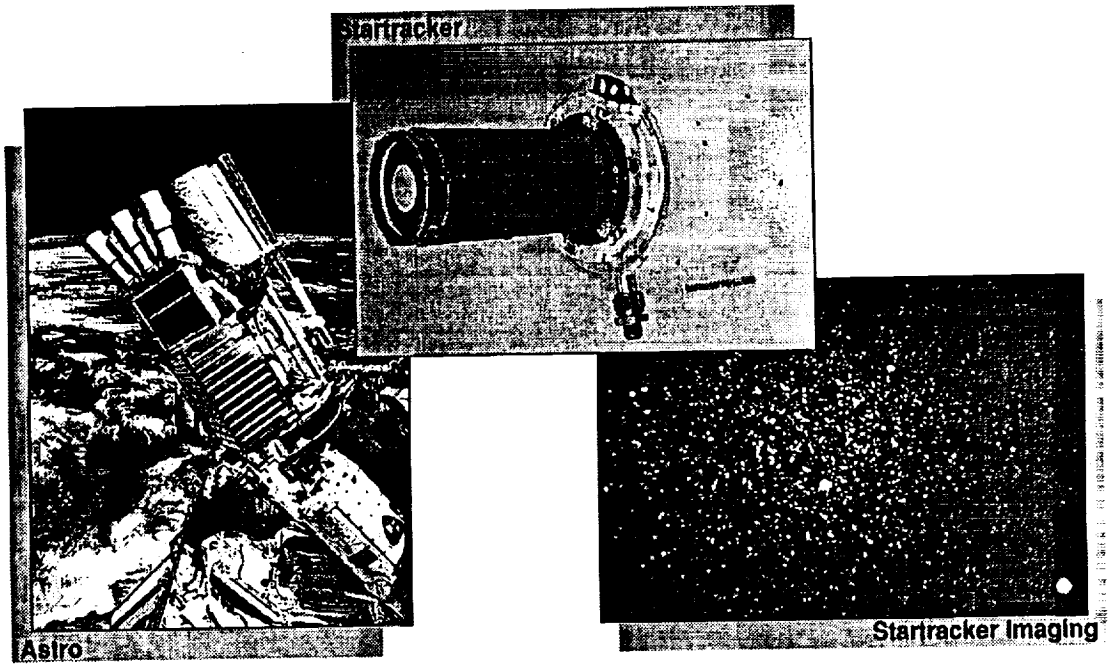


IMAGE RESTORATION FOR THE HUBBLE SPACE TELESCOPE

OAST

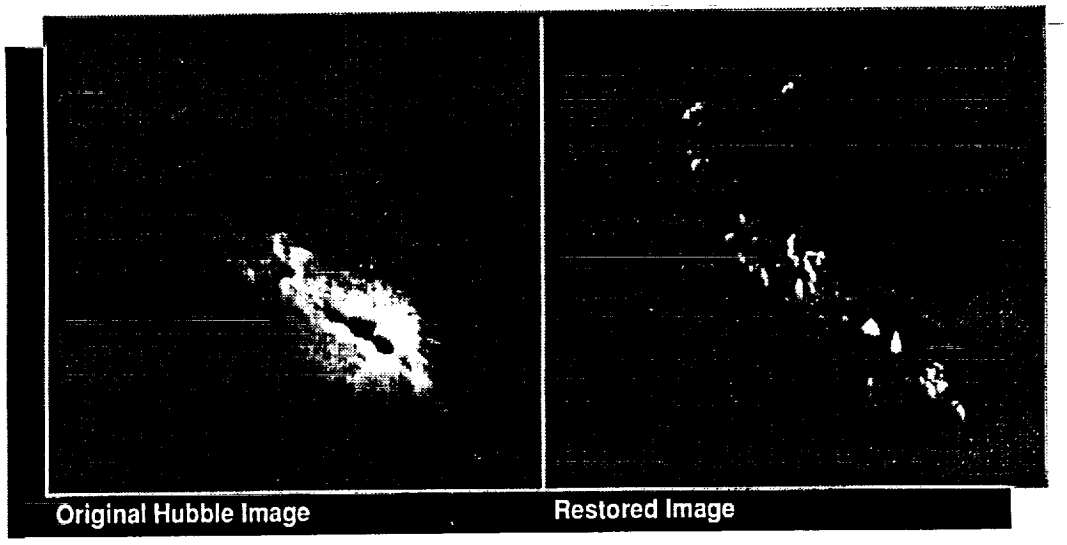
Imagine seeing the universe as if it were just outside your window. Clouds and lightning form as a storm brews on Jupiter. An icy moon revolves nearby. In the distance, you see billions of stars. The Hubble Space Telescope (HST) offers us a valuable window to the universe. Researchers at NASA are working hard to restore images being transmitted back to Earth by the HST. Technologists in OAST have actually demonstrated a ground computer processing technique that restores the Hubble image to the original design resolution. This technology compensates for the well-known flaw in the HST mirror.

Because it is considered to be somewhat of a Rosetta Stone for many astrophysical processes, the R Aquarii star system (pictured above on the left) was one of the first objects observed by the HST. Due to Hubble's spherical aberration, most of the light from the star and its surroundings has spread out into a blurred, oval nebula. The brightest areas are saturated, producing a dark, central valley of useless data. However, by means of an algorithm known as Maximum Entropy, OAST researchers have been able to enhance the structure of the image to its original design resolution. In the restored version in the upper right panel, R Aquarii- comprising a cool red giant, a hot companion and its accretion disk -- lies within the rightmost peak.

The benefits of this technology are considerable. Image restorations are now possible in minutes as opposed to hours or days of computer time. Ultimately as the technology undergoes further development, NASA will be able to enhance images to the point that they exceed the HST's design resolution. In addition, researchers will be able to apply the technology to any mission that transmits imaging data back to Earth. The technical challenge is to build up a library of the necessary tools. An important legacy of the HST may well be its advancement of restoration techniques in addition to its legacy of advancements in astronomical sciences.

OAST sponsored this technology during 1991 under the OAST Research and Technology Base at the Goddard Space Flight Center. For more information contact: Dr. Jan M. Hollis, Goddard Space Flight Center, Code 930, Bldg. 28, Greenbelt, MD. 20771. Phone - (301) 286-7591.

HUBBLE SPACE TELESCOPE IMAGE RESTORATION TECHNOLOGY



Office of Aeronautics and Space Technology

92-8025

UNIVERSITY SPACE ENGINEERING RESEARCH CENTER
VLSI CHIP DESIGN

OAST

Students at the University of Idaho Space Engineering Research Center for VLSI design are designing electronic systems which have thousands of transistors miniaturized onto a computer chip smaller than a postal stamp. This technique, known as Very Large Scale Integration (VLSI), is making it possible for NASA to enhance communications and improve information storage capabilities for a number of its current and future missions.

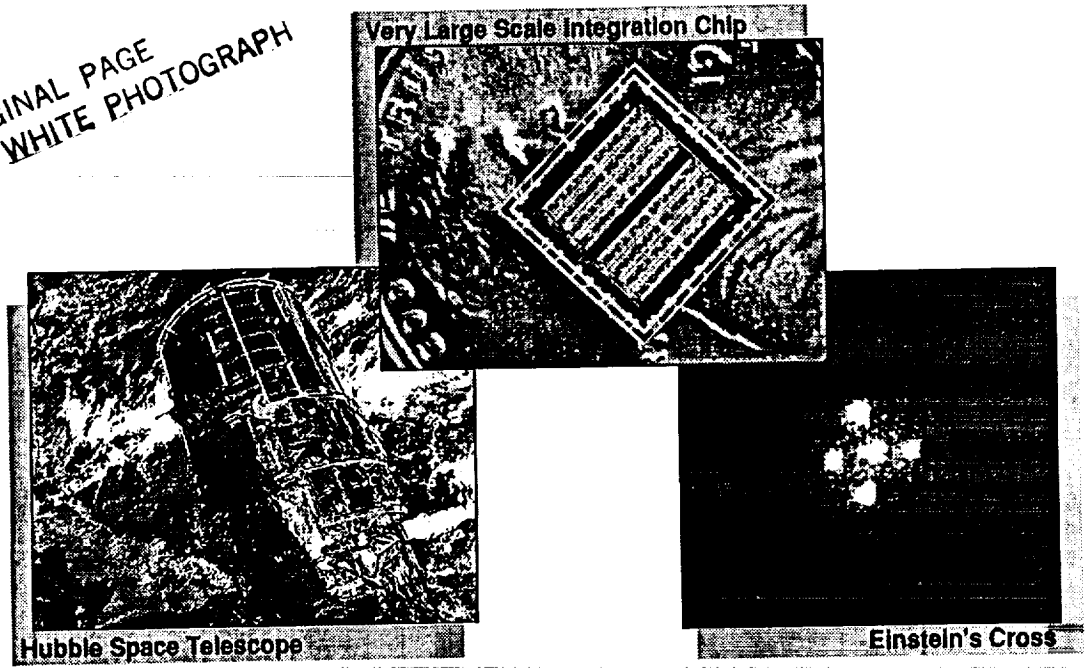
Idaho researchers designed a computer chip set for the Hubble Space Telescope that is currently being installed in the Earth-based ground data system. These chips will decode the information sent back to Earth by the telescope and will automatically check and correct errors in the data transmission. Natural events such as interference from ionized particles in space can cause errors in transmissions from the telescope to the ground. The computer chip is designed to detect and correct these errors.

The University of Idaho chips are faster, computationally more powerful, and consolidated onto fewer chips than the chips currently used by Hubble, thus reducing the complexity and parts count for the system. Having the capability to process over 80 million bits of information per second, this chip makes sure that scientists on Earth can receive valuable information they need to conduct their research. In addition, this computer chip represents the first use in a NASA mission of a product from the University Space Engineering Research Center program. This program is creating the next generation of space engineers by directly involving students in engineering research tied to NASA mission needs. The University's ongoing program is investigating future use of this chip in space, as a part of a Hubble flight data system refurbishment.

Students are working on other projects as well, including techniques to compress large amounts of data being transmitted from space. As an example, it is estimated that the Earth Observing System will transmit back to Earth on the order of one large library's worth of information every day. Such large volumes could saturate the communication channels of future space satellites. Students are meeting this challenge by developing codes which compress or condense the data and images collected by spacecraft sensors. Upon completion, this project will help meet NASA's need for high speed information processing and transmission.

The Center for VLSI design was established in 1988 as one of nine universities in the Space Engineering Research Center program. For more information, please contact: Gordon Johnston, NASA Headquarters, Code RS, Washington, D.C. 20546. (202) 453-2755.

HUBBLE SPACE TELESCOPE GROUND DATA PROCESSING



THE SPACECRAFT HEALTH AUTOMATED REASONING PROTOTYPE (SHARP)

OAST

Voyager's near encounter of Neptune in August 1989 gave NASA the opportunity to introduce automation and artificial intelligence technologies to the process of monitoring spacecraft operations. The new expert system, called the Spacecraft Health Automated Reasoning Prototype (SHARP) provides telecommunications personnel with an environment that allows them to have a more complete understanding of how the telecommunications link is functioning between a spacecraft and the Deep Space Network Tracking Stations.

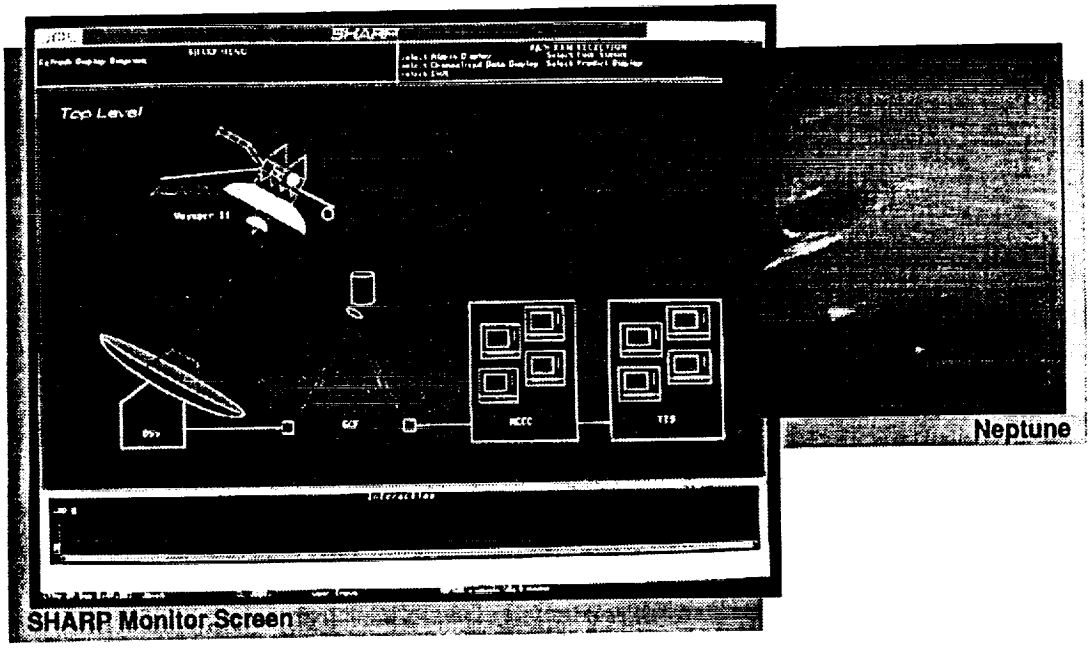
The SHARP system combines conventional computer science methodologies with artificial intelligence techniques to produce an effective method for detecting and analyzing potential spacecraft and ground system problems. The system performs real-time analysis of spacecraft and ground system engineering data, and is also capable of examining data in historical context. The data is centralized into one workstation which serves as a single access point for all data. If the real-time data fails to correlate to the expected behavior, SHARP informs the operator responsible for the condition being monitored that an alarm condition exists. It also lists the potential causes for this anomaly and suggests what actions to take in response.

The benefits of this technology were underscored prior to Voyager's Neptune encounter. SHARP helped find the cause of a science data error which appeared in the telemetry from the spacecraft. After SHARP detected the problem, its graphic displays were used by telecommunications personnel to identify the problem and characterize its magnitude. In a matter of hours, SHARP was able to assist operators in solving an anomalous condition which could have easily escalated to a more serious problem during the encounter itself, and could have taken human operators days or weeks to isolate without SHARP.

SHARP has validated the use of AI-based systems for autonomous monitoring and diagnosis of unmanned spacecraft systems. NASA plans in the future to expand SHARP functionality to application in the Deep Space Network, Network Operations Control Center at JPL, with an operational system planned for later in 1991. In addition, SHARP capabilities have been expanded to the Magellan mission currently mapping the planet Venus.

The SHARP technology was developed over a year and a half period between 1987 and 1989 under the auspices of the OAST Civil Space Technology Initiative. For additional information, contact: Melvin Montemerlo, NASA Headquarters, Code RC, Washington, D.C. 20546. Phone - 202-453-2744.

SPACECRAFT HEALTH MONITORING



CHARGE-COUPLED DEVICE (CCD) IMAGING ARRAYS FOR GALILEO AND HUBBLE

OAST

In recent years, a revolution in both home and studio video recording has been made possible by the development of the silicon charge-coupled device (CCD), a solid-state chip that turns light into the electric signals that are recorded onto video tape. CCD video cameras are light-weight, require little power (so the batteries are light as well), are inexpensive, and are more sensitive to light than the large, bulky, and power-hungry vacuum tubes previously used for television cameras. Earlier space missions, such as the Viking Orbiter mission to Mars and the Voyager spacecraft which flew by Jupiter, Saturn, Uranus, and Neptune, used versions of the old television vacuum tubes called vidicons. Since 1974, the Office of Aeronautics and Space Technology (OAST) has been investing in the new CCD technology, making it available for flight on missions such as the Galileo mission to Jupiter, the Hubble Space Telescope, the Yohkoh Soft X-ray Telescope, and the Shuttle Electronic Still Camera.

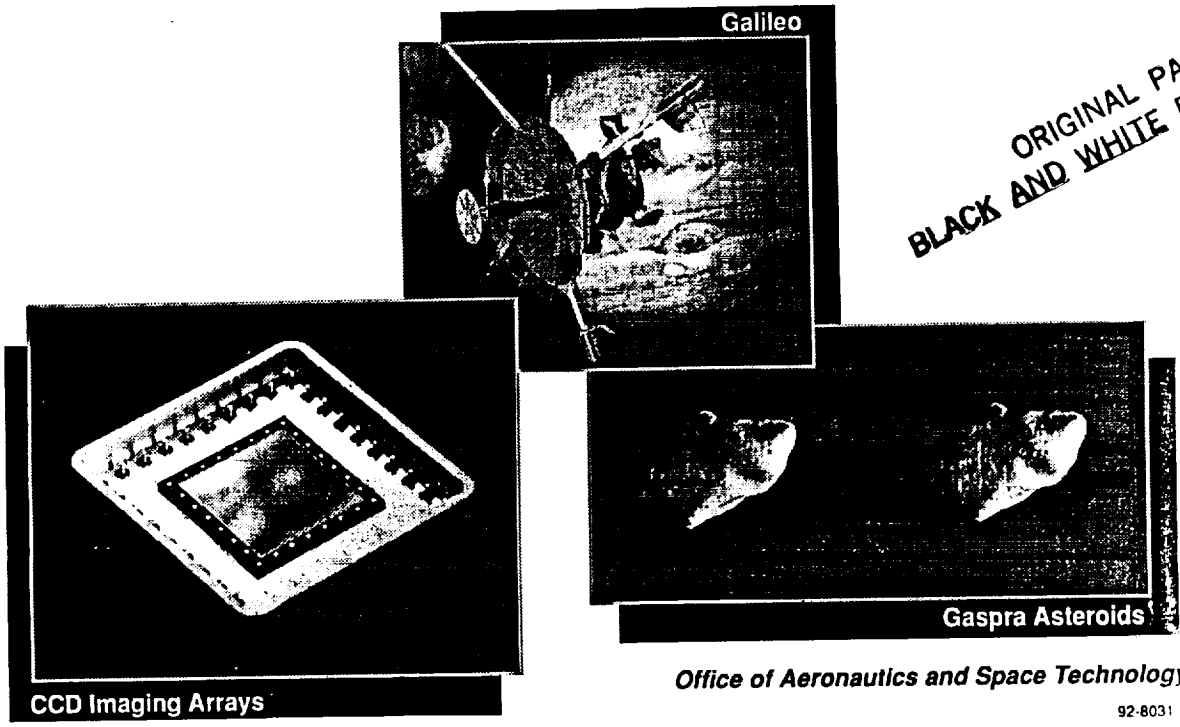
Charge coupled device technology was first demonstrated in 1969 at the Bell Laboratory. In 1974, under the sponsorship of OAST, the Jet Propulsion Laboratory began a program to increase the size of CCD arrays (then less than 100-by-100 picture elements, or pixels) and to lower their readout noise levels. Shortly thereafter, the Office of Space Science and Applications (OSSA) added funding, and by 1978 CCD arrays of 500-by-500 pixels had been produced, achieving noise levels of 10 electrons rms (root mean square). After this, OSSA continued the development of the 800-by-800 arrays that are currently being used by Galileo (1989 launch) and the Hubble Space Telescope (1990 launch).

In 1982, OAST substantially increased its funding and, combined with OSSA advanced development funds, initiated the development of the second generation of CCD detectors. This work proceeded successfully and led directly to three current CCD instruments, one of which is already operating in space. These are the Yohkoh Soft X-ray Telescope (successfully operating in orbit), the Cassini Imaging Science Subsystem, and the Advanced X-ray Astrophysics Facility (AXAF) CCD Imaging Spectrometer. These second generation CCD's surpass their predecessors in almost every characteristic. They have larger formats (1024-by-1024 verses 800-by-800), smaller pixels (12 μm verses 15 μm), lower noise (2 electrons vs 10 electrons rms), lower cost, and higher reliability, that the first generation CCD's. Such an improved CCD recently flew on the Space Shuttle as part of the Johnson Space Center's Electronic Still Camera.

OAST is not currently funding further developments of CCD technology. As the accomplishments of the current CCD missions continue to accrue, interest in the scientific community is growing for the development of a possible third generation of very large format CCD arrays. This is an area of possible future investment by NASA and OAST.

For more information contact: Gordon Johnston, NASA Headquarters, Code RS, Washington, DC 20546. Phone - (202) 453-2733.

CHARGE-COUPLED DEVICE (CCD) IMAGING ARRAYS



Office of Aeronautics and Space Technology

92-8031

ANTENNA, MIXER, AND ELECTRONICS TECHNOLOGIES FOR THE UPPER ATMOSPHERE RESEARCH SATELLITE (UARS)

OAST

All light, whether X-rays, visible light, or radio waves, is part of the electromagnetic spectrum. The difference is in the wavelength (or the frequency) of the light. Our society knows how to observe visible light and radio waves, but in between is the millimeter and sub-millimeter region, where the wavelengths are too short for radio and too long for visible light techniques. Many molecules, including ozone and many of the ozone destroying chemicals, emit light at unique frequencies in this region. Using these emissions, we can measure the amount of these chemicals in the earth's protective ozone layer.

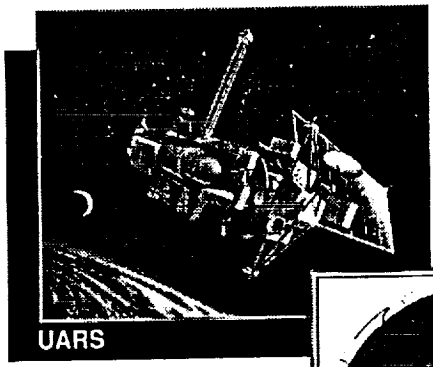
Since 1974, The NASA Office of Aeronautics and Space Technology (OAST) and Office of Space Science and Applications (OSSA) have been involved in the joint development of the Microwave Limb Sounder (MLS) instrument. OAST developed critical technology elements including antenna, mixer and electronic components while OSSA was responsible for the instrument development. A balloon version of the instrument was successfully flown on several occasions, demonstrating the technology.

In 1991, the MLS instrument was launched on the Upper Atmosphere Research Satellite (UARS), and it is currently observing atmospheric thermal emissions from chlorine monoxide (ClO), ozone (O_3), water vapor (H_2O), sulfur dioxide (SO_2), and molecular oxygen (O_2), at frequencies of 63, 183 and 205 GHz. Measurements are performed continuously day and night giving global maps of the vertical distribution of these molecules. The vertical resolution is approximately 3 km. One percent accuracy in the measurement of ozone has been demonstrated.

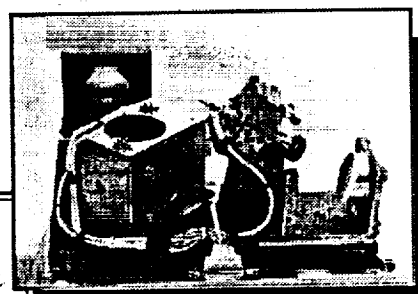
The UARS MLS uses high spectral resolution heterodyne radiometers, in which the emissions from the atmosphere of the earth are mixed with known, reference frequencies (generated by local oscillators), and the differences (which are at much lower frequencies, in the range that can be handled by conventional electronics) are measured and analyzed. The specific, OAST supported technologies involved in the UARS MLS include the local oscillator injector, the dual mode feed-horn, quasi-optical filter technology, and gallium arsenide (GaAs) Schottky diode development.

OAST continues to play a role in technology development for the follow-on MLS for the Earth Observing System (EOS), pushing the upper limit of the frequency that can be measured from space beyond the 205 GHz of the UARS MLS to the 600 GHz of the EOS MLS. For more information contact: Gordon Johnston, NASA Headquarters, Code RS, Washington, DC 20546. Phone - (202) 453-2733.

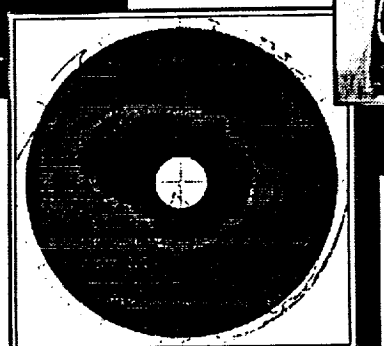
SUBMILLIMETER SENSING TECHNOLOGIES



UARS



MLS 205 GHz
Heterodyne Receiver



Antarctic Ozone Hole

Office of Aeronautics and Space Technology

92-8026

LASER RANGING TECHNOLOGIES

OAST

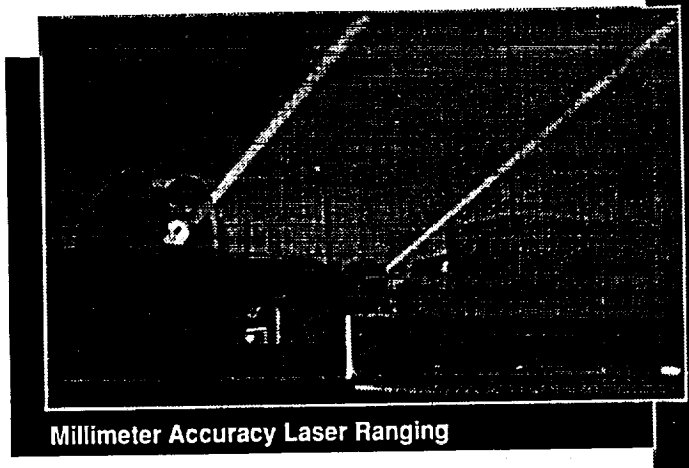
Satellite laser ranging (SLR) has been used for almost two decades in the study of a variety of geophysical phenomena including global tectonic plate motion, regional crustal deformation near plate boundaries, the Earth's gravity field, and the orientation of its polar axis and its rate of spin. The subcentimeter precision of this technique is now attracting the attention of a new community of scientists, notably those interested in high resolution ocean, ice and land topography. Over the next several years, the international SLR network will provide an essential link to two new oceanographic satellites, ERS-1 and TOPEX/Poseidon, which range to sea and ice surfaces using microwave altimeters.

In 1964, NASA was the first organization to successfully demonstrate laser ranging to satellites and has continued to support their development to the present. OAST has developed lasers, rapid detectors, and timing ciruits which have become a key part of the worldwide network managed by the Goddard Space Flight Center. In satellite laser ranging, ground based stations transmit short intense laser pulses to a retroreflector equipped satellite, such as LAGEOS. The round trip time of flight of the laser pulse is precisely measured and corrected for atmospheric delay to obtain a geometric range. Ranging to these retroreflectors with a global network of laser stations allows NASA to determine both the precise orbit of a satellite and the station positions. By monitoring these stations over time, researchers can deduce the motion of the Earth-based observing sites due to plate tectonics, or other processes such as subsidence. This system is being used in precise orbit determination support of the ERS-1 and TOPEX/Poseidon missions to measure the topography of the Earth's oceans and ice sheets.

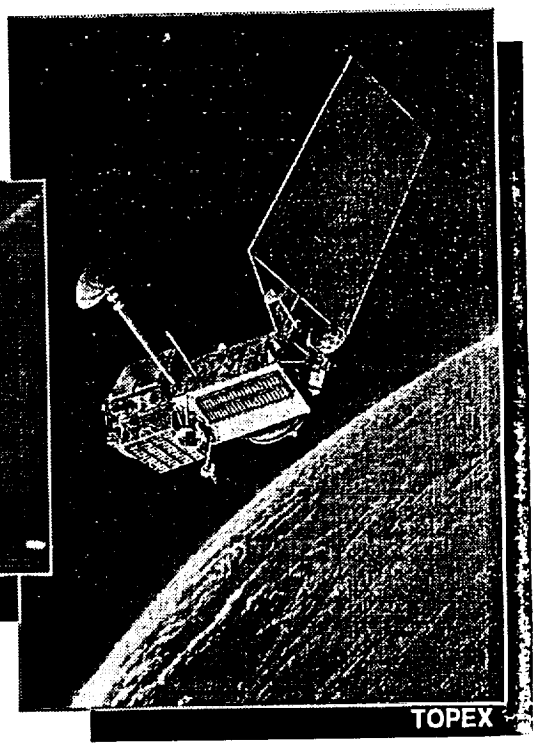
As we look to the future, OAST is developing advanced electro-optics and laser technologies for spaceborne laser ranging and altimetry earth science applications. This will invert the traditional SLR system with the ranging hardware being placed onboard a satellite and passive targets placed on the ground. This technology is a candidate to fly on the Earth Observing System B series platforms and will help measure geodynamic, ice sheet, cloud, and geological processes and features.

For more information, contact Marty Sokoloski, NASA Headquarters, Code RS, Washington, D.C. 20546. Phone- (202) 453-2273.

LASER RANGING TECHNOLOGY



Millimeter Accuracy Laser Ranging



TOPEX

Office of Aeronautics and Space Technology

92-8028

TRAVELLING WAVE TUBE AMPLIFIERS FOR DEEP SPACE COMMUNICATIONS

OAST

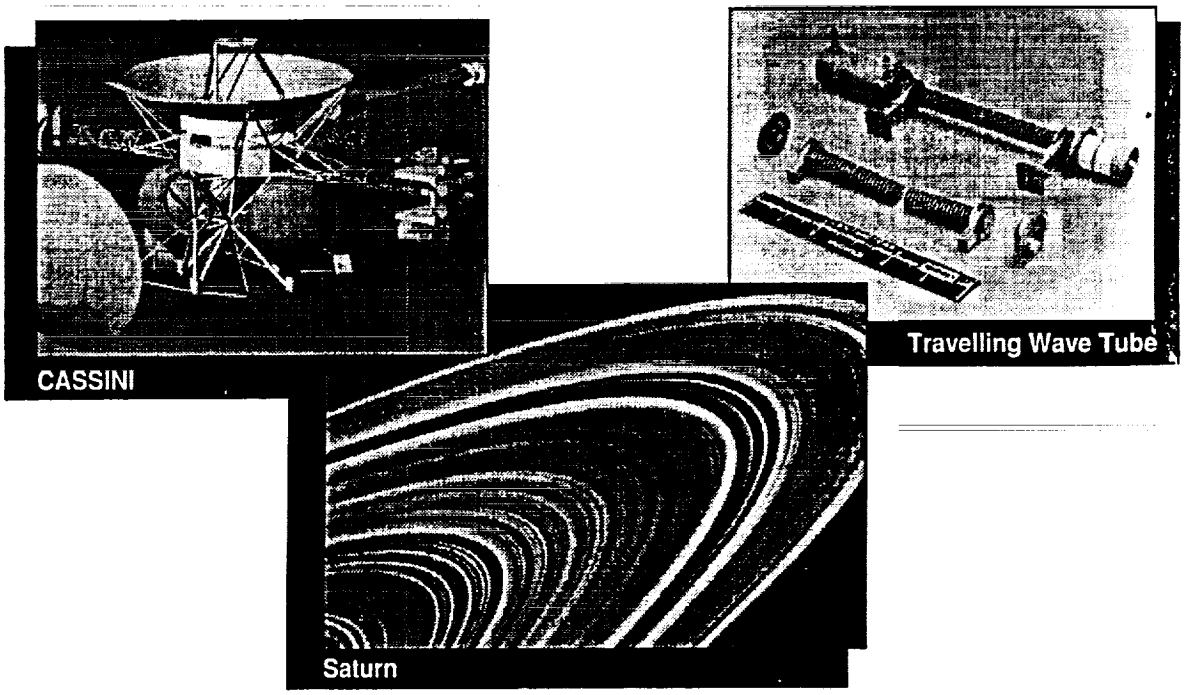
In the near future, NASA will launch a spacecraft to venture to the outer solar system and study the rich diversity of the Saturnian system. Known as Cassini, this journey will survey Saturn's rings and satellites and the surface of and atmosphere of its principal moon, Titan. These volatile-rich objects preserve unique records of different key phases in the formation and evolution of the solar system. Indeed, we think that every large object in the universe was originally formed by gas and dust coming together eventually giving rise to planets and stars and whole galaxies. By studying Saturn's rings, we will be able to see this process in operation.

OAST is developing technologies for a high-efficiency low-power travelling-wave tube amplifier (TWTA) to transmit all of Cassini's data back to earth. This technology has been baselined to fly on the Cassini flight. The required radio frequency power output of the TWTA is 9.6 watts, while the input dc power from the spacecraft is limited to about 30 watts. To achieve this capability, more than doubling the efficiency of Ka-Band TWTA's now available at this power level, several novel technologies are incorporated into the tube. One contribution, a slow wave circuit, has made it possible to sharply increase the output power and efficiency of the communications system. Other technologies have made it possible to recover energy being used for data transmissions so that it can be reused for future communication of mission data. These advances will enable Cassini to send greater volumes of information back to earth with low distortion and less energy than is currently possible. Mission planners will thus be able to acquire greater science return from Cassini.

The potential commercial applications of this technology include intersatellite communication links and other low power uses. Most of the technology advances to be incorporated into the TWTA can also be scaled for higher-power uses including uplinks to satellites. Significant increases in efficiency with attendant reduced energy usage can be expected with these applications. As currently planned, the OAST program will conclude with the delivery of four fully-functional Engineering Model TWT's along with one breadboard model electronic power conditioner that will be integrated and tested with one of the TWT's.

Initiated in early 1990, this technology is being developed under the auspices of the OAST Research and Technology Base program at the Lewis Research Center. Over the past twenty years, Lewis has pioneered advances in TWT technologies that have become the industry standard for civil and military spacecraft communications. For additional information, contact: Arthur Curren, Lewis Research Center, Cleveland, Ohio. Phone - (216) 433-3519.

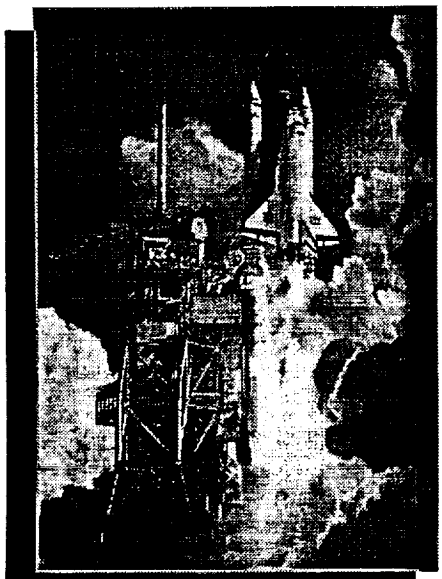
DEEP SPACE COMMUNICATIONS TECHNOLOGY



Office of Aeronautics and Space Technology

92-8018

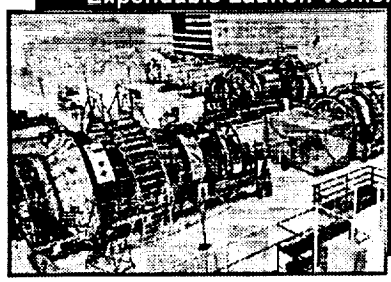
TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION



Space Shuttle

- Structural Analysis for Solid Rocket Motor (SRM) Redesig
- Vacuum Plasma Spray Coatings & Chambers
- Health Monitoring (Test Facilities)
- Thermal Protection System
- Bearing Cooling Analysis
- Real Time Data System
- Orbiter Experiments
- Damping Seals
- Modified Tires

Expendable Launch Vehicles



- Advanced Primary Battery

Office of Aeronautics and Space Technology

92-8023

ADVANCED PRIMARY BATTERY FOR TRANSPORTATION SYSTEMS

OAST

Lithium-thionyl chloride primary batteries are of interest to both NASA and the military because of their enhanced energy storage capability and long active shelf life. NASA is planning a number of unmanned low-power planetary space missions for the late 1990's and early 2000's to send probes into comets, asteroids, and outer planets. Based on these interests, OAST has sponsored a research and technology program at the Jet Propulsion Laboratory (JPL) to meet the needs of these missions.

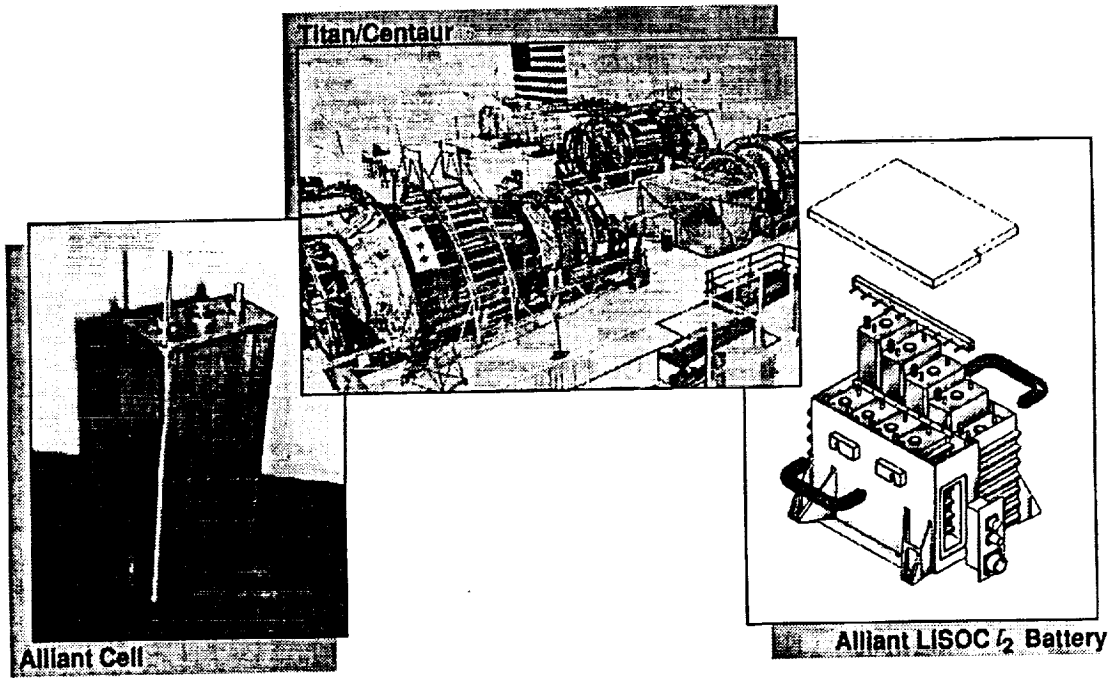
In 1987, the JPL Battery Systems Group demonstrated the capability of a high specific energy (> 300 Watt hours per kilogram), high discharge rate lithium-thionyl chloride battery. The technology development effort had been geared towards developing a high specific energy, safe, primary cell for NASA mission which could be discharged within two hours. Following this demonstration, the Air Force Space Division became interested in the efforts at JPL based on an Air Force requirement for a battery system with a reduced mass that could provide extended periods of power. The Air Force then contracted with JPL to develop 250 amper-hours, 300 watt hours per kilogram, prototype lithium - thionyl chloride cells and batteries for the Centaur Launch Vehicle.

This effort involves the transfer of the OAST funded technology developments at JPL to two contractors (Alliant Techsystems and Yardney Technical Products) to meet the Air Force's requirements. The Centaur Phase 1 effort was to develop a 250 amper-hour cell that is capable of meeting launch vehicle performance, environmental, and safety requirements. This has now been completed. The phase 2 effort to develop batteries has involved assembling and environmental testing of mock-up batteries and is currently under way. JPL plans to deliver a Manufacturing Control Document to the Air Force in the Fall of 1991 to procure lithium-thionyl chloride batteries.

JPL's demonstration of this technology verifies the capability of this electrochemical energy storage device to exceed that of all other existing primary cells by a factor of 3 to 5. In addition, the lithium-thionyl chloride battery will result in a 50% weight savings over the current Centaur power silver-zinc system. Success can be ascribed to three factors: having a fundamental understanding of the process and design considerations, cooperation with manufacturers with experience in this technology, and a critical need on the part of the Air Force. In terms of future considerations, the three fold increase in energy density of this device offers a unique opportunity to significantly reduce mass and cost for any application where a primary battery is needed. Such examples include tethered spacecraft and an Assured Crew Return Vehicle for Space Station.

For additional information, please contact, Gary Bennett, NASA Headquarters, Code RP, Washington, D.C., 20546. Phone: (202) 453-2856.

BATTERY TECHNOLOGY



DAMPING SEALS FOR THE SPACE SHUTTLE MAIN ENGINE (SSME)

OAST

Turbopumps for rocket engines are very high power rotating machines that move large quantities of liquid propellants in short periods of time. They are subjected to loads and forces that can quickly trigger severe and sometimes catastrophic rotor dynamic instabilities. The Space Shuttle Main Engine (SSME) liquid oxygen and liquid hydrogen turbopumps represent the highest pressure and highest power rocket engine turbomachines ever built in ths country. It became apparent during the development of the SSME that the liquid oxygen pump had potential rotor dynamic instabilites (termed subsynchronous whirl) under certain operating conditions.

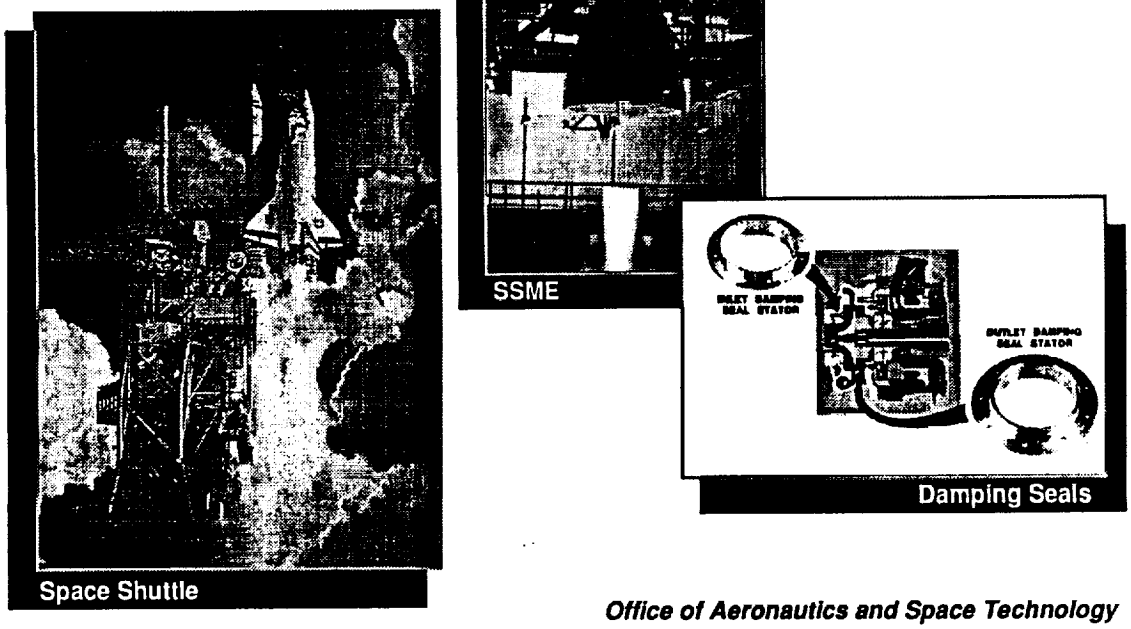
Generic research on approaches to improving the damping characteristics and rotordynamic response of turbopump rotor support structures has been part of the OAST ETO Propulsion Technology Program for many years. Damping seals for high speed turbomachinery were identified as one of the most promising approaches towards alleviating rotor instability problems. Their technology development and demonstration thus became a major focus of the propulsion technology program. The major advantage of damping seals is that they can be designed to not only significantly reduce seal leakage compared to standard seal designs, but also to act like fluid film bearings in that fluid trapped between the damping seal and the rotating shaft provides rotor support similar to that provided by rolling element mechanical bearings. The demonstrated effectiveness of this concept in rig testing offered evidence that it could provide increased damping in the SSME liquid oxygen pump and thus help alleviate the instability problem by increasing the subsynchronous whirl margin.

The SSME liquid oxygen pump is different from most rocket engine pumps in that there are actually two pumps mounted on one shaft. The main liquid oxygen flow enters and exits the primary pump radially at the center of the shaft, while a small, but very high pressure centrifugal pump that delivers a fraction of the total oxygen flow to the turbine drive gas generators (preburners) is mounted on one end of the shaft. The turbine that rotates the shaft and drives the pumps is mounted on the other end of the shaft. Two pairs of ball bearings support the shaft and complete the overal pump assembly. With so many rotating parts mounted on the shaft, the difficulty of balancing the overall assembly becomes more pronounced.

It was determined by analysis and subsequent testing that if the standard labyrinth seals used in the small high pressure pump were replaced with damping seals, a signicant increase in the subsynchronous whirl margin would be realized. Damping seal designs based on the technology development results were incorporated in the small preburner pump and indeed, signicant improvements in the subsynchronous whirl margin were achieved, thus significantly enhancing engine reliability and safety.

Damping seal technology is being continued with the objective of achieving even better damping characteristics and lower leakage than were demonstrated in earlier designs. Improved designs will be available for the next generation and all future engines. The earlier damping seal technology was developed over a four year period, from 1983 through 1986, as part of the OAST Earth-to-Orbit Propulsion Technology Program. The work is continuing under the same program which is now a key element of the OAST Civil Space Initiative (CSTI). For additional information, contact William J. D. Escher, NASA Headquarters, Code RP, Washington, D.C. 20546. Phone: 202-453-2858.

DAMPING SEALS TECHNOLOGY



Office of Aeronautics and Space Technology

92-8021

VACUUM PLASMA SPRAY COATING - SPACE SHUTTLE MAIN ENGINE FUEL VALVE HOUSING

OAST

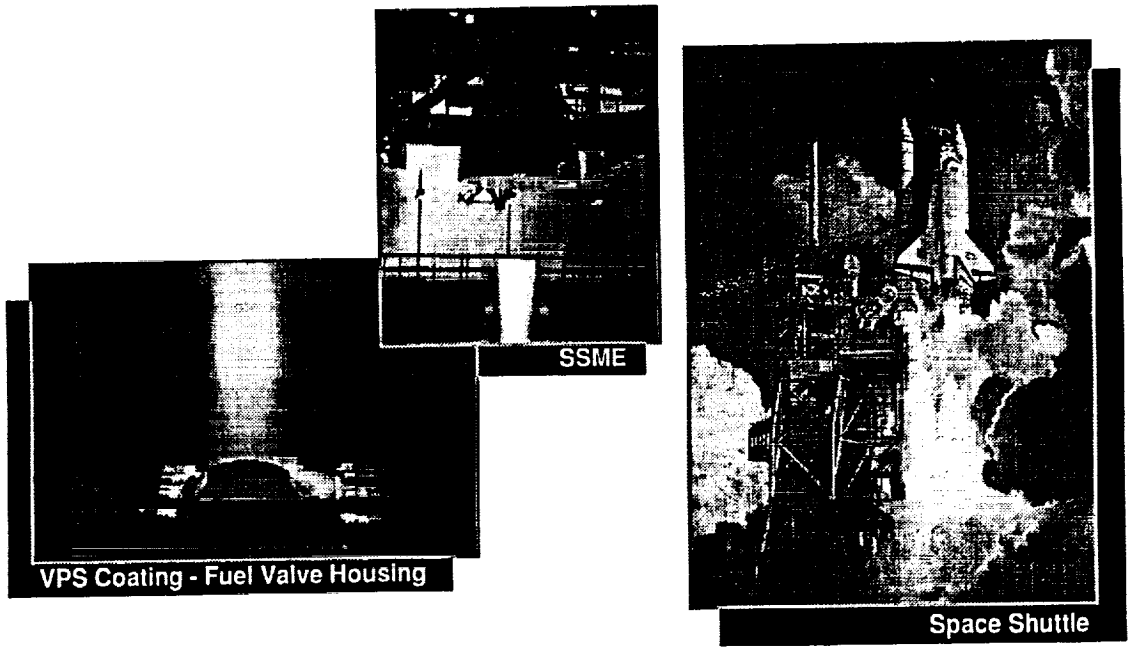
Developing processes for successfully applying metallic or non-metallic coatings to liquid rocket engine components has long been a focus of the OAST rocket engine materials research program. One of the primary drivers for perfecting such processes has been the need for and benefits of protecting and extending the life of metal engine parts subjected to very high combustion temperatures and heat transfer rates. Earlier attempts at developing thermal barrier coatings utilizing air plasma spray (APS) techniques have been generally unsuccessful due to poor bonding properties attributed to high oxide content. Thermal barrier coatings applied to Space Shuttle Main Engine (SSME) turbine blades in this manner consistently flaked off due to inadequate bonding.

The development of vacuum plasma spray (VPS) coating techniques has essentially solved this problem by producing a tough coating in a single application. A key aspect of this advance was eliminating most oxides in the coating. Excellent bond properties have now been achieved. For example turbine blades coated in this manner with ceramic materials have undergone severe thermal shock testing with essentially no coating removal. The success of this process has greatly expanded our horizons in searching for potential applications. Valve bodies are currently being fabricated for the SSME with the VPS process and offer the promise of significantly reducing fabrication time and cost, as well as greatly improving producibility.

The future of this coating process is limitless. For example, if used to fabricate combustor liners for future rocket engines, NASA could realize considerable savings due to lower production costs and ease of reproducibility. In addition, higher reliability and ultimately increased flight safety is envisioned because of higher quality products and very few welds. The ability to apply effective thermal barrier coatings to turbine blades operating in very high temperature, turbulent environments offers the possibility of greatly extending blade life and/or improving engine performance by allowing higher turbine inlet temperatures without compromising engine reliability or life. A number of commercial applications could also take advantage of this technique, such as in the fabrication of oxide-free, structurally sound crucibles and test tube-like containers for chemical process applications.

This technology was developed over a ten year period starting in the early 1980's as part of the OAST Earth-to-Orbit Propulsion Technology Program, which is now a key element of the OAST Civil Space Initiative (CSTI). For additional information, contact William J. D. Escher, NASA Headquarters, Code RP, Washington, D.C. 20546. Phone: 202-453-2858.

VACUUM PLASMA SPRAY COATINGS & CHAMBERS TECHNOLOGY



Office of Aeronautics and Space Technology

92-80

MODIFIED SPACE SHUTTLE MAIN LANDING GEAR TIRE

OAST

The high landing speeds of the Space Shuttle coupled with the highly textured runway surface at the Kennedy Space Center (KSC) result in excessive Shuttle main-gear tire wear. Because the runway surface is textured to avoid tire hydroplaning during wet landing operations, grinding the runway smooth is an impractical way to reduce tire wear. Researchers at NASA's Langley Research Center Aircraft Landing Dynamics Facility (ALDF) took the alternative approach of modifying the tire to improve tread life and increase safety during Shuttle landing operations.

The Space Shuttle's landing speed is 200 knots, much more than commercial aircraft. The tire instantly experiences wear at touchdown. However, steering adjustments during roll-out to counter the effects of a crosswind and maintain alignment with the runway centerline cause the most wear. Testing showed that the maximum allowable wear limit for Space Shuttle tires is the tread plus six cords. This wear limit sets the landing crosswind limit. Maintaining the Shuttle on the runway in a 15 knot crosswind requires the pilot to continually apply steering pressure, exposing the main-gear to approximately 2.5 million foot-pounds of side energy due to the steering friction force between the tire and the textured runway. Spin-up during landing on the textured runway destroys about two-thirds of the tread depth.

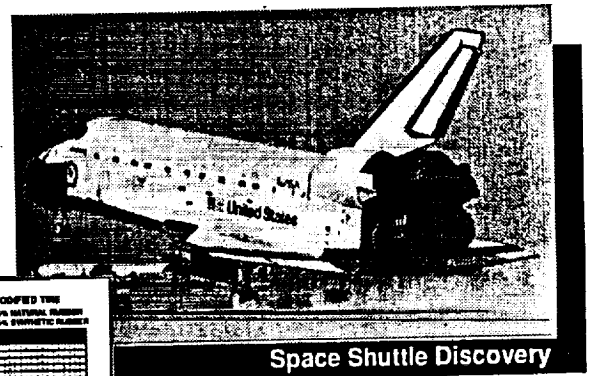
The current and modified tires differ only in the tread design. The current tire tread is 0.2 inches of 100 percent natural rubber (0.1 inches of groove and 0.1 inches of undertread). The modified tire's undertread was doubled and the tread was changed to a composition of 65 percent natural rubber and 35 percent synthetic rubber. Under identical landing conditions, changing the composition reduces the amount of tread destroyed due to spin-up to less than 40% of the current tire loss. This allows the tread to absorb more energy during the critical roll-out.

The current Shuttle tire crosswind limit at KSC is 15 knots, less than the design goal of 20 knots, because the associated side energy is sufficient to destroy six cords. With the new tread, six cords of the modified tire are destroyed only after it has dissipated more than 8.5 million foot-pounds of side energy--an improvement in tire life of more than 300 percent. The modified tire easily handles a 20-knot crosswind, since the main-gear is exposed to a maximum of 4 million foot-pounds of side energy.

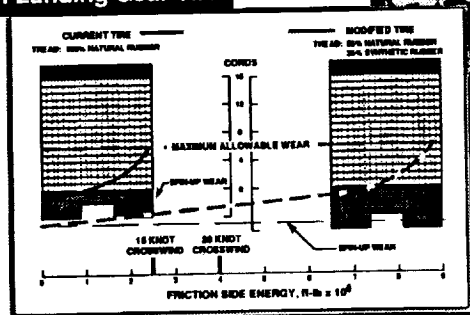
As a result of the marked improvement in treadlife, the Shuttle Project Office is accelerating the certification tests for the modified tire for installation on the orbiter for STS-45 which is currently scheduled for mid-1992. Tire development began in 1986. This collaborative effort, led by the Aircraft Landing Dynamics Facility, included the Michelin Aircraft Tire Company, NASA Johnson Space Center, and the USAF Wright Laboratory, and was performed under the auspices of the OAST Material and Structures Division with additional funding from the Office of Space Flight. For additional information, contact: Terrence J. Hertz, NASA Headquarters, Code RS, Washington, D. C. 20546. Phone: 202-453-2865.

SPACE SHUTTLE LANDING GEAR TECHNOLOGY

Modified Main Landing Gear Tire



Space Shuttle Discovery



Main Gear Tire Wear

Office of Aeronautics and Space Technology

92-8015

ORBITER EXPERIMENTS
AEROTHERMODYNAMIC DESIGN TOOL VALIDATION

OAST

The Orbiter Experiments (OEX) Program has enabled use of the Shuttle Orbiter as an entry flight research vehicle. OEX experiment hardware/instrumentation are unique in that they are installed integrally with the Orbiter structure, rather than simply "riding" in the Orbiter payload bay as a mission cargo. Integrated in this fashion, the experiments do not interfere with the normal operational missions of the Shuttle. A primary focus of the OEX Program has been the collection of benchmark entry aerothermodynamic flight data to be used for validation of design tools which will be used for the design of the next generation of space transportation vehicles.

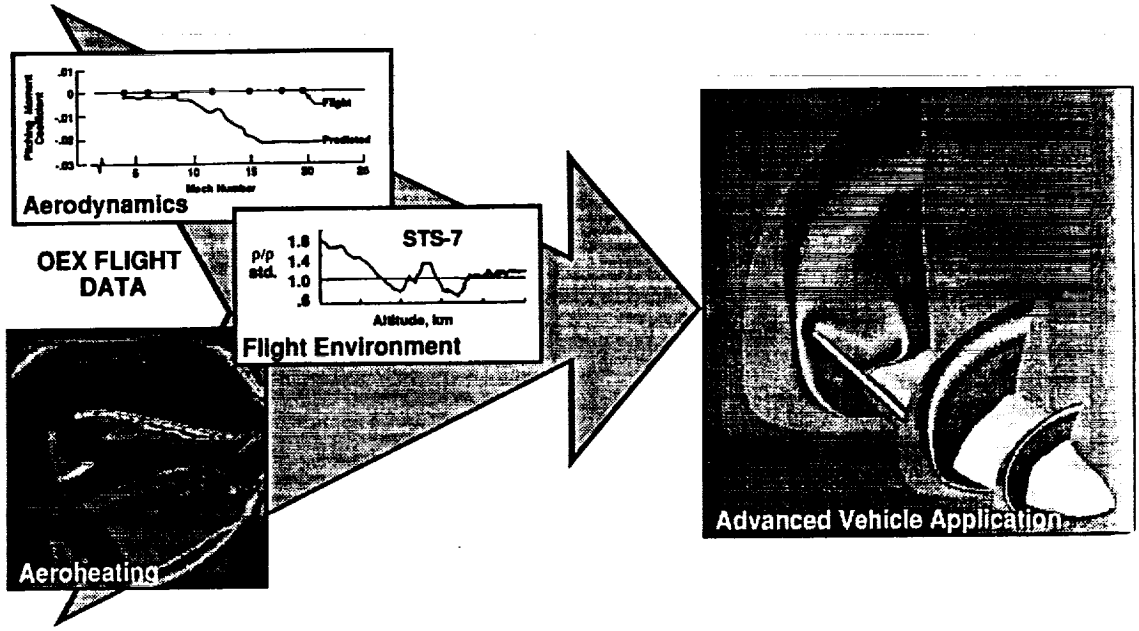
The OEX Program experiment complement comprises multiple instruments, each of which obtains data for ongoing research. This experiment complement includes instruments which: provide in situ measurements of the freestream flight environment and vehicle attitude throughout atmospheric entry; measure vehicle dynamic motions (from orbital altitude to landing) to determine aerodynamic characteristics; and measure aerodynamic surface temperatures to determine aerodynamic heating rates experienced by the vehicle during entry.

Ground-based experimental facilities cannot provide fully accurate simulations of the aerothermodynamic flight environment of an entry vehicle. Consequently, efficient aerothermodynamic design of advanced space transportation vehicles demands validation of state-of-the-art computational fluid dynamic techniques which will be applied in that design process. The data derived from the OEX complement of experiments represent benchmark hypersonic flight data not available, heretofore, for a lifting entry vehicle. These data are being used in a continual process of validation of state-of-the-art methods for predicting the aerothemodynamic characteristics of advanced space transportation vehicles.

Elements of OEX instrumentation first flew aboard the Orbiter Columbia on STS-1. Major OEX aerothermodynamic experiments were flown over a four flight period during 1989-91. The final flight scheduled to carry OEX experiment hardware will occur in 1992.

For further information, please contact: David Throckmorton, Langley Research Center, Aerothermodynamics Branch, Hampton, Virginia, 23665. Phone:(804) 864-4406

ORBITER EXPERIMENTS
AEROTHERMODYNAMIC DESIGN TOOL VALIDATION



Office of Aeronautics and Space Technology

91-8058

REAL TIME DATA SYSTEM (RTDS)

OAST

By introducing state-of the art techniques in expert systems, software engineering, human/computer interfaces, and distributed systems, NASA is improving the quality of flight decision making and the cost effectiveness of Space Shuttle Mission Control Operations. As manned spacecraft missions and flight operations increase in frequency and complexity, greater demands are being placed on flight controllers to perform more problem solving tasks. The goal of the RTDS is to relegate the repetitive, monotonous monitoring tasks in mission control to automated systems and free the flight controller to concentrate on the more challenging aspects of space flight such as schedule modifications and trouble shooting.

Under the RTDS program, a number of real-time expert systems have been introduced into Mission Control Center (MCC) consoles at the Johnson Space Center. The principal mission benefits from the RTDS applications are improved data monitoring and more thorough analysis of fault data in a shorter period of time. By supplying this capability, RTDS will provide much needed savings in manpower.

RTDS has resulted in dramatic and new capabilities. For example, by acquiring real-time telemetry, RTDS enables an animated view of the position of the Space Shuttle's Remote Manipulator System (RMS). Flight controllers who monitor the RMS traditionally had to determine the position of the robot arm by observing digital readouts of the angles of each of the arms joints. A combination of off line tools and mental gymnastics allowed operators to determine the arm's position. This new capability not only lowers the flight controller's workload, but also allows the controller to visually monitor for potential collisions of the Shuttle and payloads. During retrieval of the Long Duration Exposure Facility (LDEF) on STS-32 in January 1990, this system was used by the MCC to monitor RMS activity during a video loss of signal.

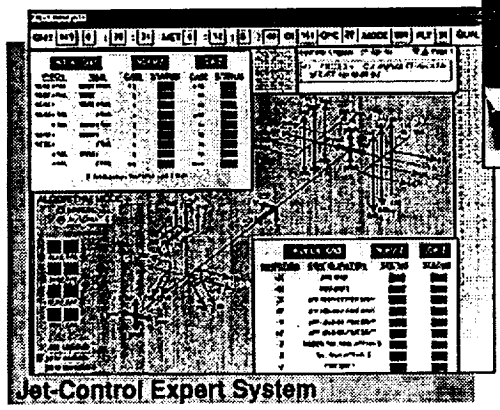
RTDS also provides a Reaction Control Expert System that monitors the performance of the 38 attitude control jets on the shuttle via real time telemetry and determines the valid attitude control modes based on the jet availability. This monitor diagnosed the loss of 3 thrusters on STS-31 in April, 1990 and concluded that there was no loss of control capability. The future plan for RTDS is to upgrade most flight controller consoles at the MCC to give them a RTDS capability and to add a capability for coordinating between expert systems.

RTDS has been developed over the last 4 years beginning in 1987 under the auspices of the OAST Civil Space Technology Initiative. For additional information, contact: Melvin Montemerlo, NASA Headquarters, Code RC, Washington, D.C. 20546. Phone - 202-453-2744.

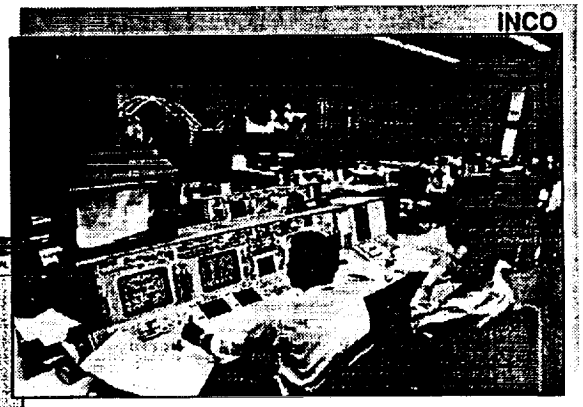
REAL TIME DATA SYSTEM

APPLICATION

- **INCO Systems Monitor**
- **Main Engines**
- **Tire Pressure Monitor**
- **Jet-Control Expert System**
- **OMS/TVC Monitor**



Jet-Control Expert System



- **Wind Monitoring System**
- **RMS Position Monitor Display**
- **RMS Temperature Monitor**
- **DATACOM Expert System**
- **Fuel Cell Expert System**

THERMAL PROTECTION SYSTEM FOR THE SPACE SHUTTLE

OAST

In the 1970's our space flight scientists and engineers undertook the challenge of building a reusable launch system that would give the country routine access to space. The 1981 debut of the National Space Transportation System, better known as the Space Shuttle, symbolized the largest and most complex technological project ever undertaken by our country during peacetime. The Shuttle carries satellites, experiments, and flight crews into space and has engaged in dramatic rescues and repairs of disabled satellites, such as the Solar Maximum Satellite rescue in April, 1984. As we look to the coming century, the Shuttle will play the key role in building and maintaining a permanent Space Station in-orbit.

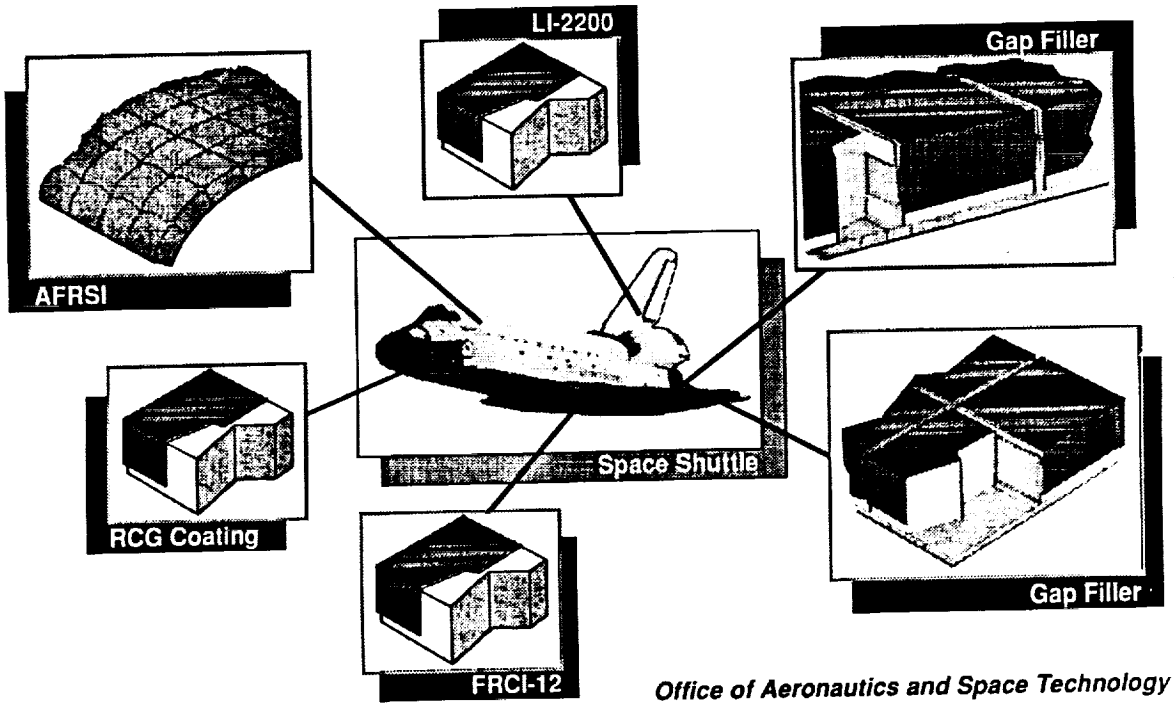
Thermal tile insulation and blankets (also known as the thermal protection system) cover the underbelly, bottom of the wings, and other heat-bearing surfaces of the Shuttle orbiter and protect it during its fiery reentry into the Earth's atmosphere. Some 24,000 individual tiles- no two alike- must be installed on the orbiter's surfaces. OAST invented a black borosilicate coating called Reaction Cured Glass which covers two-thirds of the orbiter surface. This glass coating provides a thermally stable high emittance surface for the silica tiles and has made it possible to manufacture tiles to the demanding tolerances required.

Through the Ames Research Center, OAST has played a major role in advancing the state of the art in tile technology for the Shuttle. In response to a critical tile strength problem encountered by Columbia, OAST developed a stronger insulation material that replaced 10% of the baseline tile system on the orbiter. OAST also developed a new more durable class of tile materials called Fibrous Refractory Composite Insulation (FRCI-12) that has led to weight savings of more than 1,000 pounds. In addition, OAST working with a contractor designed a blanket insulation material for the Shuttle's top surface called Advanced Flexible Reusable Surface Insulation which is cheaper, lighter and more easily maintained than the material it replaced. These advances have yielded tiles that are as light as balsa wood, and dissipate the heat so quickly that a white hot tile can be taken from an oven and held in bare hands without injury.

Finally, OAST technology has solved the serious problem of hot gas flow between tiles during atmospheric entry. OAST developed a gap filler, consisting of a ceramic cloth impregnated with a silicone polymer, that has now been standardized on all the orbiters. In excess of 10,000 are used on each Shuttle.

This technology and its derivatives could be used for future aerobraking and manned entry vehicles such as the Personnel Launch System. Each of the technologies discussed were adopted by the Shuttle over a period spanning from the mid-1970's to the early-1980's. For further information, please contact: Murray Hirschbein, NASA Headquarters, Code RS, Washington, D.C. 20546. Phone - 202- 453-2859.

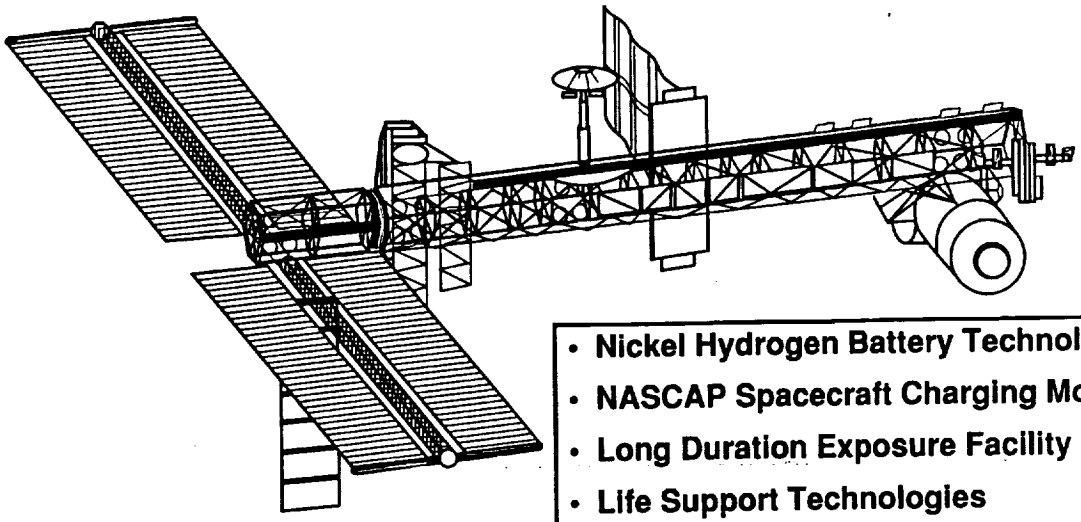
REUSABLE THERMAL PROTECTION MATERIALS



Office of Aeronautics and Space Technology

92-8014

TECHNOLOGY CONTRIBUTIONS TO SPACE PLATFORMS



- Nickel Hydrogen Battery Technology
- NASCAP Spacecraft Charging Model
- Long Duration Exposure Facility
- Life Support Technologies
- Multipropellant Resistojet
- Large Area Solar Cells
- Arcjet Thruster

Office of Aeronautics and Space Technology

92-8024

BATTERY TECHNOLOGY (SPACE STATION FREEDOM)

OAST

The nickel-hydrogen battery design has resulted in the most advanced, long-life, rechargeable battery technology developed over the last 50 years. The dramatic advances in capabilities of this technology are opening a whole range of possibilities for both NASA and the commercial space sector. During periods of darkness, rechargeable batteries supply the power needs of the spacecraft. Recently, breakthroughs have been achieved in the low-Earth-orbit (LEO) cycle life of individual pressure vessel nickel-hydrogen battery cells. The cycle life was improved by more than a factor of 10 over state-of-the art cells. Ground test cells containing 26 percent potassium hydroxide (KOH) electrolyte were cycled for 40,000 stressful accelerated LEO cycles at a deep depth of discharge (80%). Cells containing 31 percent KOH had previously achieved only 3500 cycles.

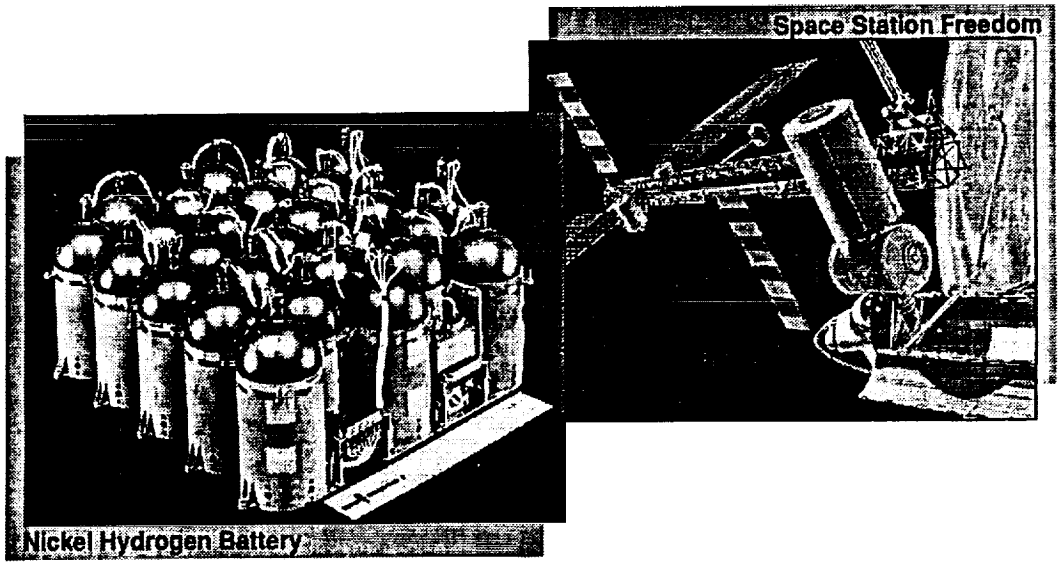
The significance of this breakthrough is that long term LEO missions, such as Space Station Freedom, can now rely on a greater than 5 year life span for advanced nickel hydrogen batteries. This advance will result in a significant reduction in life cycle cost. In addition, nickel-hydrogen batteries provide the capability of operating at a deep depth of discharge which could enable reductions in the mass devoted to batteries and increases in payload capability.

This program is based on a close working relationship with NASA mission offices, the military, and industry. Technologists at the Lewis Research Center are coordinating with the Space Station Freedom power office on advanced nickel hydrogen cell design features which promise to significantly enhance the SSF mission. In addition, the Earth Observing System has chosen to use OAST's nickel-hydrogen battery technology. Technologists at Lewis are working closely with OSSA to meet this mission's power needs. The Air Force, meanwhile, is using Lewis's advanced nickel hydrogen cell technology for military flights. Finally, the aerospace industry has adopted a scaled-up version of the Lewis design which is currently undergoing cell testing at Loral Corporation.

As we look to the future, nickel-hydrogen is fast replacing nickel-cadmium as the standard satellite storage system. It is projected that nickel-hydrogen will be the major rechargeable battery system for future aerospace applications. The ongoing technology development efforts at Lewis are aimed at increasing the life, power density, and reliability and at reducing the mass and lowering the cost of the nickel-hydrogen battery system.

Sponsored under the auspices of OAST, work was initiated on nickel-hydrogen battery technology at Lewis in the early 1980's. For additional information, contact: Gary Bennett, NASA Headquarters, Code RP, Washington, D.C., 20546. Phone: (202) 453-2856.

BATTERY TECHNOLOGY



NASCAP SPACECRAFT CHARGING MODEL

OAST

In the space environment, spacecraft materials undergo a variety of electrodynamic behaviors resulting from space radiation, magnetic fields and electric currents, particularly in the ionosphere around the earth. NASCAP (NASA Charging Analysis Program) is a computer program that models this electrodynamic behavior in terms of the electricalpotential and currents of spacecraft surfaces. It permits the prediction of the electrodynamic conditions that result in payload or instrument damage or in materials degradation in space.

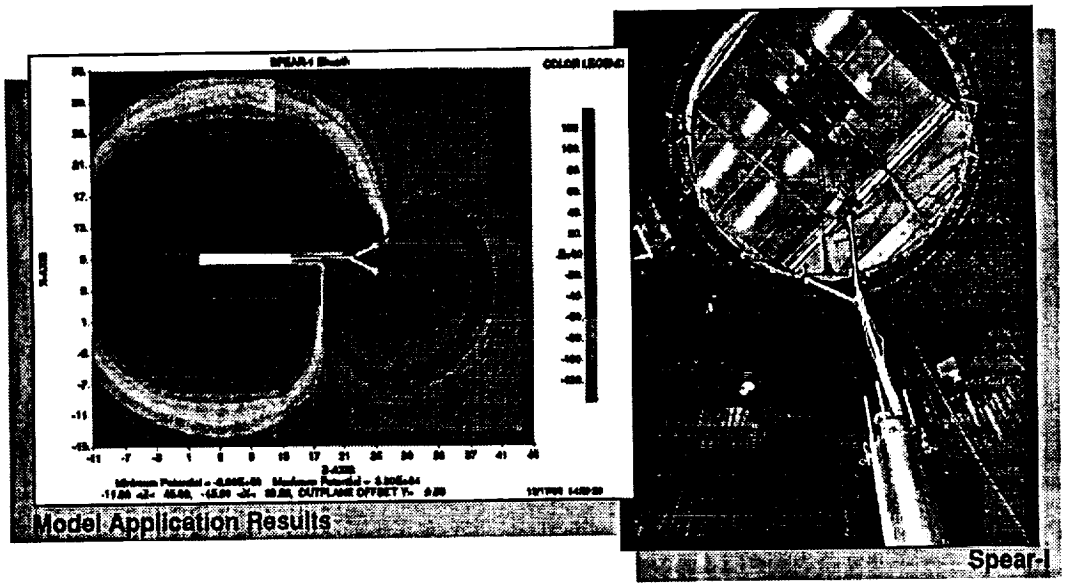
The SPEAR-I flight experiment was conducted to demonstrate the feasibility of using gas release as a grounding mechanism for spacecraft and to determine the parameters that could allow a ground test chamber to more effectively simulate flight conditions. Spear-1 was flown in December 1988 on a Black Brant sounding rocket by the Defense Nuclear Agency and SDIO. NASCAP was used to calculate the expected steady state surface potentials and collected currents for low earth, polar orbits. The flight experiment applied bipolar potentials up to 45 kilovolts to exposed surfaces in the ionosphere without causing electric discharge or breakdowns. The NASCAP predictions were in agreement with the measured values taken by SPEAR-I instruments.

Use of NASCAP in modeling Space Station Freedom (SSF) identified a potential problem from deleterious high voltage interactions. SSF solar cells are larger than standard solar cells and have a peculiar geometry. NASCAP determined that the floating potential of the cells in the space plasma resulted in a negative ground (about -140 volts) relative to the plasma. The magnitude of this voltage is high enough that the incoming positive ions in the plasma will hit with sufficient energy to "knock off" material from SSF (that is, sputtering will occur). Moreover, dielectric breakdown could occur, that is, the voltage is high enough that there would be arcing or breakthroughs of the anodized surface. The calculated arc rate is one arc every two seconds. If this occurred all surfaces would be denuded in two to three years. Awareness of this problem and quantitative predictions by NASCAP about its effect have permitted a solution to be devised - change the floating potential by either increasing the ion collection or decreasing the electron collection.

NASCAP was first initiated in 1975 and funded mainly by OAST, with some support from the Air Force Geophysics Laboratory. OAST continues to support improvements, along with the Office of Space Flight. Detailed improvements will be made in NASCAP for low-Earth orbit (LEO) applications. Furthermore, several models including NASCAP will be integrated into an analytical tool that can be used for design of spacecraft for these environments.

For more information, please contact Gary Bennett, NASA Headquarters, Code RP, Washington, D.C. 20546. Phone: (202) 453-2856.

NASCAP SPACECRAFT CHARGING MODEL



ARCJET THRUSTER TECHNOLOGY

OAST

A significant part of the OAST technology program is directed toward support of NASA's needs for advanced vehicles and propulsion capabilities. Much of the research OAST is conducting has benefits to the commercial space sector as well. As an example, OAST sponsored the development of an arcjet thruster for station keeping on geosynchronous communications satellites. Arcjets have recently been baselined for use on AT&T's Telstar 4 satellite series.

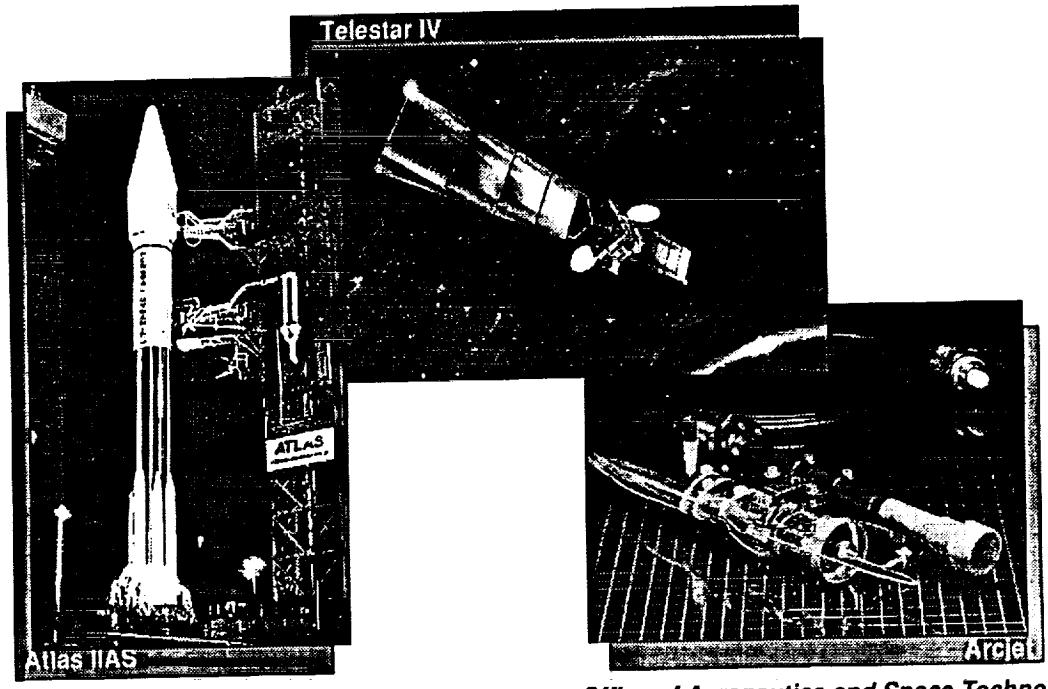
Arcjet technology is of interest to the spacecraft community because it offers 1.5 to 2 times the fuel efficiency currently available from state-of-the art chemical or resistojet thruster systems. This improved efficiency can be used to extend mission life by more than 50 percent, to reduce launch mass, or to increase payload. Switching to arcjet systems for north-south stationkeeping on a geosynchronous communications satellite can reduce propellant requirements by several hundred pounds. In the case of the Telstar 4 satellite, the arcjet's direct weight savings enable the use of the Atlas launch vehicle as opposed to a larger vehicle which would have been required for a conventional station keeping system.

The arcjet system consists of a thruster, a gas generator, and a power processing unit. The hot, slightly ionized gas exits the rocket nozzle at an average velocity 1.5 to 2 times that attained in conventional thrusters. For example, the 1.8 kilowatt (kW) arcjet systems developed by Rocket Research Company of Redmond Washington for the Telstar 4 program, provide a specific impulse (thrust divided by the propellant consumption rate) of about 500 seconds.

Arcjet research and development efforts began in 1983 at Lewis Research Center. The ongoing goal of this program is to provide and transfer this technology to the user community. The future issues to be addressed are system performance, lifetime/reliability, and other issues important to the integration of arcjet systems on spacecraft. Results to date suggest that electromagnetic interference with satellite systems should be minimal and that there will be no problem sending radio signals through the thruster exhaust plume.

Lewis researchers are also investigating a range of power options to enhance the versatility of hydrazine arcjet technology. Examples include low power (1 kW) systems for power limited satellites and high specific impulse systems for advanced communications satellites. For additional information please contact: Frank Curran, Code RP, NASA Headquarters, Washington, D.C., 20546. Phone: (202) 453-2869.

ARC JET



Office of Aeronautics and Space Technology

91-2182

SPACE STATION LIFE SUPPORT TECHNOLOGIES

OAST

Space Station Freedom (SSF) will be a permanently manned space station in low Earth orbit. Its mission requirements include the recycling of air and water in order to confine the 90 day resupply requirements to food, makeup nitrogen and some oxygen. With the restructuring of SSF, which includes a long man-tended phase, the regenerative air and water systems are being deferred and less recycling will be used initially.

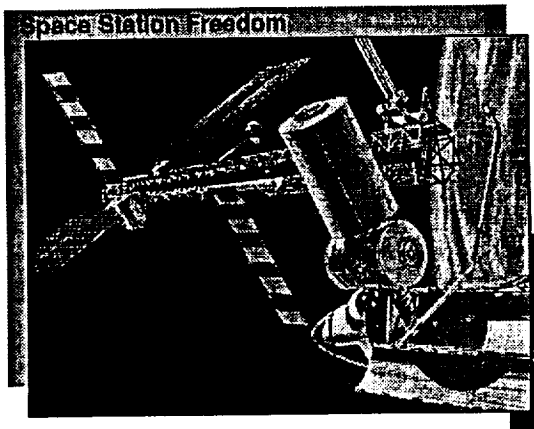
However, because future plans for SSF require increased air and water recycling, four technologies will be integral to closing the life support system. These are technologies which have been developed by OAST and picked up by the mission office for SSF use: (1) Atmospheric CO_2 exhaled by the crew will be collected from the cabin air by a molecular sieve - a technology which was first flown on Skylab. The Sabatier processor for CO_2 reduction will then convert the CO_2 to carbon and oxygen of which the O_2 will then be recyled into the cabin air for breathing. (2) The multi-filtration potable water recovery unit will remove contaminants from humidity condensate water which is collected from the cabin atmosphere and comes primarily from crew expiration. This multi-filtration unit can convert the humidity condensate to potable-quality (drinking) water for crew consumption. (3) The static feed electrolysis oxygen production unit will electrolyze a portion of the recovered waste water to produce additional oxygen for crew consumption. (The reduction of collected CO_2 in the Sabatier processor as described above does not furnish enough O_2.) (4) The vapor compression distillation hygiene water recovery unit (VCD) will recover water from crew showers and commode flush operation for reuse as hygiene-grade, but not potable-grade water.

These air and water regeneration technologies have been developed over a period of 20 years under NASA's research and technology development (R&T Base) program. In fact, the VCD has been in a R&T status since 1958, begun by the Air Force. Some of these technologies were first tested by NASA in a closed chamber environment in the early 1970's as a feasibility project. Currently, the technologies above are being tested with some use of human subjects in closed environment tests in which the product air and water are being carefully analyzed for chemical and microbial constituents. The goal is to produce water and air which have the consistently high-grade quality needed for human consumption.

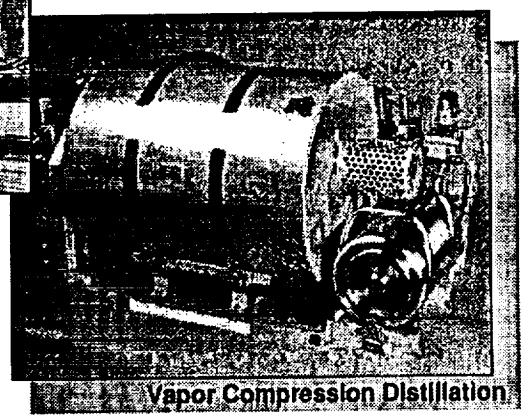
The validation and use of air and water recovery systems on the future SSF will lead to increased confidence and knowledge of the ability of humans to live for extended periods of time in space. Furthermore, this data and experience will guide the development of life support technologies for a future lunar and/or Mars mission.

For further information, please contact, Ms. Peggy Evanich, NASA Headquarters, Code RP, Washington, D.C. 20546. Phone: (202) 453-2857.

SPACE STATION LIFE SUPPORT TECHNOLOGIES



- Sabatier Processor CO_2 Reduction
- Multi-Filtration Potable Water Recovery
- Static Feed Electrolysis Oxygen Recovery
- VCD Hygiene Water Recovery



MULTIPROPELLANT RESISTOJETS FOR SPACE STATION FREEDOM

OAST

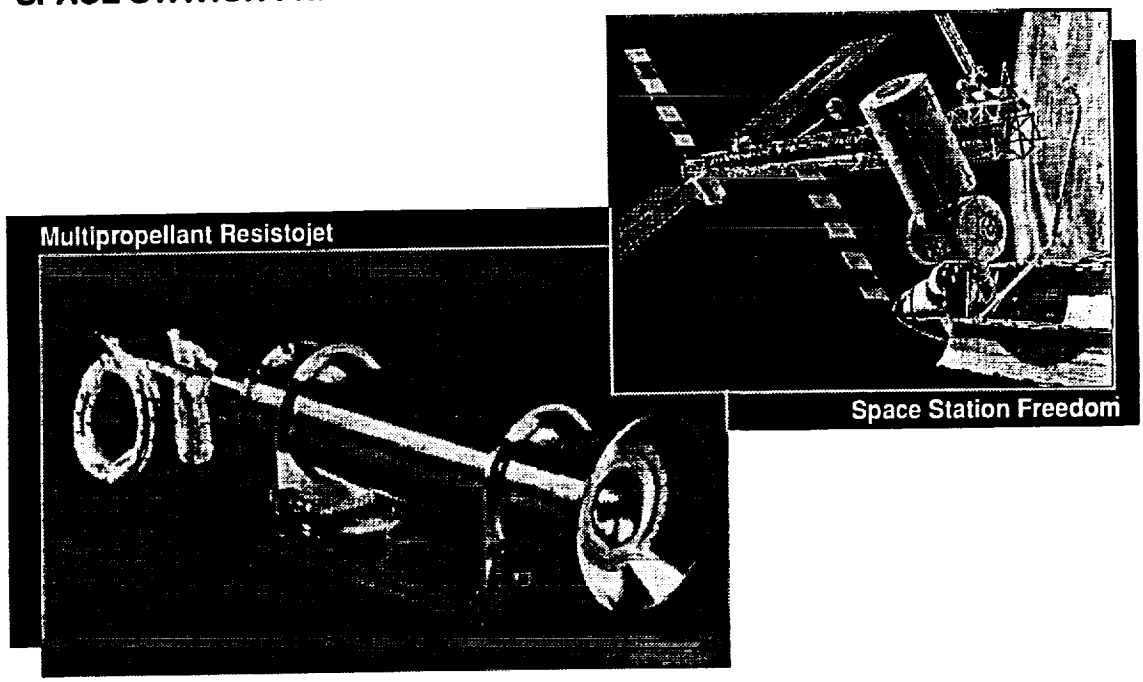
The Space Station Freedom (SSF) propulsion system must provide reboost to compensate for the atmospheric drag that space platforms encounter in low earth orbit. OAST has developed a resistojet which helps provide this capability while also having the added benefit of using wastes as a fuel. This advance will minimize propellant resupply requirements for SSF and eliminate the need to return some wastes to Earth. In the multipropellant resistojet, a resistive element is used to heat waste gases which are then exhausted through a nozzle to produce thrust. The design of these low power, low thrust devices is driven both by performance and by long life and integration considerations.

The waste gas resistojet has been baselined for the permanently manned configuration of SSF. In addition, a program is currently in place to develop the zero-g vaporizer technology necessary for a resistojet to operate with a water/waste gas system .

Use of the waste gas resistojet leads to a savings of at least 3000 pounds/year in launch weight alone. Utilization of a water/waste gas system (currently under development) to provide the entire SSF propellant reboost requirement would lead to savings of over 12,000 lbs/year. In addition, significant ground processing costs would be avoided through the use of water/waste gas system. A Rocketdyne/Technion team has designed and fabricated a low power (~ 0.5 kW) thruster utilizing grain-stabilized platinum in critical areas. This device has been successfully tested on hydrogen, helium, methane, nitrogen, argon, air, carbon dioxide, and steam and has demonstrated 10,000 hours of operation.

As we look to the future, water/waste gas resistojets could provide a key capability for commercial space platforms. Due to the ease and safety of water resupply, aerospace companies have proposed that water resistojets be considered for application on the Industrial Space Facility as these platforms become a reality. Multipropellant resistojet technology has been and is currently supported by OAST's Research and Technology Base Program. For additional information, contact: David C. Byers, NASA Lewis Research Center, Cleveland, Ohio 44135 (M/S SPTD-1). Phone (216) 977-7543.

SPACE STATION FREEDOM PROPULSION SYSTEM



Office of Aeronautics and Space Technology

92-8017

MATERIALS DESIGN DATA FOR SPACE STATION FREEDOM

OAST

Snatched from a decaying orbit weeks before it would have plunged into Earth's atmosphere, the Long Duration Exposure Facility (LDEF) tested the effects of long-term exposure on spacecraft materials, components, and systems. Its 12-sided, 30-foot long aluminum frame provided an open grid on which 86 experiment trays of varying sizes were secured. In all, 57 experiments containing 10,000 test samples flew on LDEF, representing the work of scientists from the U.S. and eight other countries. The LDEF experiments gathered unique information on space radiation, atomic oxygen, meteoroids, contamination, space debris, space systems and life sciences, information crucial to the design of future spacecraft such as the Space Station.

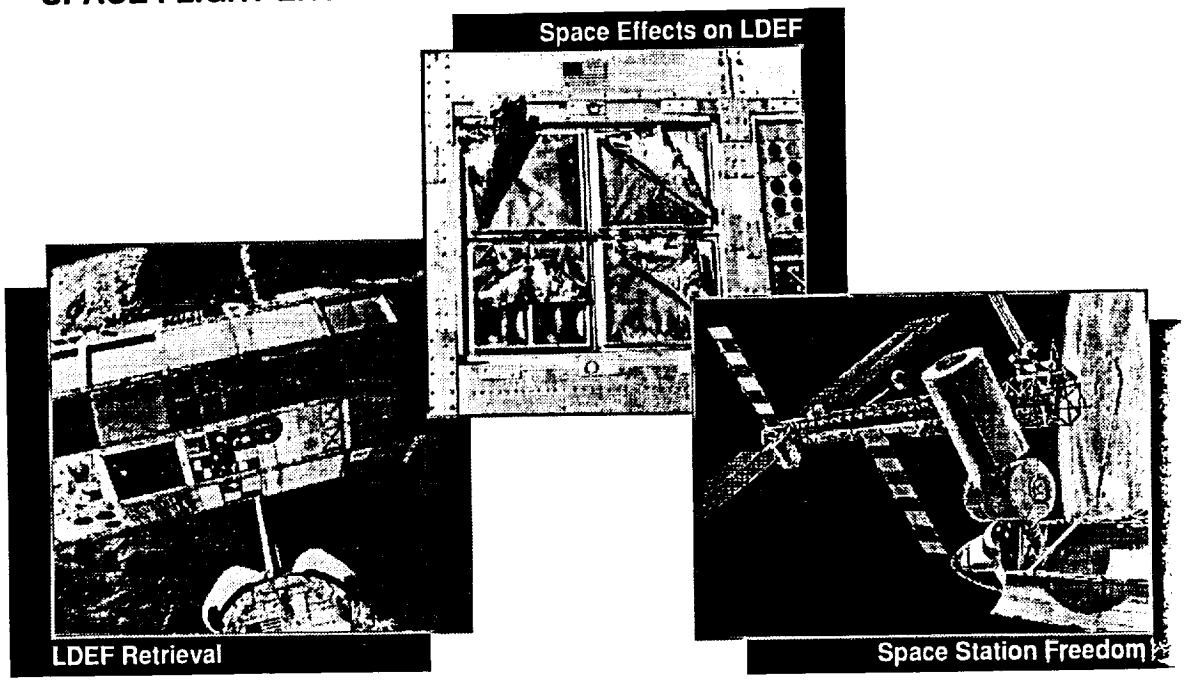
LDEF has already directly influenced Space Station design. For example, LDEF confirmed that NASA needs to shield the most vulnerable areas of the Station with bumpers to protect it from meteoroids and space debris. Light foil bumpers currently being designed by engineers at the Johnson Space Center to benefit from the tendency of small, high velocity projectiles to shatter on contact with thin outer layers of material, protecting the structural surface beneath. LDEF also brought back unique information about the direction of approach of meteoroids and space debris. The impact pattern will be similar for the Space Station. Confining the heavier shielding to susceptible areas can save thousands of pounds of material - perhaps a shuttle load. That would represent a savings of considerable funds in launch costs alone.

LDEF is also dispelling many of the unknowns of the radiation hazards inherent in low earth orbit. Using radiation measurements obtained from the spacecraft, researchers are improving the models used to develop Space Station radiation protection requirements. LDEF gives the first precise long-term measurements of the radiation's intensity and destructive capability. These measurements, like those of debris and meteoroids, will lead to significant savings in construction of the Space Station.

Selecting materials that can last up to 30 years - Freedom's projected lifetime - has been made easier as a result of data collected from LDEF. Important changes have already been made to coatings on Freedom's radiators, solar arrays, and to the material used for its trusses. LDEF leaves an important legacy as NASA will be developing "lessons learned" guidelines that promise to impact the design of future spacecraft for years to come.

Continuing support for this program is being provided by OAST under the Research and Technology base.
For more information, contact: Robert J. Hayduk, NASA Headquarters, Code RS, Washington, D.C. 20546.
Phone - (202) 453-2962.

SPACE FLIGHT ENVIRONMENTAL EFFECTS



Office of Aeronautics and Space Technology

92-8016

omit

JON PAUGH

DEPARTMENT OF COMMERCE

NIH ROYALTIES

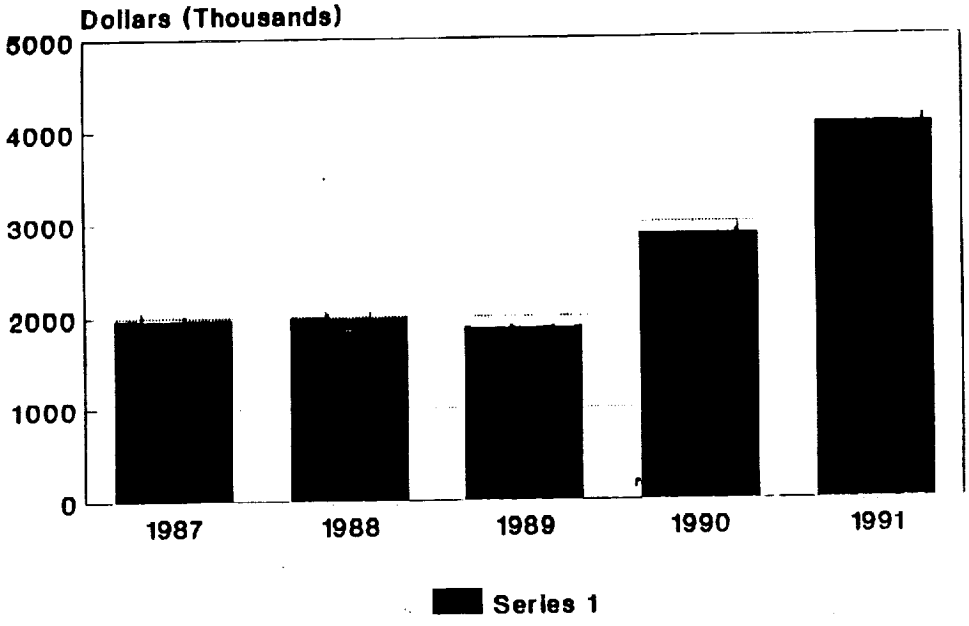
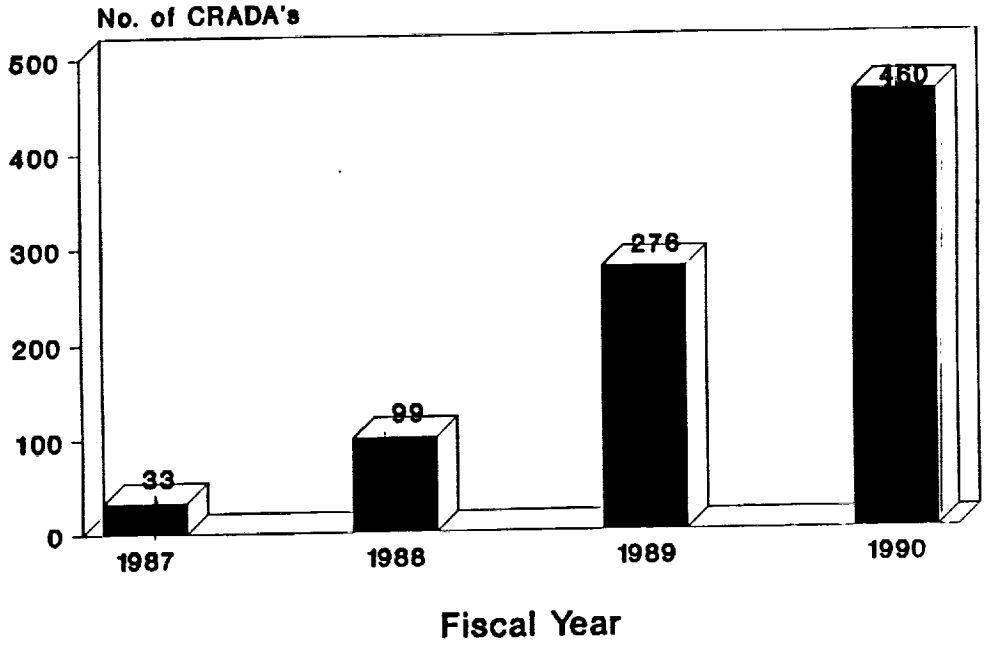


FIGURE 1

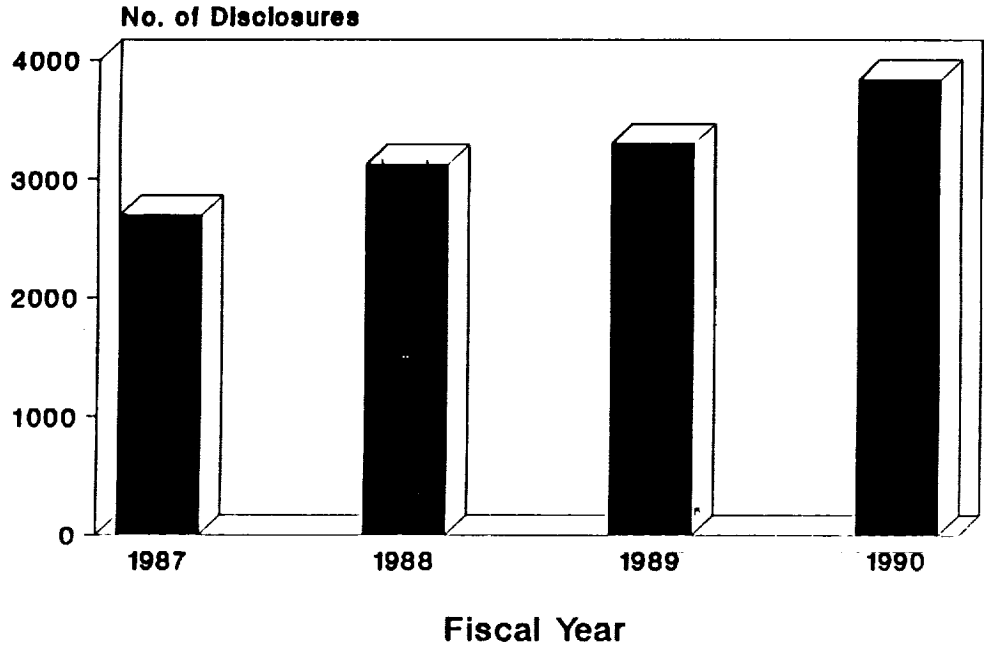
ACTIVE CRADAS



(All Federal Agencies)

FIGURE 2

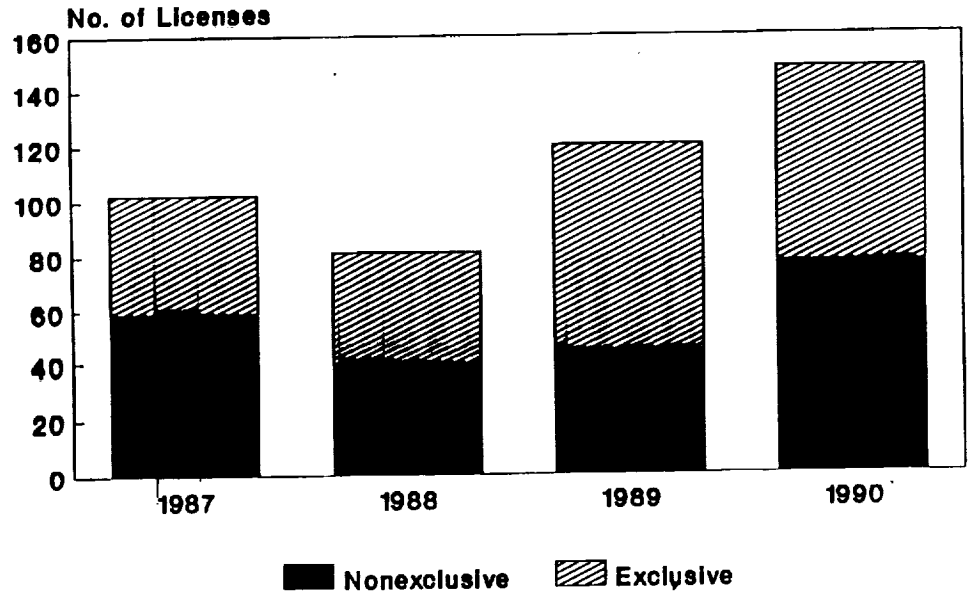
INVENTIONS DISCLOSED



(All Federal Agencies)

FIGURE 3

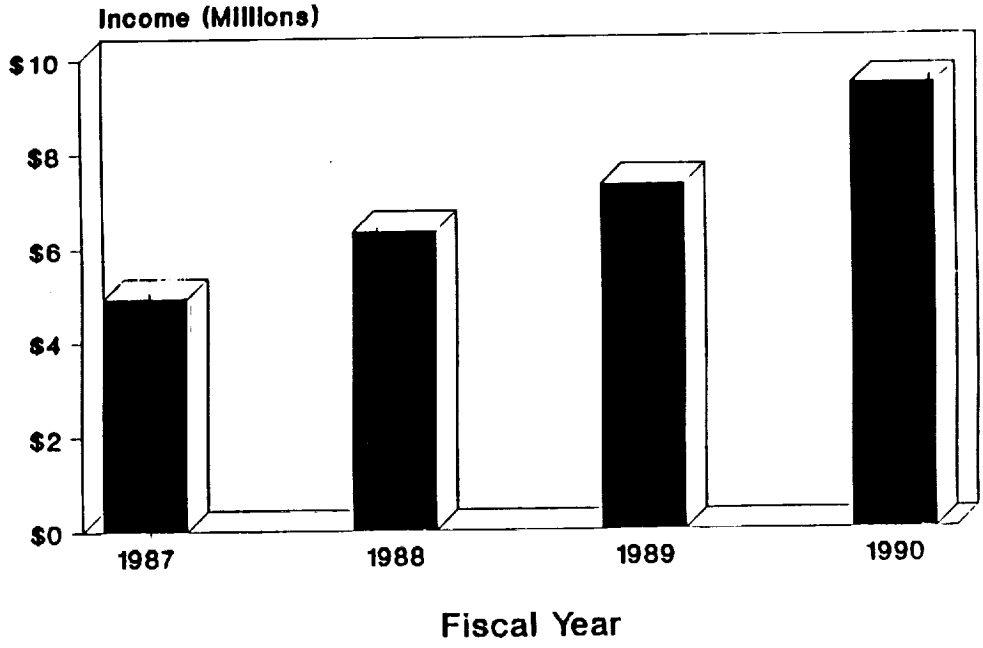
LICENSES GRANTED



(All Federal Agencies Except HHS Which Had No Data For 1987 & 1988)

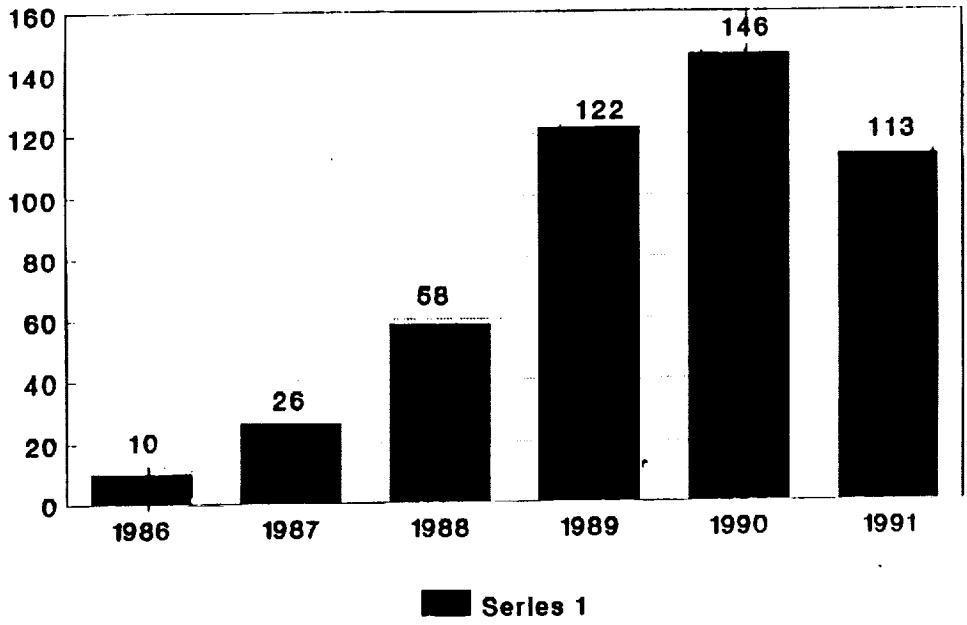
FIGURE 4

LICENSING INCOME

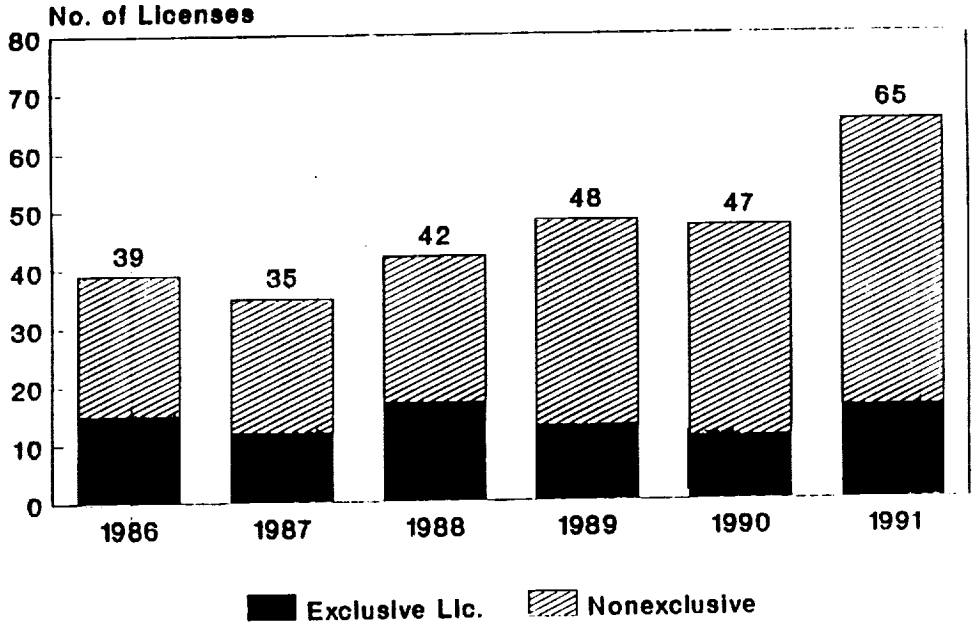


(All Federal Agencies)

NIH ACTIVE CRADAs



NIH PATENT LICENSES



DEPARMENTAL TECHNOLOGY TRANSFER UPDATE

By
Mr. Roger A. Lewis
Deputy Director
Office of Technology Analysis
U.S. Department of Energy

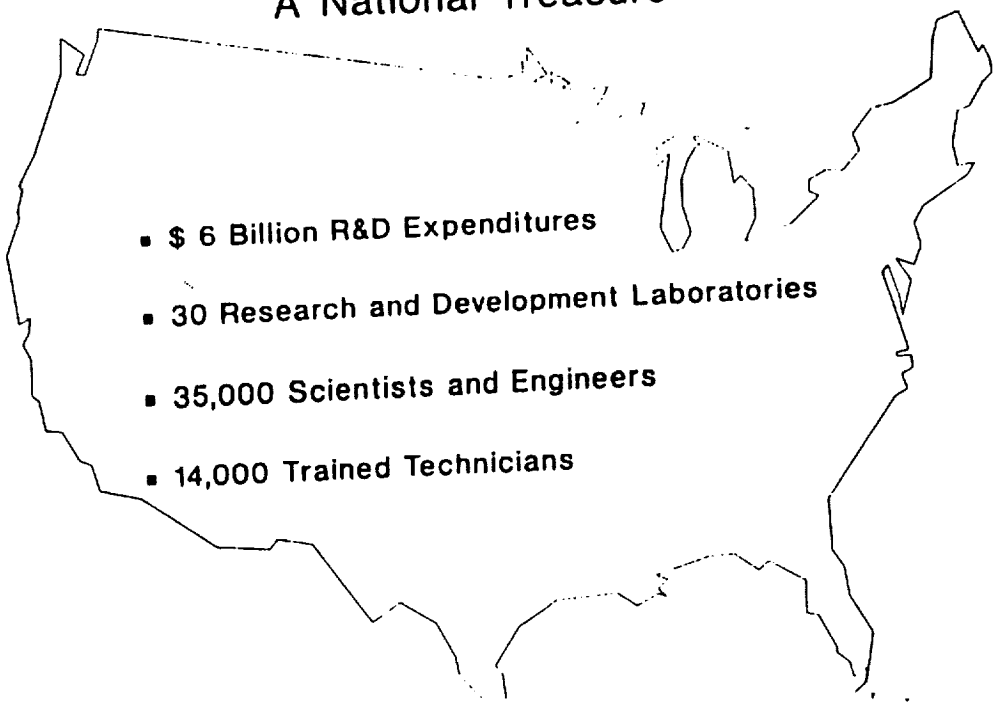
OBJECTIVE

- Provide the Perspective of the Department of Energy
- Emphasize New and Emerging Initiatives
- Address Unresolved Issues that Might Impact Successful Program Implementation

APPROACH

- Provide a brief overview of DOE, its R&D portfolio, and its technology transfer assets
- To briefly describe the evolution of DOE's Enhanced Technology Transfer Program
- To report on specific progress and achievements over the past year--as the spring board for our current and future plans
- To Present our near and longer term plans
- To survey the remaining issues and the resolution process

The DOE Laboratory System: A National Treasure



Scientific and Technical Capabilities of the Laboratories

- Energy Technologies
- Environment and Waste Management
- Analysis and Instrumentation
- Biology and Medicine
- Computers and Communications
- Materials Science and Manufacturing Processes

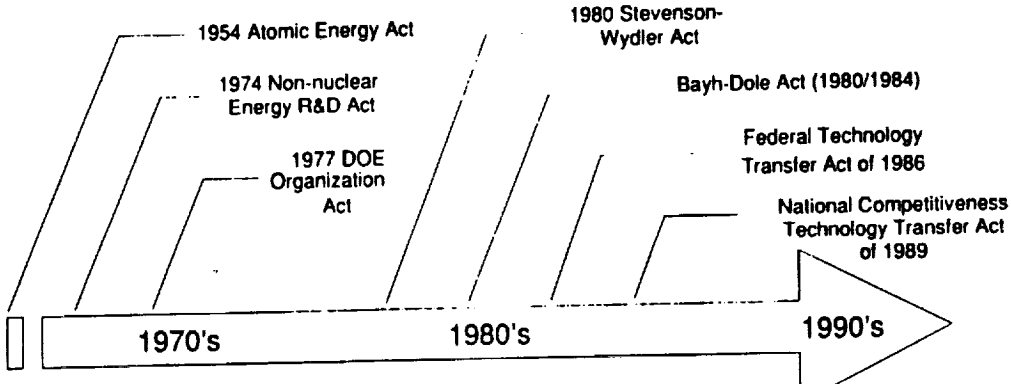
Different Technology Transfer Missions for Different Segments of DOE

Program Office	OMB Budget Category	Tech Transfer Role
Energy Research	Research	Worldwide Access to Scientific Knowledge & Spin-Offs
Fossil Energy Conservation Nuclear Energy	Energy Supply	Direct Transfer of Applied Research
Defense	Defense Activities	Applied Technology Know-How to Critical Defense Industries

DOE's Technology Transfer Menu

- Cooperative Research and Development Agreements (CRADAs)
- DOE Cooperative Agreements
- Cost-Shared Contracts/Subcontracts
- R&D Consortia
- Personnel Exchange Programs
- User Facility Agreements
- Work for Others Agreements
- Licensing
- Data Exchange Agreements
- Joint Ventures

Policy and Legislative Context



National Priorities:

"Oil Crisis" + "Competitiveness Crisis" + "Environmental Crisis"

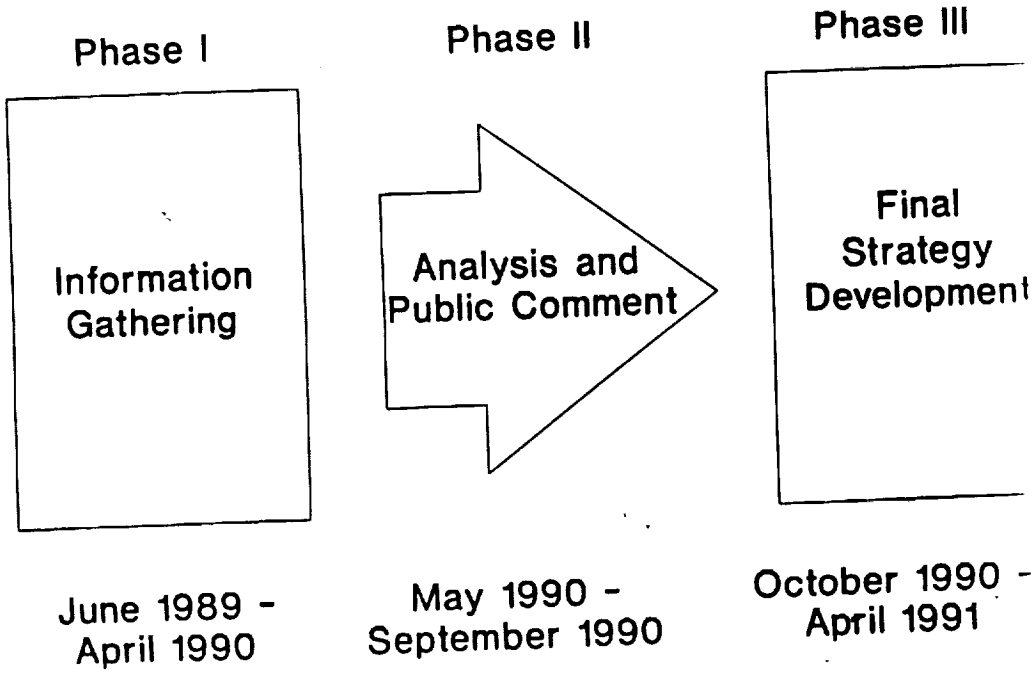
DOE Policy Emphasis:

Applied Energy Research → Long-Term High Risk R&D + Lab Technology Transfer → An Integrated Approach

THE EVOLUTION OF DOE'S ENHANCED TECHNOLOGY TRANSFER PROGRAM

- DOE impacted very little by early legislation
- 1989 Developments
  -NCTTA
  -National Energy Strategy process started
- 1990
  -NES action completed--integrated approach
  -Technology Transfer Project Group Policy--Management--R&D Programs
- Technology Transfer Field Task Force
  -200 individuals (DOE, other agencies, contractors)
  -Initial model CRADA/Guidelines released
- January 1991
  -Secretary of Energy Notice
  -Major orientation initiative
- February 1991
  -NES issued as Administration Policy

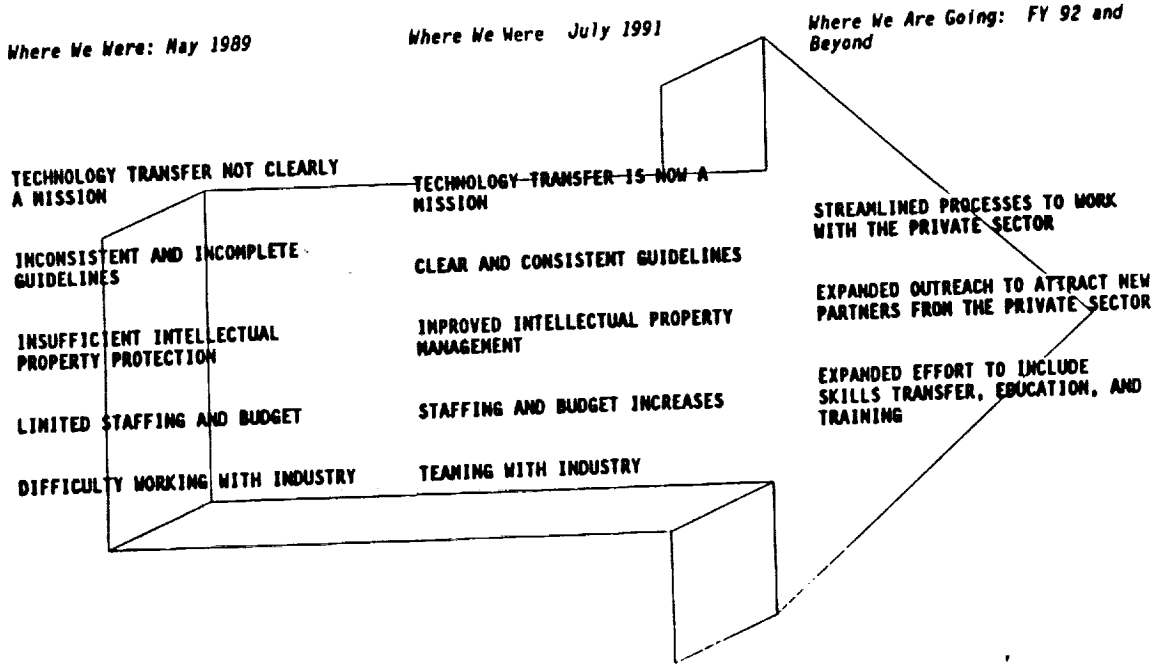
The NES Development Process



Phase I: Information Gathering

- Public Hearing Record
  - 15 Public Hearings (379 Witnesses)
  - Special Conference on Science Education
  - Technology Transfer Round Table
- Written Public Input
  - Over 1000 Written Submissions (12,000 Pages)
  - 20 Federal and State Government Plans
  - 27 Public Plans
- DOE Sector Profiles (13)
  - 6 Supply Sectors
  - 4 End Use Sectors
  - 3 Cross-Cutting Sectors
- Laboratory White Papers (5)
  - Energy Efficiency: How Far Can We Go?
  - The Potential for Renewable Energy
  - Energy and Climate Change
  - The Technology Transfer Process
  - Energy Technology for Developing Countries
- Over 400 Additional Sources

SETTING THE COURSE
TECHNOLOGY TRANSFER



Executive Commitment

Secretary Watkins:

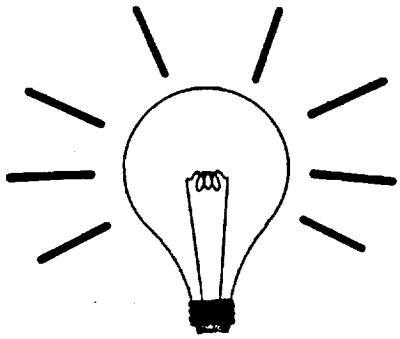
"Over the course of the National Energy Strategy process, I have become convinced that effectively and efficiently transferring the results of Federal research and development to the private sector is one of the keys to success for achieving our energy, environment, and economic goals."

Report to Congress
on NCTTA Implementation
May 29, 1990

"Because U.S. competitiveness in international markets is seriously challenged, I feel that it is important to move as quickly as possible to expand and enhance DOE's cooperative work with industry."

Secretary of Energy
Notice on Technology Transfer
January 23, 1991

Philosophy of Operations: The DOE Vision



A DOE and Industry Partnership

for the Future to

Enhance U.S. Competitiveness

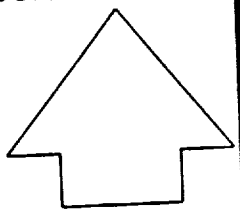
Philosophy of Operations:
Objective

Enhance US competitiveness by increasing the transfer of Federally funded technologies and knowledge to the private sector for commercial application.

Goal 1:

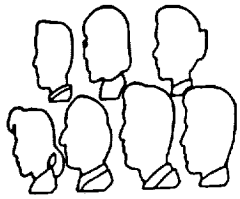
Increase U.S.-based industry participation in DOE's programs.

Increase collaboration and cost-sharing



Promote intellectual property protection

Ensure fairness of opportunity

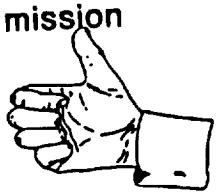


Seek to maximize U.S. economic benefits

Goal 2:

Increase the level of DOE and contractor activity in technology transfer.

Establish technology transfer as a mission



Integrate with other DOE missions

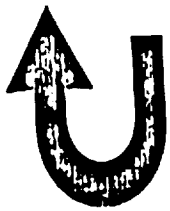
Provide incentives to reward success

Provide sustained funding and resources

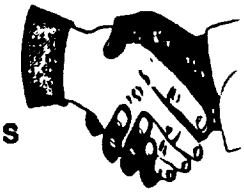
Goal 3:

Accelerate the process of transferring technology and knowledge

Increase use of advisory groups for R&D



Improve "outreach" to potential partners



Eliminate administrative barriers

Build a better network for making "matches"

Philosophy of Operations
Roles and Responsibilities

- DOE Secretarial and Staff Offices
  - To establish broad policies and guidelines
  - To delegate implementation to line organizations
  - To establish standards of success
  - To provide required financial and human resources
  - To coordinate policies with other agencies/Congress and ensure conformance with policies and legislation

- Program Offices
  - To evaluate each program's technology transfer role
  - To develop supporting strategies and plans
  - To request the required resources to implement
  - To conduct targeted outreach initiatives
  - To evaluate progress and effectiveness of programs and ensure conformance to missions and legislation

Philosophy of Operations
Roles and Responsibilities

- Field Offices
  - -To support directions and policies of HQ/Programs
  - -To assist in formulating policies and procedures
  - -To negotiate contracts with M&O contractors
  - -To review and approve lab/industry agreements
  - -To appraise and report on technology transfer efforts

- Laboratory Director or Equivalent
  - -To transfer technology using CRADAs, other means
  - -To provide input on DOE policies and procedures
  - -To comply with agreed upon policies and procedures
  - -To define lab procedures to implement the mission
  - -To evaluate and report on progress
  - -To demonstrate fiscal and mission responsibility

DOE Management Philosophy: A Partnership Approach

There are two keys to success:

Improve the Speed:

- More decentralization
- More flexibility
- Simpler procedures

Improve Predictability:

- Maintain DOE oversight
- More consistency
- Clearer policies

Achieving the appropriate balance requires a partnership approach between DOE, its facilities, and the private sector.

DOE ACCOMPLISHMENTS

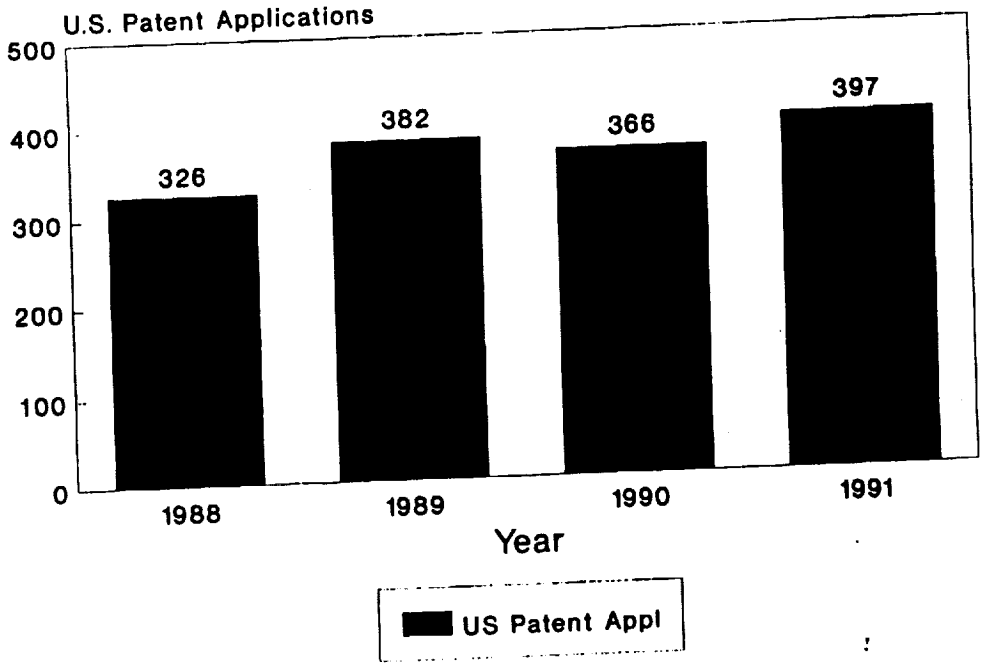
- SEN-30-91 "Setting the Course for Technology Transfer at the Department of Energy" (January, 23, 1991)
- Orientation Seminar January 24, 1991
- 25 Labs "On Board" with contract clause
- CRADA Tracking System established
- Contract clause developed for production facilities
- SEN-33-91: STA/Director of Technology Utilization
- CRADA process workshop updated tools and guidelines
- Letter of Agreement with the Department of Commerce

- The Department of Energy signed a Memorandum of Understanding with the National Center for Manufacturing Sciences
- A model CRADA tailored to the needs of the computer industry was developed through discussion with the Computer Systems Policy Project which consists of 12 computer manufacturers.
- The President announced a cooperative agreement with the Advanced Battery Consortia
- A significant DOE laboratory presence at the NASA's Technology 2001
- A significant DOE laboratory presence at GM's Garage show
- DOE, DOC, DOT and NASA initiate the National Technology Initiative (NTI) with President Bush's support
- The President attended the signing of a CRADA in Oak Ridge, TN.

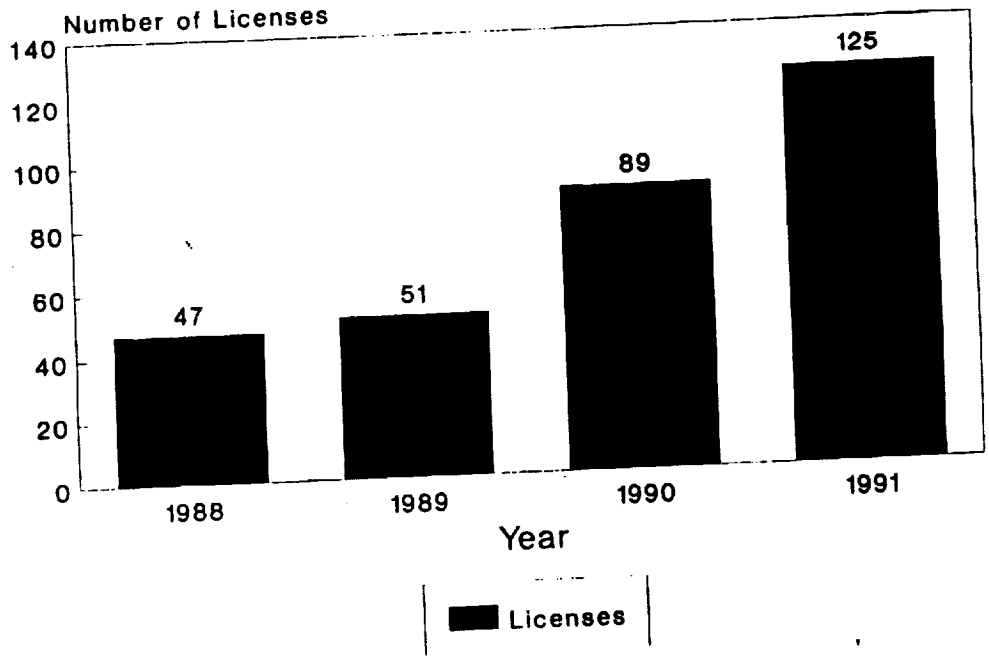
IMPLEMENTING MECHANISMS

- **Management and Operating (M&O) Contracts**
- **Policies and Procedures**
- **Training, Handbook, and Other Tools**
- **Regulations (only when necessary)**

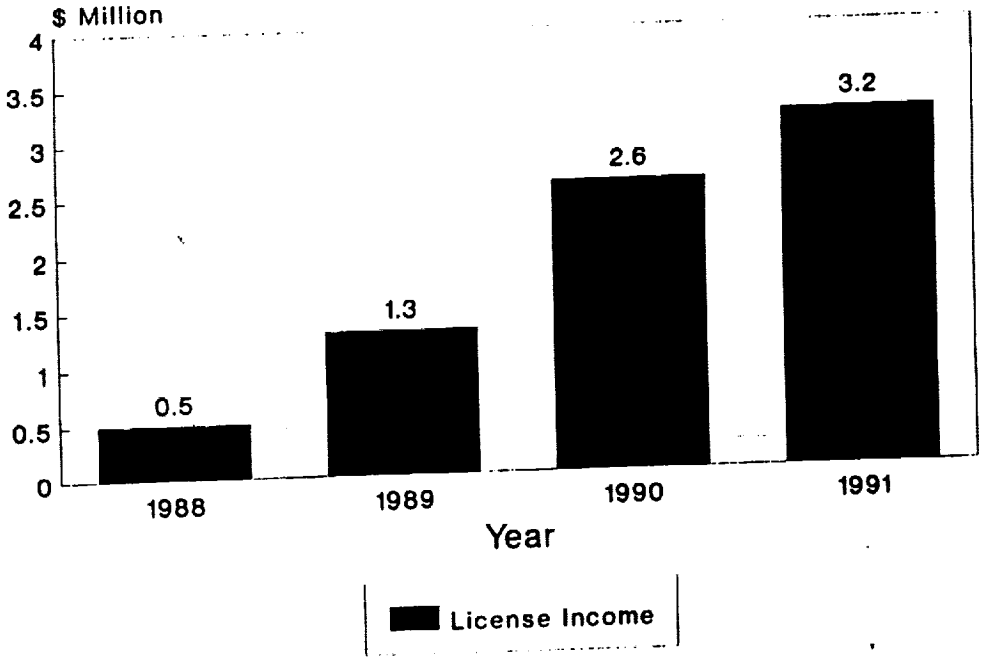
U.S. Patent Applications



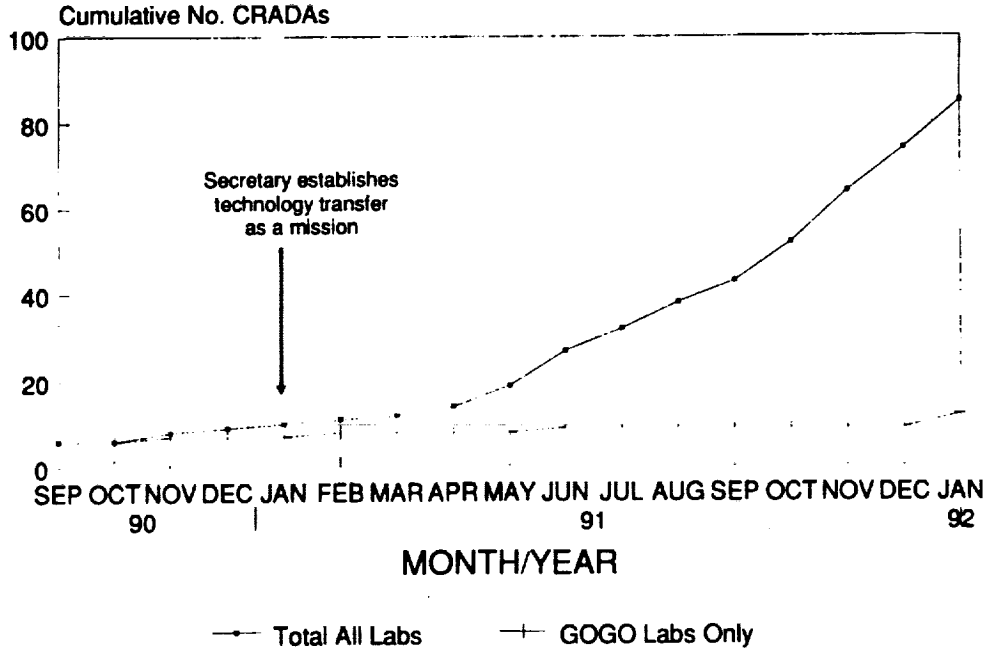
Licenses Awarded



License Income

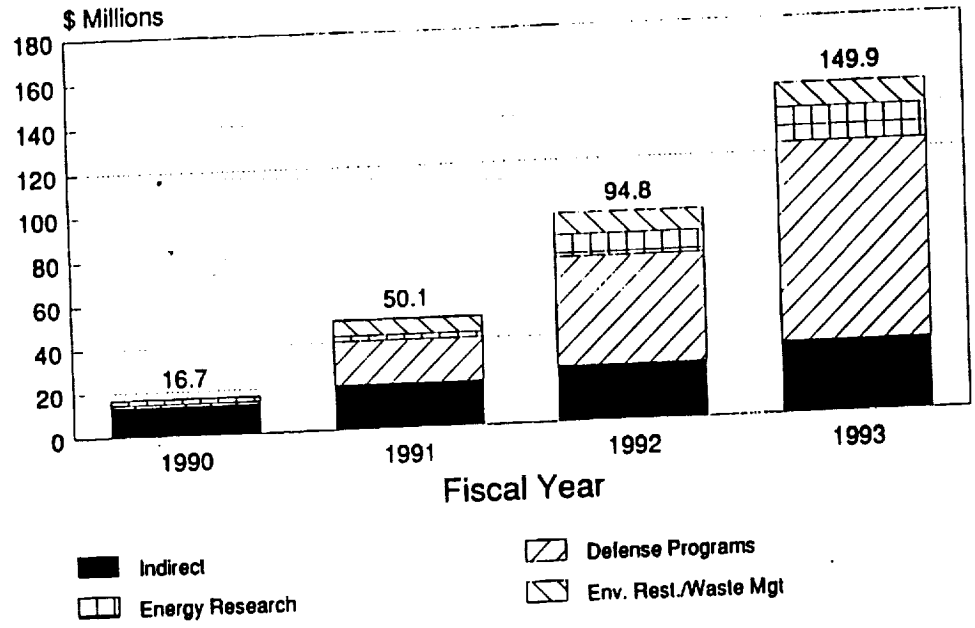


DOE CRADA Approval



Prepared from OSTI monthly CRADA report

DOE Technology Transfer Budget



PLANS AND PROBLEMS

- MAJOR UNRESOLVED DOE ISSUES
- NATIONAL TECHNOLOGY INITIATIVE
- INTERAGENCY ISSUES

Current Focus:
Get the Management System in Place

- Complete Negotiations of Contract Clauses
- Issue Revised Model CRADA and Guidelines
- Adjust Technology Transfer Resources
- Issue Updated Handbook to DOE Community
- Develop Outreach Plan
- Improve HQ/Field/Lab Communications

Major Policy Issues

- Intellectual Property Protection
- Conflict of Interest
- Fairness of Opportunity
- Foreign Participation

International Technology Transfer

- Not a Separate DOE focus
- Often a Program Office Focus
- Not Usually Mechanism Dependent
- Not Discouraged/Often Encouraged
- Not Unusual/Becoming an Integral Part of Some Efforts

Foreign Participation: Achieving a Proper Balance

Promoting Foreign Participation

- Advancing basic science
  - High energy physics
  - Human genome research
- Accessing foreign markets
- Accessing foreign capital
- Accessing foreign technology
- Encouraging competition

Promoting Domestic Participation

- Advancing U.S. industry
  - Developing new products
  - Developing new processes
- Creating new jobs
- Increasing tax revenues
- Promoting national security
- Improving the trade balance

NATIONAL TECHNOLOGY INITIATIVE

- The NTI will include a series of regional meetings designed to stimulate U.S. economic competitiveness by informing industry of opportunities they may not know exist, followed by agency specifics

- President Bush said, "Look to the longterm, and we've got work to do...steps we can take right now to guarantee progress and prosperity into the next American Century. We get there by investing in the technologies of tomorrow, with federal support of R&D at record levels.

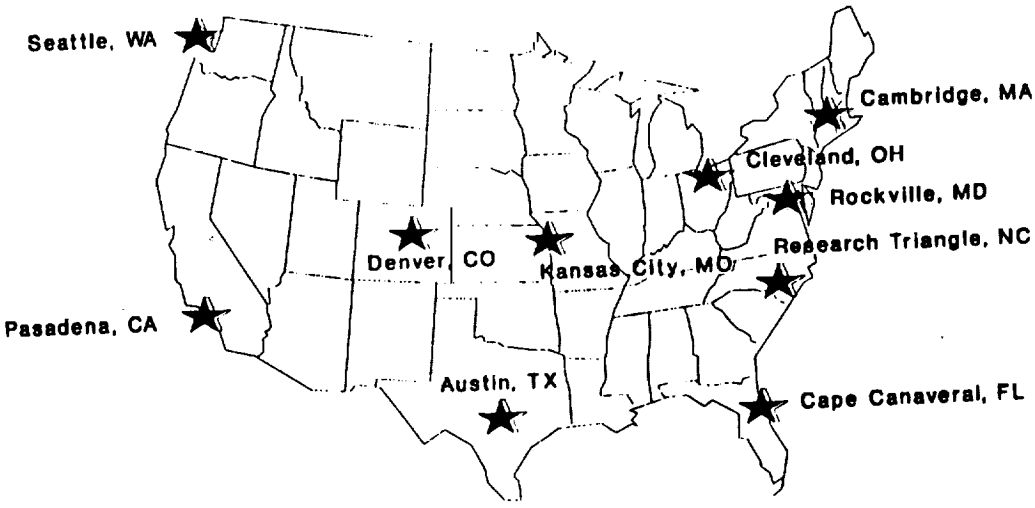
- Senior policy makers from various federal agencies as well as experts from business and academia will provide participants with practical suggestions on making better use of our Nation's technological strengths

- This new initiative will identify ways in which government-industry-university cooperation can help the private sector commercialize technology and become more competitive in global markets

- These meetings will give laboratory personnel an opportunity meet with industry and share an unprecedented dialogue

- There are currently plans for at least 10 of these dialouge meetings through mid-July

Proposed Locations for the National Technology Initiative



EXECUTIVE BRANCH TECHNOLOGY TRANSFER

- President's Council on Competitiveness: Working Group on Commercialization of Government Technology
- Federal Coordinating Council on Science, Engineering, and Technology (FCCSET): Working Group on Federal Laboratory Technology Transfer
  -Conflict of Interest
  -Freedom of Information Act
  -Intellectual Property
- International:
  -General Agreements on Tariffs and Trade
  -Other Trade Agreements
  -NSA
  -NAFTA

So now what?

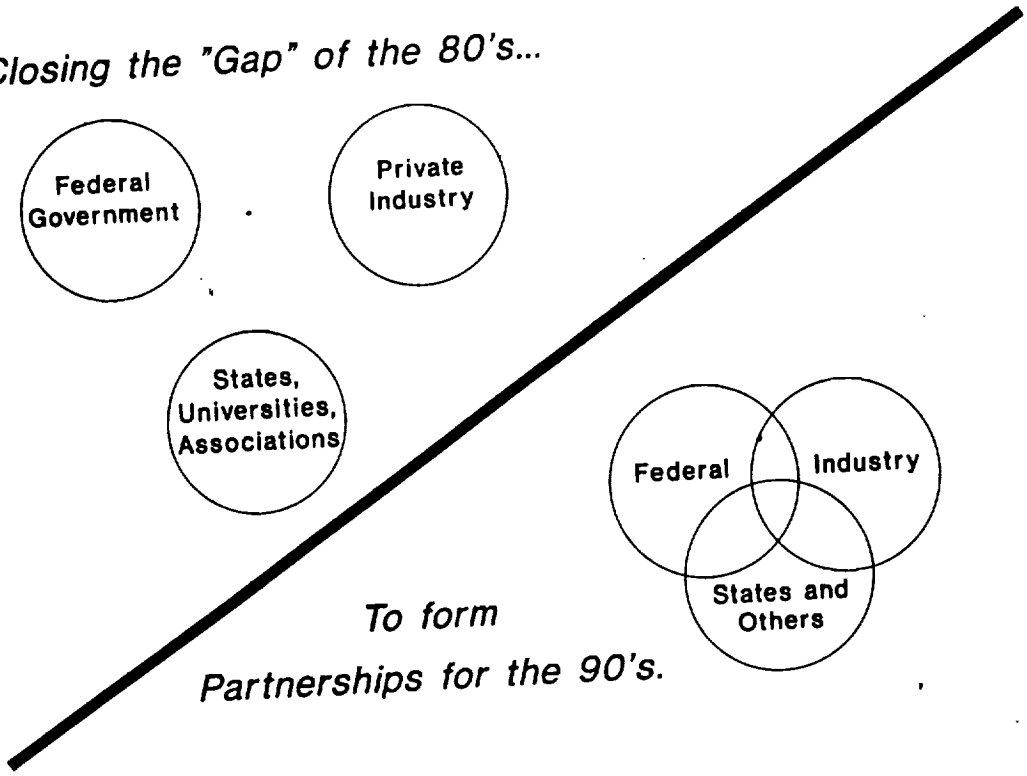
Building for the Future

- In the last year, there has been a significant increase in intra-departmental communication and interaction.
- DOE and its laboratories have worked together to look beyond their differences and begin to find workable solutions to common problems.
- We have established a foundation of increased interaction and communication with industry, States, universities, other agencies, and Congress.
- The changes are fragile and will need to be nurtured over the coming months and years.
- We need to work together to develop and sustain an environment of teamwork, open communication and trust among all participants in the process.

Only in this way, can we learn from our combined experiences and continue to improve technology transfer in response to changing national circumstances.

The Technology Transfer Challenge:

Closing the "Gap" of the 80's...



To form

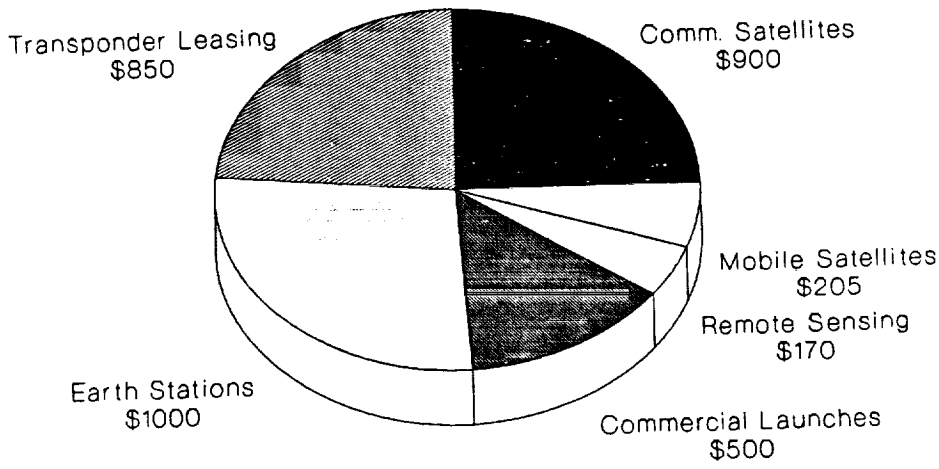
Partnerships for the 90's.

DR. SCOTT PACE

DEPARTMENT OF COMMERCE

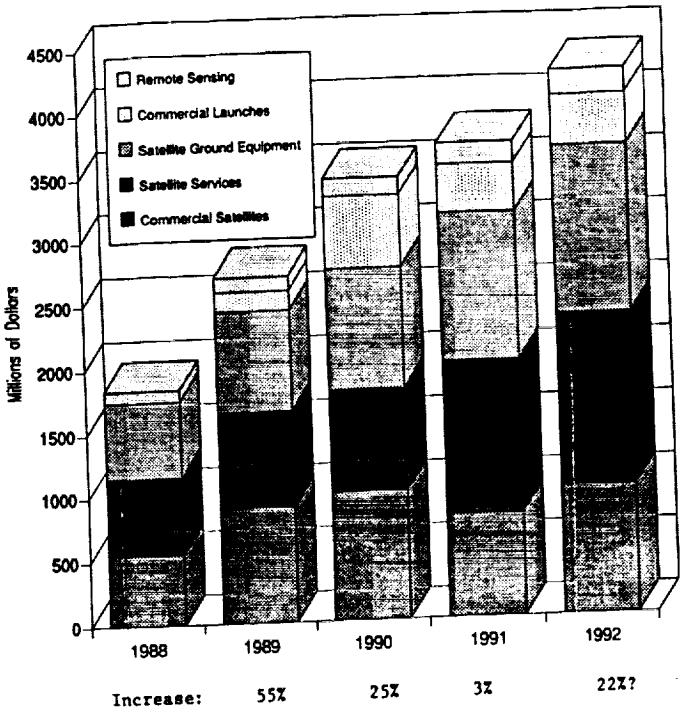
U.S. Space Commerce, 1991

($ millions)

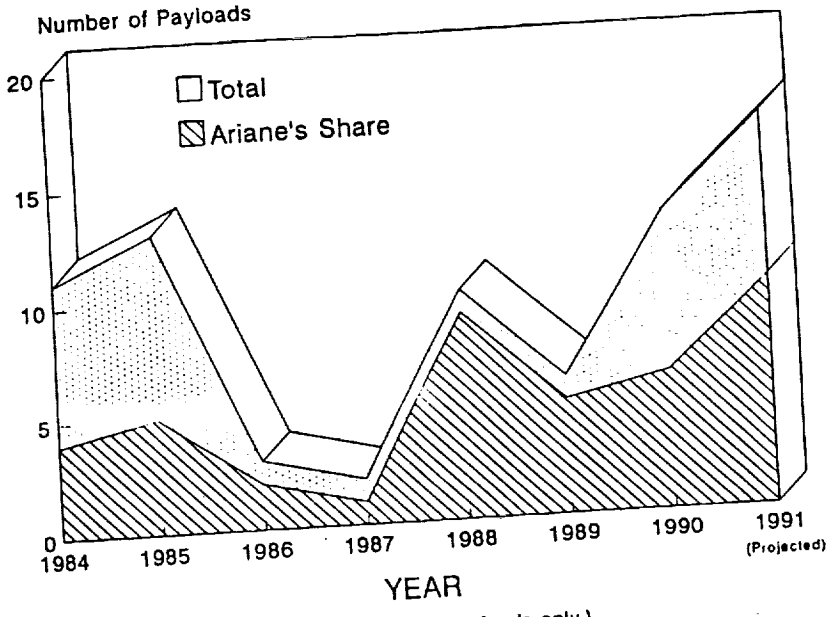


Total Revenue: $3.6 billion

U.S. Commercial Space Revenues

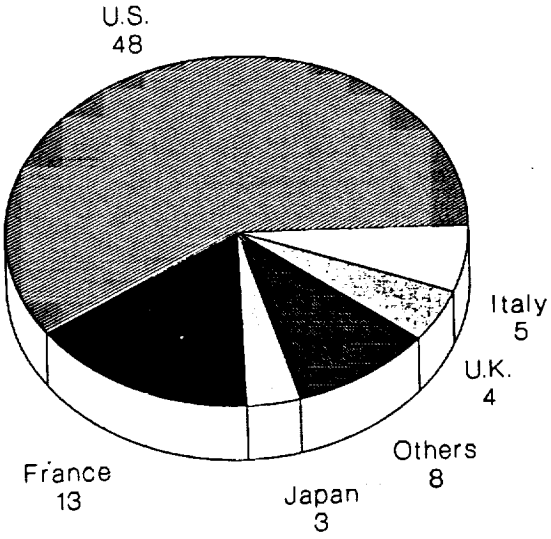


The US Share of Commercial Payloads has Decreased as Ariane's Share has Grown



(Chart includes non-captive commercial payloads only.)

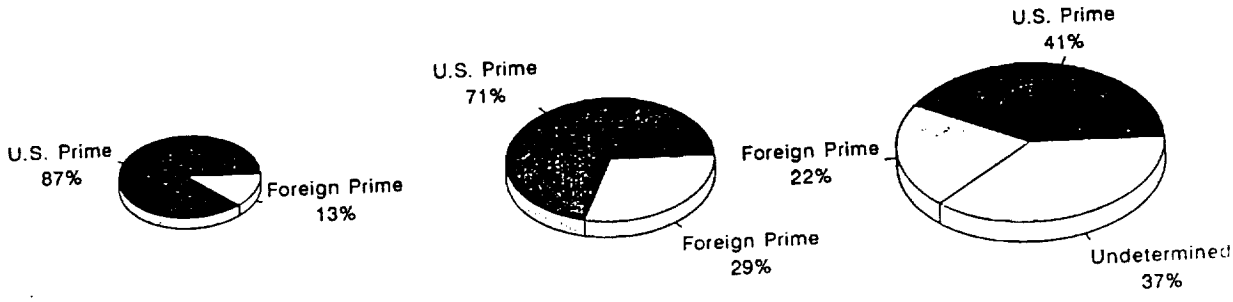
World Communications Satellite Orders
Orders Scheduled for Delivery, 1991-1995
Large capacity geostationary satellites



Total: 81

Office of Telecommunications

The U.S. Share of Prime Contracts for the Construction of Commercial Communications Satellites is Decreasing



Emerging Markets

Lightsats
- lower capital and insurance requirements
- many potential applications

Remote sensing data
- value-added markets, new technologies

Navigation
- ground equipment and services, GPS-driven

Mobile communication
- land, air, and sea

Fusion of all of the above in consumer products

Office of Space Commerce

Space Activities at the Commerce Department

NOAA
- weather satellites, Landsat

National Telecommunications and Information Agency
- World Administrative Radio Conference '92
- international telecommunications policy

International Trade Administration
- monitors space trade agreements, competitions

Bureau of Export Administration
- export licensing for dual-use technologies

Office of Space Commerce

OSC Mission Description

- Serve as the principle unit for the coordination of space-related issues, programs and initiatives within the Department;
- Represent the Department in the development of U.S. policies and in negotiations with foreign countries to promote free and fair trade internationally in the area of space commerce;
- Act as industry's advocate within the Executive Branch to ensure that the Government meets its space-related requirements;
- Promote private sector investment in space by collecting, analyzing and disseminating information on space markets, and conduct seminars to increase awareness of commercial space opportunities;
- Assist commercial space companies in their efforts to do business with the U.S. government;
- Ensure that the U.S. Government does not engage in space-related activities that preclude or deter the commercial sector, and to promote the export of space-related goods and services.

Office of Space Commerce

Key Drivers for Commercial Space

- **Future Government Commitment to New Space Activities**
  - Space Station, new launch vehicle, NASP, SSTO
  - Mission to Planet Earth and the Moon-Mars program
  - Strategic Defense Initiative
- **U.S. Response to Increased International Competition**
  - Federal and State governments
  - private industry
  - dual-use technology proliferation, the industrial base, and national security
- **Role of Commercial Space Activities**
  - Source of Major New Markets
  - Spur to other Industries
  - A Means of Making Public Activities more Efficient

Office of Space Commerce

General DOC Space Policy Themes

- **Stress importance of Economic Competitiveness**
  - embed concern for competitiveness and quality in USG programs
  - keep in mind during international cooperation discussions
  - open overseas markets, deter unfair trade practices
- **Use Commercial Goods and Services**
  - promote technology transfers between government and industry
  - discourage government competition with private industry
  - use anchor tenancy, service-buys, etc.
  - avoid direct subsidies, use market forces
- **Ensure Commercial Concerns are part of National Decisions**
  - seek and use industry input
  - national security, technology policy, and foreign policy

Office of Space Commerce

Themes in Specific Discussions

- **Export Controls**
  - consistency with multilateral agreements
  - predictability and timeliness in application
- **Trade Negotiations**
  - limitations on government supports, especially direct subsidies
  - consistent enforcement
  - reciprocity
- **Government Procurement**
  - encourage commercial-like practices in contracts
  - discourage government competition with industry
  - focus on operational requirements, not specifications
- **Economic Policy**
  - lower barriers to entry, foster competition
  - minimize government interventions in specific companies and industries

Office of Space Commerce

Getting Information on Space Business

Department of Commerce sources

- Office of Business Liaison
- Economic and Statistics Administration
- Economic Bulletin Board / CD-ROM
- Japan Information Center
- Trade Information Center (800) USA-TRADE
- U.S. Foreign and Commercial Service
- Bureau of Export Administration
- National Technical Information Service

Other Government sources

- Securities and Exchange Commission
- Federal Communications Commission
- State Department Defense Trade Controls
- U.S. Trade Representative's "Foreign Trade Barriers"

Office of Space Commerce

What does U.S. Space Commerce Need to Successfully Compete?

Strategic Vision encompassing:

- Superior technology - lower costs, higher quality
- Fair trade environment with minimal distortions
- Patient, affordable capital
- Removal of Government-created impediments
- Effective cooperation between Federal and State governments, academia, and industry

Office of Space Commerce

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM
A Workshop to Address Issues and Strategies

McLean, Virginia
March 17, 1992

White House/OSTP Perspective

Donald Pryor
Senior Policy Analyst
Office of Science and Technology Policy

Thank you for the opportunity to come talk with you and to learn something from this workshop.

Let me begin by pointing out that what I have to say may not be the view from the White House. Technology transfer -- making the most of our federal R&D investment -- has been and continues to be a great concern to Dr. Bromley as the President's Science Advisor and the head of OSTP. But, in fact, within the Executive Office of the President, on any issue related to civil space technology transfer, you would expect to find considerable interest and slightly different perspectives from OSTP, from OMB, and from the National Space Council. The Council of Economic Advisors, the National Security Council, the Office of Federal Procurement Policy, and the U.S. Trade Representative's Office may also have interests in a particular issue.

I would like to talk to you about two aspects of OSTP's work -- first, efforts to state the overarching technology policy in which technology transfer plays an important part and, second, efforts to coordinate federal R&D programs in several technology areas through the FCCSET process.

The U.S. Technology Policy statement, released by OSTP in September of 1990, for the first time brought together the many facets of technology policy, described what they are, and showed how they fit into a comprehensive framework. It is not a perfect document nor a final statement. It is largely retrospective rather than prospective and, of necessity, it has to describe very complex subjects in broad-brush terms. But it has provided a valuable baseline for continuing dialogue, both inside and outside the government.

A very basic goal of our technology policy is to ensure a quality workforce that is educated, trained and flexible in adapting to technological and competitive change. Without getting ahead of myself, let me mention that the FCCSET crosscut on Math and Science Education takes on this challenge and that of making U.S. students first in the world in math and science by the year 2000. This program proposes to coordinate

education activities, reform the education system, retrain educators, set standards, and pursue new initiatives.

In addition to improving our workforce and preserving our traditional strength in discovery through research, policies must allow and encourage technology to be the engine of economic growth. Policies must encourage investment — reduce the capital gains tax, and make the research and experimentation tax credit permanent. Policies must foster commercialization. This is where technology transfer plays a prominent role. Special emphasis on small business is warranted since 70% of new jobs in the last decade were created in companies with less than 500 employees. Small high-tech firms also innovate more efficiently than larger firms producing 2 to 4 times the number of products and patents per R&D dollar. Policies must mitigate under-investment due to market failure. Much of research produces benefits which are not appropriable and, consequently, the private sector lacks the incentive to invest adequately. Generic, pre-competitive stages of technology development are similar. The government, therefore, has a role to play as do industry consortia. Finally, policies must reward and safeguard innovation. Intellectual property rights must be protected.

The budget proposes to spend $579 million on technology transfer activities in FY 1993. Included are cooperative activities (such as direct technical assistance, personnel exchanges, cooperative R&D agreements), commercialization activities (that is, patenting and licensing of innovations, identifying markets and users, payments of royalties and cash awards to inventors), and information exchange (seminars and dissemination of papers, articles, and reports).

Effective technology transfer must be considerably broader than just that set of activities that have transfer as their primary goal. Aerospace, in many respects, has been a leader in this area. NASA has long had a close link with the aviation industry; it has had authority for cooperative R&D agreements since the Space Act; and the charge to "encourage" commercial space activities was made by the President in 1989. Some of these efforts have worked well and others have not. Today there is a sense of need to improve the effectiveness of technology transfer activities, a desire to evaluate the success of present mechanisms and to consider experiments with new approaches.

With that said about the overarching technology policy, let me spend a few minutes talking to you about the coordination of some technology programs within the federal government through FCCSET. FCCSET is the Federal Coordinating Council for Science, Engineering, and Technology. It is a cabinet-level body headed by Dr. Bromley. Under it are seven interagency committees. This past year, five of these committees, working closely with OSTP and OMB, undertook cross-cutting analyses in specific areas of science and technology and developed coordinated national strategies with long-term goals and priorities. The FCCSET process is a truly cooperative mechanism, resting on the combined efforts of the agencies involved with oversight by the full council. Agencies can mesh their own activities within a broad national strategy while simultaneously increasing their abilities to carry out the critical missions that they have been assigned. It is a positive-sum endeavor in which all gain.

Three of these cross-cutting initiatives are technology-oriented — High Performance Computing and Communications, Advanced Materials and Processing, and Biotechnology. A fourth, Global Climate Change, particularly from NASA's perspective, is technology-intensive. The fifth is Math and Science Education which I have mentioned previously.

The High Performance Computing and Communications initiative is designed to sustain and extend U.S. leadership in all advanced areas of computing and networking. This program is now in its second year and involves nine federal agencies. For FY 1992 Congress appropriated a 27% increase for the program and, for FY 1993, the budget proposes a further increase of 23% to a total of $803 million.

During the past year, major new high performance systems have been delivered, including scalable, massively parallel systems that go much of the way to the five-year goal, established just last year, of creating a teraop system. New software systems have been developed or adapted for such high performance systems. Traffic on the already operational digital communications network has doubled, as has the number of interconnected local and regional networks. And many more people have been trained to develop and use these emerging systems. These four components of the initiative – hardware, software, networks, and training – are poised for further major advances.

Advanced Materials and Processing is a one of two new Presidential Initiatives developed from FCCSET cross-cuts this year. It is a coordinated effort to exploit opportunities in materials R&D to meet national goals and extend U.S. leadership in the materials area. Ten federal agencies are involved. The budget proposes $1.8 billion for the program in FY 1993, an increase of over 10% from the levels of FY 1992.

The promise is that of materials with properties and performance tailored for specific applications that can be fabricated by cost-effective and environmentally sound processes. The Advanced Materials and Processing Program will focus additional resources on R&D in synthesis and processing, in particular, in areas that encompass the creation of new materials and processes, applied R&D to transfer the laboratory achievement to pilot plants, and process integration with design and manufacturing requirements. Special attention will be given to the interfaces between universities, government laboratories, and industry.

The second of the new Presidential Initiatives is that in Biotechnology research. This program will maintain the U.S. lead in health-related biotechnology research and will expand research in other critical areas, such as agriculture, energy, and the environment, where applications of biotechnology research promise significant breakthroughs. The National Institutes of Health has been the largest supporter of biotechnology research, but eleven other agencies are also involved in this initiative. The FY 1993 budget proposes that funding for biotechnology research increase by 7% to over $4 billion.

The U.S. Global Change Research Program is the world-leading program seeking to

monitor, understand, and model the entire Earth system to support the needs of policy makers for sound information on the science and economics of global change. The FY 1993 budget proposes a total of $1.37 billion for the eleven agencies involved in this program, an increase of 24%. Major objectives include integration of new scientific discoveries into the Global Circulation Models used to predict world climate changes and improvement of these models so that they can begin to give accurate regional predictions. Technology elements, particularly NASA's Mission to Planet Earth, are major components of the program.

Finally, I want to mention that FCCSET has recently approved Advanced Manufacturing as a candidate initiative for the FY 1994 budget. The focus is on lean and flexible manufacturing techniques. The FY 1993 federal budget includes $321 million for civilian manufacturing R&D and over $1 billion when defense manufacturing R&D is included. The goal of the FCCSET crosscut is to improve the effectiveness of this investment through coordination and enhancement.

These programs aim at accomplishing the missions of the agencies involved. In some cases an agency's mission may be to encourage the development and use of socially-desirable technology by the nation, whereas in other cases technology may be needed to meet internal needs. In all cases, however, the desirability and need of involving the private sector, of technology transfer, is recognized.

Thank you for your time. I hope that this has provided some insight into OSTP's activities.

Technology Policy

- Encourage Investment
  - Capital Gains Differential
  - R&E Tax Credit
- Foster Commercialization
  - Technology Transfer
  - Small Business Programs
- Mitigate Under-Investment
  - Industry - Gov't Consortia
  - Generic Technologies
- Reward and Safeguard Innovation

Table 6–4. THE BUDGET PROPOSES A 23 PERCENT INCREASE FOR ALL ASPECTS OF HIGH PERFORMANCE COMPUTING

(Dollar amounts in millions)

Description	Budget Authority			
	1992 Enacted	1993 Proposed	Dollar Change: 1992 to 1993	Percent Change: 1992 to 1993
Program Components				
High Performance Computing Systems	152	178	+26	+17%
Advanced Software Technology and Algorithms	278	346	+68	+24%
National Research and Education Network	92	123	+30	+33%
Basic Research and Human Resources	132	156	+24	+18%
Agency				
Defense (DARPA)	232	275	+43	+18%
National Science Foundation	201	262	+61	+30%
Energy	92	109	+17	+18%
National Aeronautics and Space Administration	71	89	+18	+25%
Health and Human Services	41	45	+4	+8%
National Oceanic and Atmospheric Administration	10	11	+1	+10%
Environmental Protection Agency	5	8	+3	+60%
National Institute of Standards and Technology	2	4	+2	+95%
Total, All agencies	655	803	+148	+23%

Table 6–5. THE BUDGET PROPOSES A 10 PERCENT INCREASE FOR A NEW INITIATIVE IN ADVANCED MATERIALS AND PROCESSING

(Dollar amounts in millions)

Description	Budget Authority			
	1992 Enacted	1993 Proposed	Dollar Change: 1992 to 1993	Percent Change: 1992 to 1993
Program Component				
Synthesis and Processing	683	748	+65	+9%
Theory, Modeling and Simulation	224	253	+30	+13%
Materials Characterization	474	503	+29	+6%
Education/Human Resources	21	27	+6	+27%
National User Facilities	257	291	+33	+13%
Agency				
Energy	603	678	+75	+12%
Defense	449	432	-17	-4%
National Science Foundation	266	319	+53	+20%
National Aeronautics and Space Administration	125	154	+29	+23%
Health and Human Services	77	82	+5	+7%
Agriculture	57	66	+9	+16%
Commerce	46	48	+2	+4%
Interior	25	24	-1	-4%
Transportation	9	16	+7	+76%
Environmental Protection Agency	3	4	+1	+33%
Total, All agencies	1,659	1,821	+163	+10%

Table 6–6. THE BUDGET PROPOSES A 7 PERCENT INCREASE IN FEDERAL INVESTMENTS IN BIOTECHNOLOGY

(Dollar amounts in millions)

Description	Budget Authority			
	1992 Enacted	1993 Proposed	Dollar Change: 1992 to 1993	Percent Change: 1992 to 1993
Program Component				
Research Areas	3,759	4,030	+271	+7%
Agriculture	191	208	+17	+9%
Energy	80	107	+27	+33%
Environment	69	83	+14	+20%
Manufacturing/Bioprocessing	99	124	+25	+25%
Health	1,594	1,680	+86	+5%
General/Foundations	1,418	1,500	+82	+6%
Social Impact Research	9	9	—	—
Infrastructure	301	320	+19	+6%
Agency				
Health and Human Services	2,963	3,125	+162	+6%
(National Institutes of Health)	(2,801)	(2,944)	(+143)	(+5%)
Agriculture	179	168	-11	-9%
National Science Foundation	174	206	+32	+18%
Energy	182	243	+61	+34%
Veterans Affairs	86	90	+4	+5%
Defense	81	87	+6	+7%
National Aeronautics and Space Administration	37	45	+8	+22%
Agency for International Development	21	31	+10	+48%
Environmental Protection Agency	16	18	+2	+13%
Commerce	13	13	—	—
Interior	5	5	—	—
Justice	2	2	—	—
Total, All agencies	3,759	4,030	+271	+7%

Table 6–12. U.S. GLOBAL CHANGE RESEARCH PROGRAM

(Dollar amounts in millions)

Description	Budget Authority			
	1992 Enacted	1993 Proposed	Dollar Change: 1992 to 1993	Percent Change: 1992 to 1993
Program Component				
Ground-based	733	915	+182	+25%
Oceans	62	85	+23	+37%
Modeling	33	51	+18	+55%
Land Processes	80	92	+12	+15%
Human Dimensions	7	9	+2	+29%
Economics	4	13	+9	+225%
Other	547	665	+118	+22%
Space-based	378	457	+80	+21%
Earth Observing System (NASA)	188	308	+120	+64%
Other Programs (NASA)	190	139	-51	-26%
Energy	—	10	+10	—
Agency				
National Aeronautics and Space Administration	756	891	+135	+18%
National Science Foundation	109	163	+54	+50%
Energy	77	113	+36	+47%
Commerce (NOAA)	47	78	+31	+66%
Agriculture	44	48	+3	+7%
Interior	40	36	-4	-9%
Environmental Protection Agency	24	26	+2	+8%
Smithsonian	6	11	+4	+68%
Defense	6	7	+1	+5%
Health and Human Services	1	1	—	—
Tennessee Valley Authority	*	*	—	—
Total	1,110	1,372	+262	+24%

*Less than $500 thousand.

MILLBURN PRESENTATION TO THE
NASA INTEGRATED TECHNOLOGY PI
WORKSHOP - MARCH 17-18, 1992

NATIONAL CENTER FOR ADVANCED TECHNOLOGIES

THE NCAT PROCESS

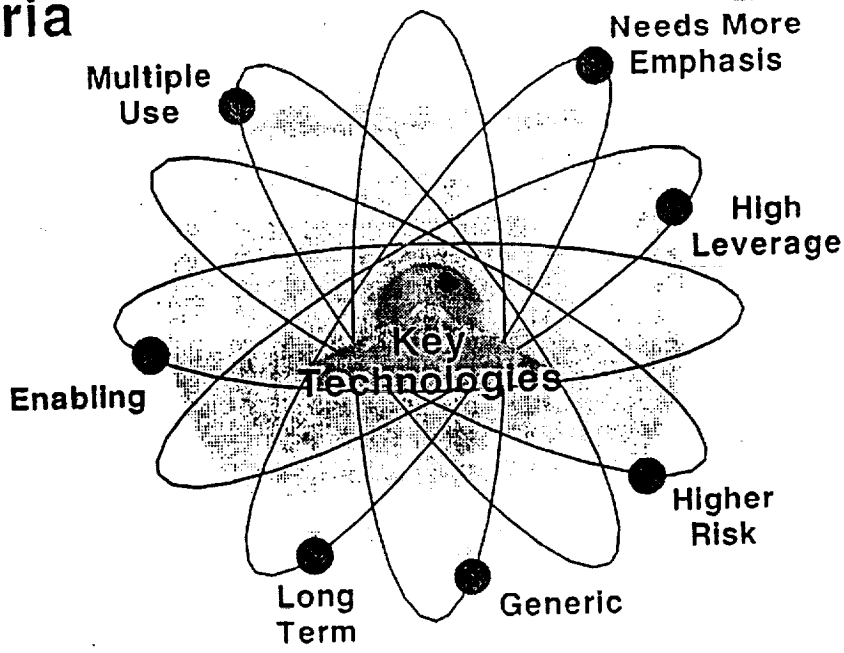
PLANS ➡ DEMOS ➡ PRODUCTS

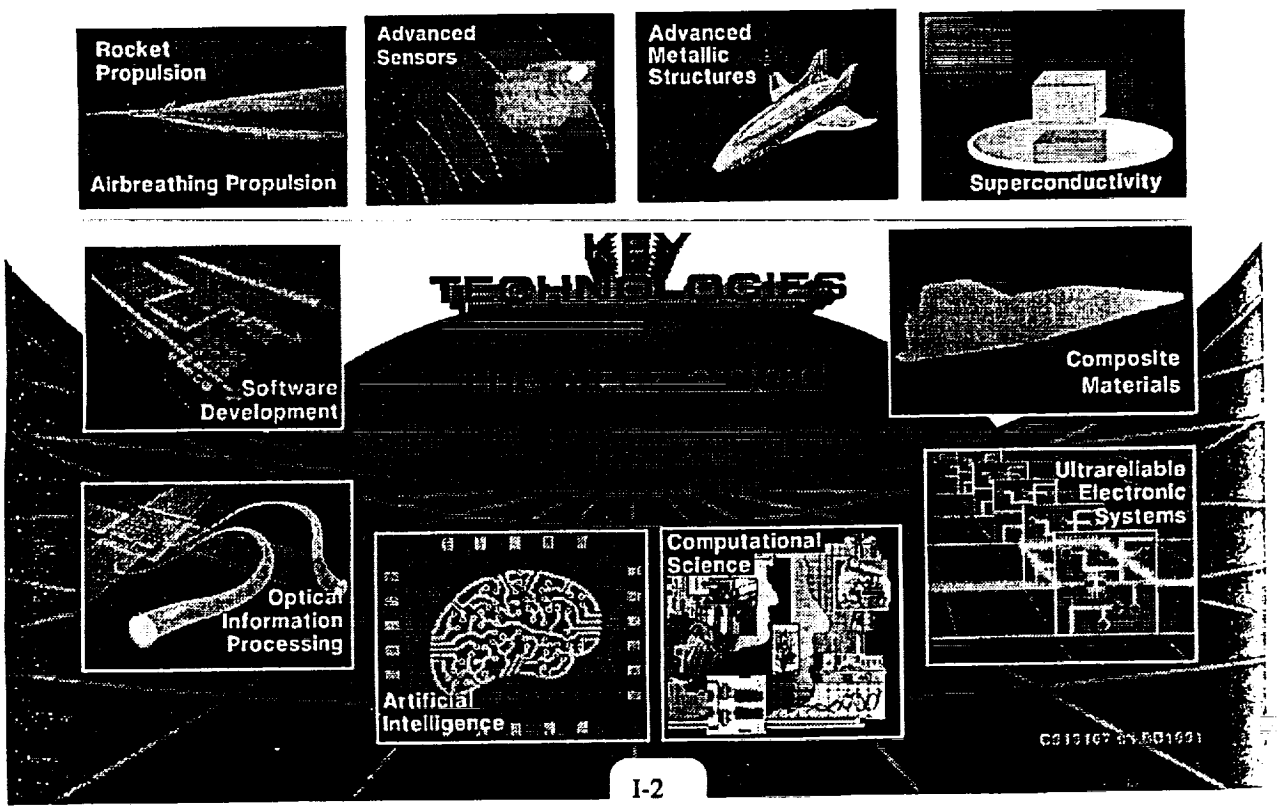
NCAT HISTORY

- CHARTERED JANUARY 1989 AS 501(c)(3) NON-PROFIT EDUCATIONAL AND RESEARCH FOUNDATION FUNDED BY SPECIAL AIA ASSESSMENT FOR 3 YEARS
- GOAL IS TO COORDINATE AND INTEGRATE "KEY TECHNOLOGIES" WITH OTHER ACTIVITIES AND CREATE NATIONAL TECHNOLOGY STRATEGIC PLANS
- NCAT DEVELOPED CONSENSUS PLANS; SPONSORED TECHNOLOGY SYMPOSIA; HELD SEPTEMBER '91 POLICY SYMPOSIUM
- NCAT IS WORKING ON TECHNOLOGY DEMONSTRATIONS TO BRING TECHNOLOGIES TO PRODUCTS FASTER

Technologies Selection Criteria

KEY TECHNOLOGIES FOR THE YEAR 2000



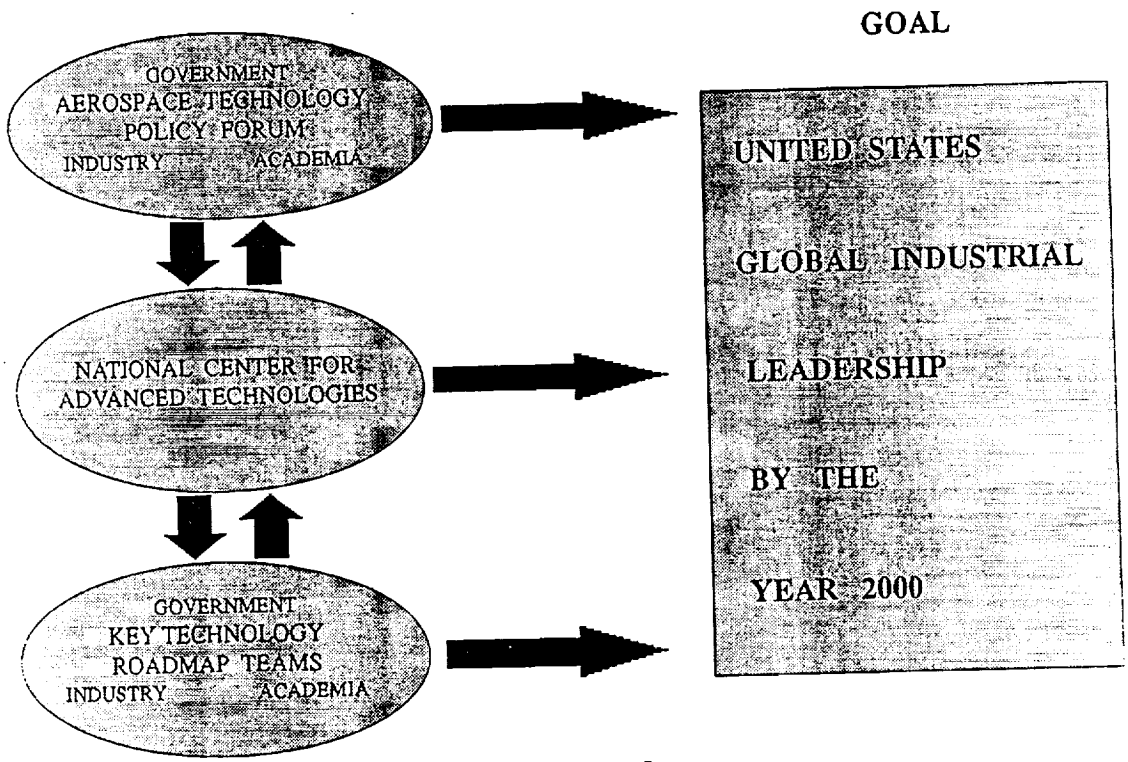


STRATEGIC PLAN STATUS

TECHNOLOGY	ROADMAP	DRAFT PLAN	COMPLETED PLAN
Rocket Propulsion	X	X	X
Advanced Sensors	X	X	
Advanced Composites	X	X	X
Ultra-Reliable Electronic Systems	X	X	X
Airbreathing Propulsion	X	X	X
Optical Information Processing	X		
Software Development	X	Working w/ DoD SoftwareTechnology Strat.	
Artificial Intelligence	X	X	
Superconductivity	X	Discontinued, applications not emerging	
Computational Science	X		
Advanced Metallic Structures			

As of 3/92

IMPLEMENTATION FRAMEWORK



FORUM COMPOSITION

GOVERNMENT:

OSTP
NASA
OSD (DDR&E)
NSF
DOE
AIR FORCE
NAVY
ARMY
DOC
DARPA

INDUSTRY:

AIA
NCAT
LOCKHEED
WESTINGHOUSE
ALCOA

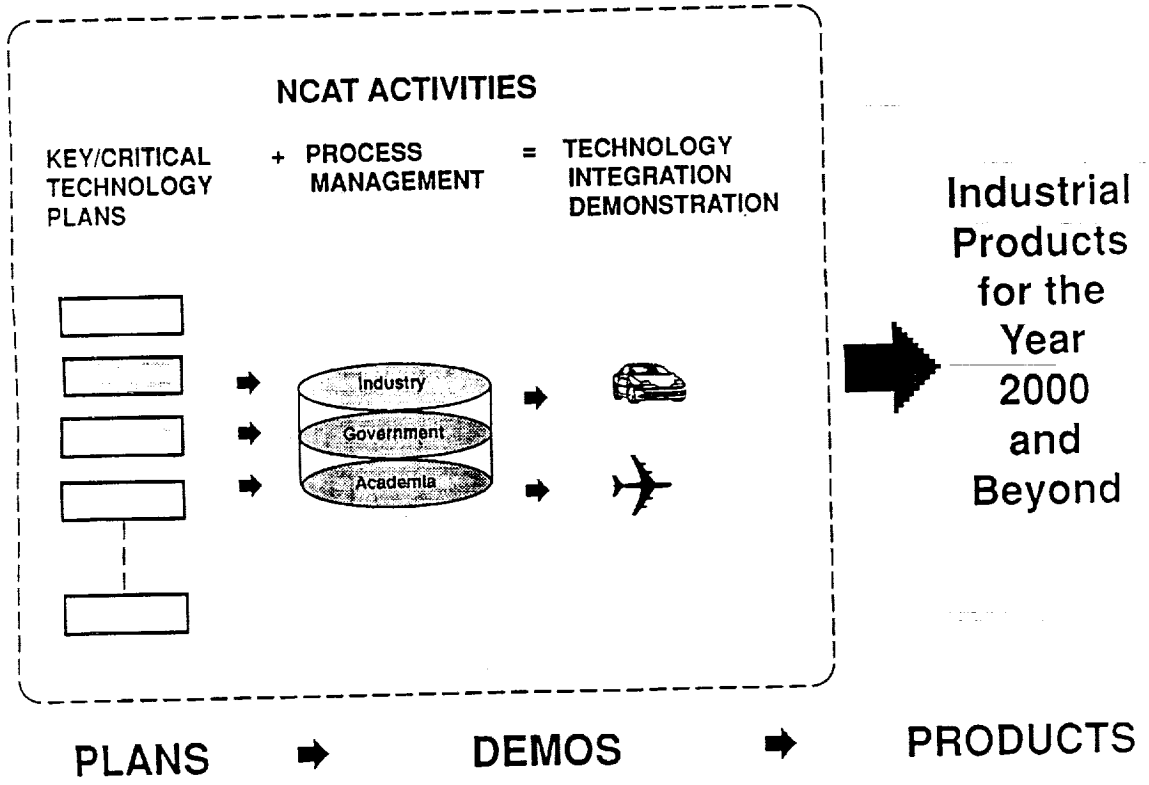
UNIVERSITIES:

UNIVERSITY OF WASHINGTON
STANFORD UNIVERSITY
TEXAS A& M
PENN STATE UNIVERSITY
GEORGIA TECH

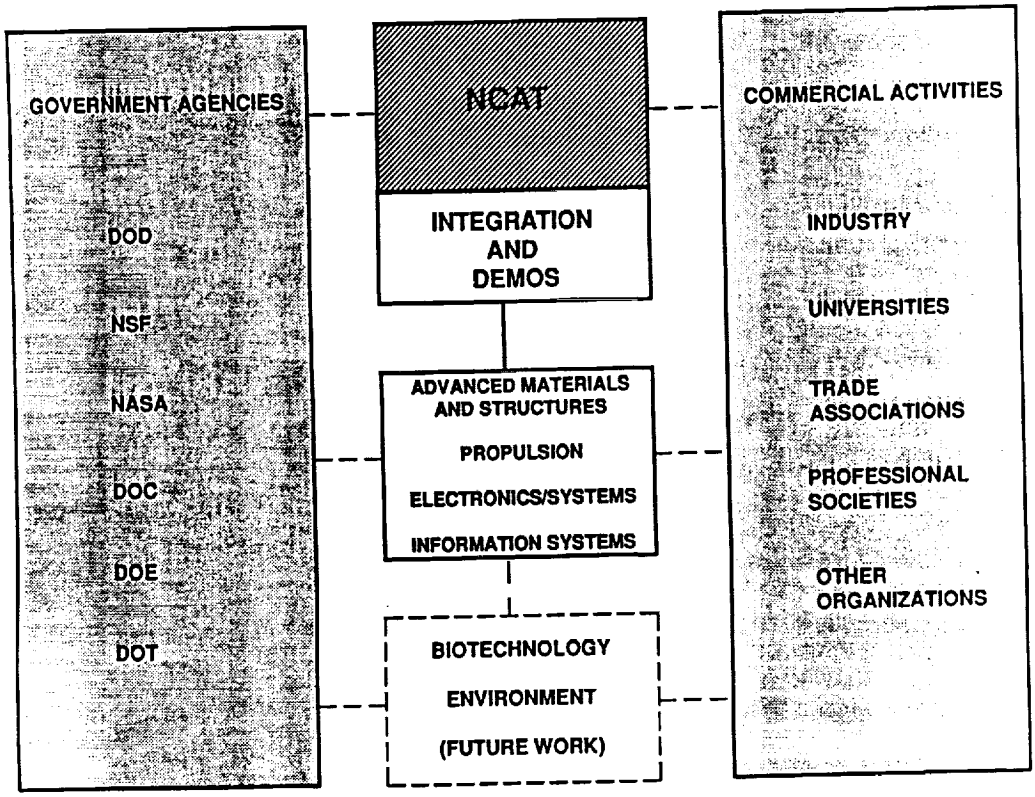
CONGRESSIONAL ADVISORS:

SENATE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY
HOUSE APPROPRIATIONS DEFENSE SUBCOMMITTEE
HOUSE SCIENCE, SPACE AND TECHNOLOGY COMMITTEE

NCAT ROLE AS INTEGRATOR



GOVERNMENT/ INDUSTRY COORDINATION



IDENTIFICATION AND SELECTION PROCESS FOR DEMOS

- REVIEWED NCAT KEY TECHNOLOGY DEVELOPMENT PLANS
- REVIEWED SUGGESTIONS FROM NCAT KEY TECHNOLOGY TEAMS
- REQUESTED INPUT AT AIA/NCAT KEY TECHNOLOGY SYMPOSIUM IN SEPTEMBER 1991
- CONVENED INDUSTRY/GOVERNMENT/UNIVERSITY MEETING IN JANUARY 1992 TO DEVELOP SELECTION CRITERIA
- CONVENED NCAT WORKSHOP IN FEBRUARY 1992 TO DEVELOP A LIST OF POTENTIAL DEMONSTRATIONS ACCORDING TO JANUARY 1992 CRITERIA
- KEY TECHNOLOGIES COMMITTEE DEVELOPED A "SHORT LIST" OF POTENTIAL DEMOS
- ITERATIVE AND CONTINUING PROCESS

CRITERIA FOR DEMOS

1. Broad Applicability
2. High Leverage
3. Existence of Need for Product Lines
4. Enhanced Emphasis on Product and Processes
5. Life - Cycle Cost, Performance, Quality, Cycle Time
6. Timely Product Generation
7. Wealth/Job Generation
8. Process Scalability
9. Large Market for Product
10. Involve Potential U.S. Suppliers
11. Represents a Leap Frog Capability
12. Environmentally Beneficial

CRITERIA FOR NON-SELECTION

DUPLICATIVE OF OTHER PROGRAMS

NOT GENERIC

EXISTING EFFORT OLD TECHNOLOGY

CANNOT DEFINE WITH SUFFICIENT SPECIFICITY

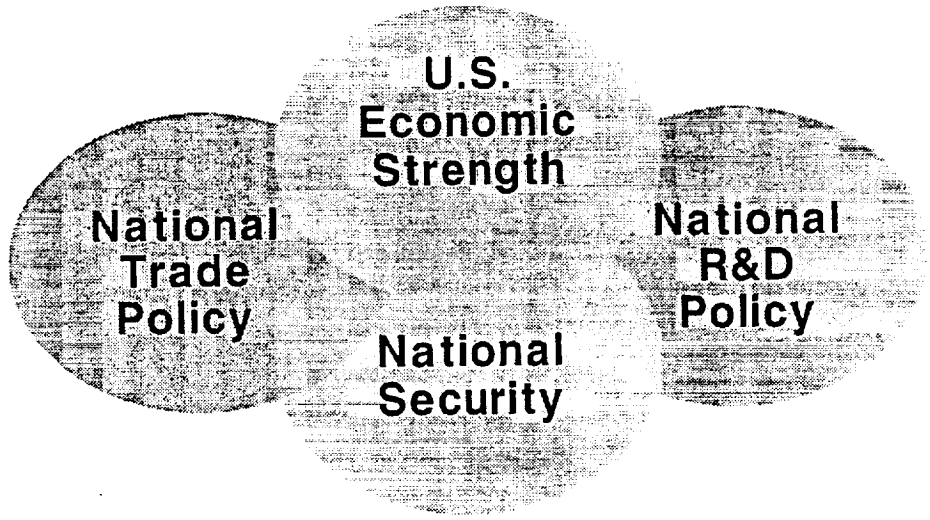
NOT BOUND IN SCOPE/DEPTH

FUTURE ACTIONS

- NCAT/Key Technologies Committee needs to arrive at a consensus regarding a better "Short List".
- DEMO writeups need to be completed on all the "Short List" candidates to verify their candidacy.
- AIA T&O Council in April '92 will consider candidate programs.
- The results should be briefed to the Policy Forum in June '92 for advice on implementation steps/teaming partners/funding sources for the candidate DEMO programs.
- Government/Industry/University teams should be assigned, based on advice from the Policy Forum on candidates, to refine agreed to DEMO programs.
- Planning sessions should be held for each candidate program, its candidate partner set, and potential sponsors to finalize program definition, define funding commitments, and start the DEMO process.

Forging a New National Consensus - International Competitiveness

KEY TECHNOLOGIES FOR THE YEAR 2000



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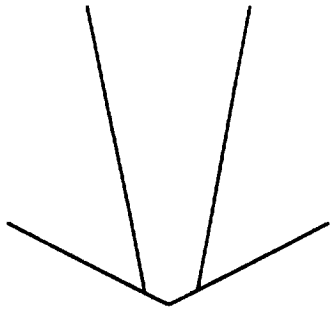
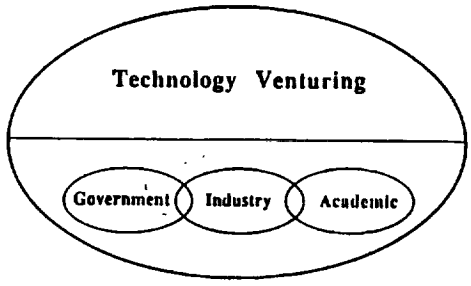
Technology Venturing



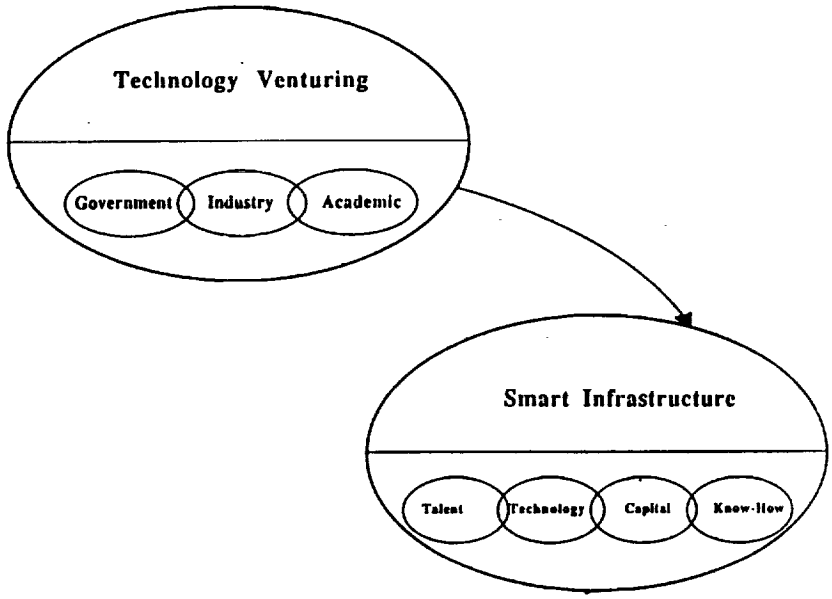
Technology Competitiveness and Economic Leadership

GEORGE KOZMETSKY

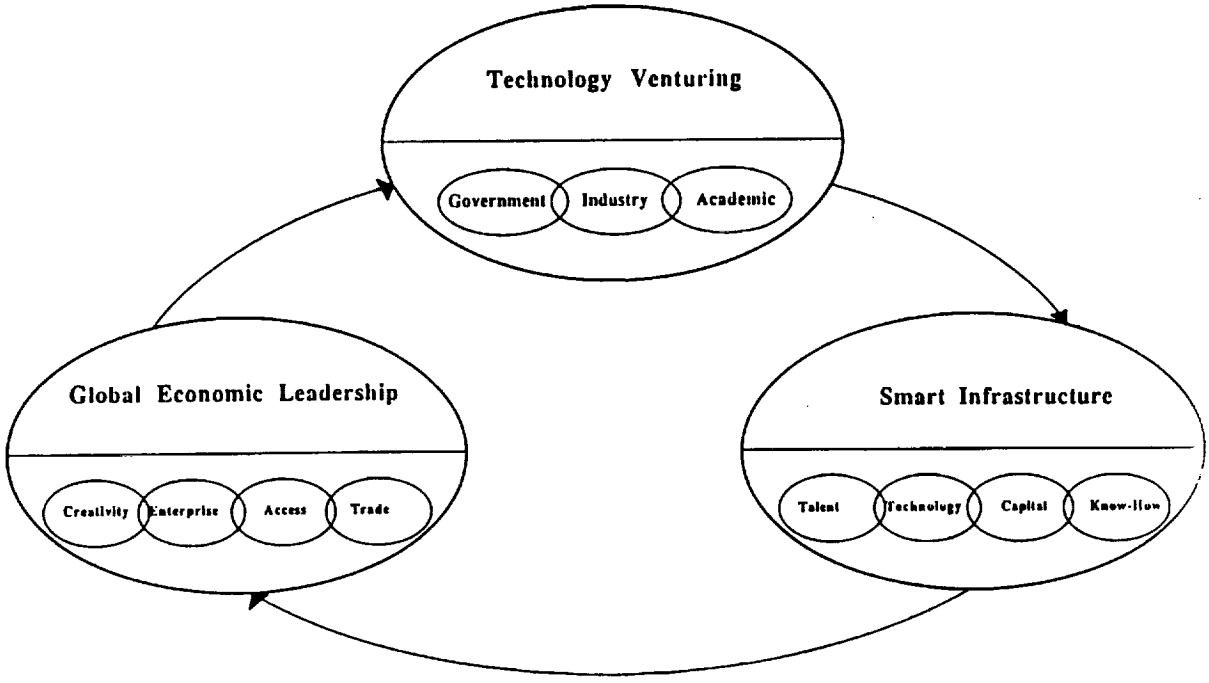
Technology Competitiveness and Economic Leadership

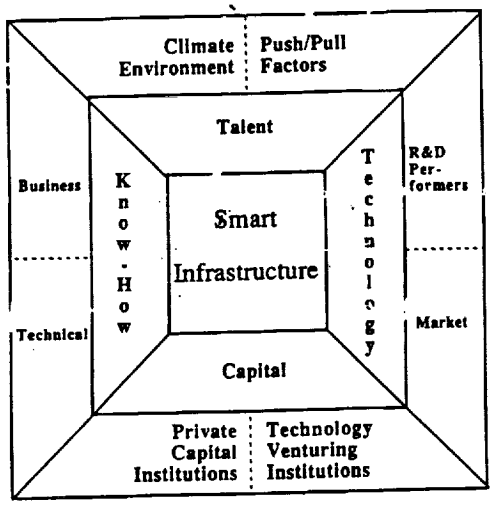


Technology Competitiveness and Economic Leadership

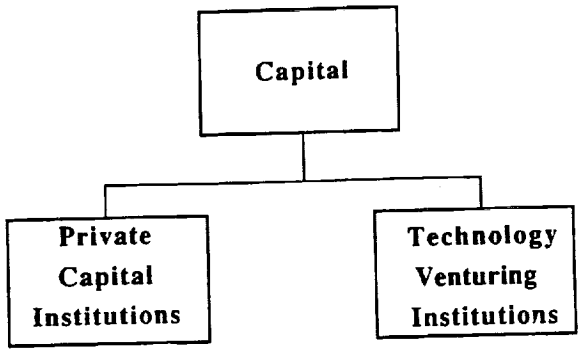


Technology Competitiveness and Economic Leadership

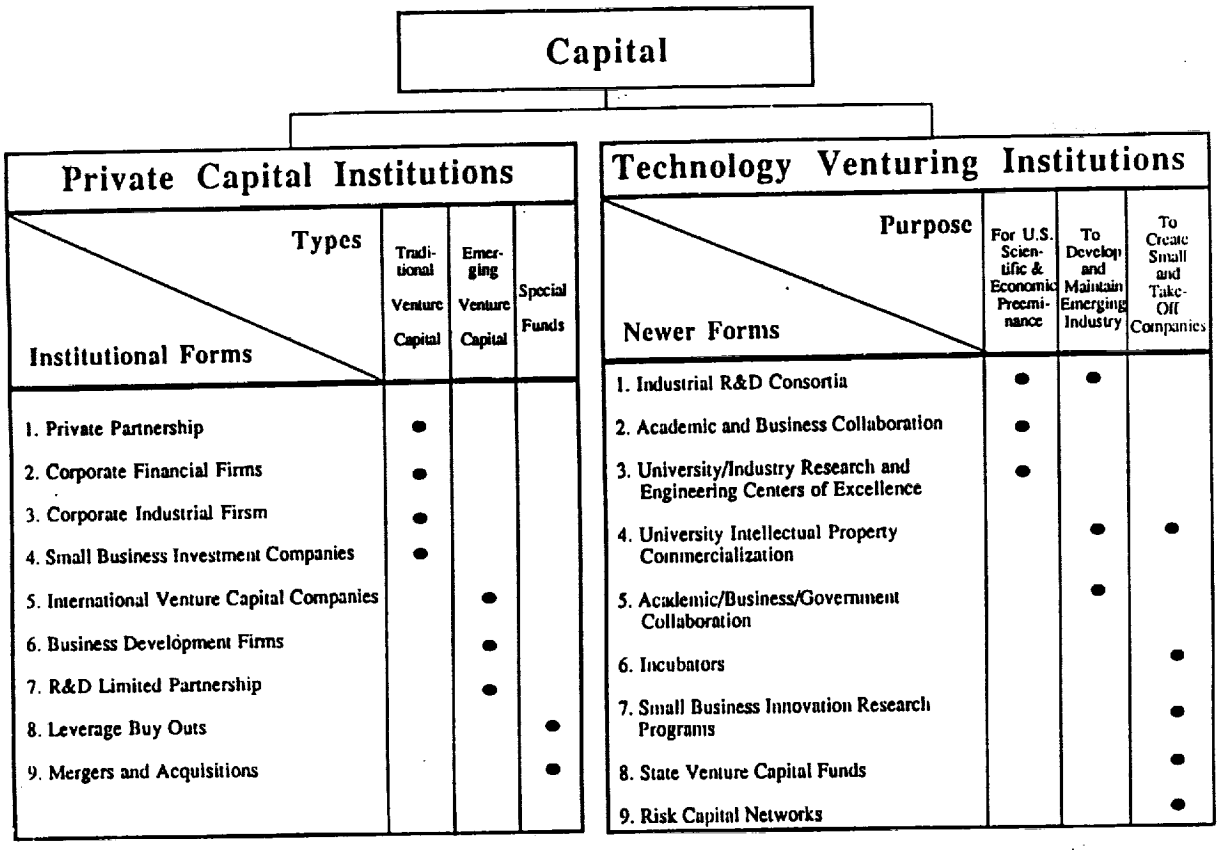




Financing Technology



Financing Technology



Private Capital Institutions: Drivers for Investments

1. **Require proprietary idea or invention**
2. **Expect a management team with business knowledge and experience**
3. **Build well-defined market niche**
4. **Demonstrate technical knowledge**
5. **Have early stage financing**

- **Emphasis is on profitability of an investment in short-term and shareholder values.**

Technology Venturing Institutions: Drivers for Investments

1. Invest in longer-term technology
2. Leverage "know-how"
3. Create a new type talent pool — technology management and entrepreneurship
4. Organize for collaborative entrepreneurship
5. Foster application-driven creativity

- Emphasis is on longer term technological investments, new market developments, and job creation.

Four Freedoms for Global Economic Leadership

- Creativity — to encourage innovation and new market formation
- Enterprise — to foster movement towards entrepreneurship
- Access — to allow people and organizations to move freely and easily with access to human, technological, and financial resources
- Trade — to build relationships that expand openness, lessen protection, and provide access to markets

Biographical History

John Preston is the Director of the Technology Licensing Office at the Massachusetts Institute of Technology. As Director, he manages the patenting and licensing of M.I.T., Lincoln Laboratory and Whitehead Institute inventions and software. He is a member of the Board of Directors of Molten Metal Technology, Environmental Bioscience and Ergo Computing, Inc. and is Chairman of the Technology Transfer Advisory Panel for the Strategic Defense Initiative of the United States Department of Defense.

Mr. Preston received his B.S. in Physics from the University of Wisconsin, and his M.B.A. from Northwestern University. His professional activities have been directed toward technology transfer, and specifically toward issues related to starting new high technology companies. He has founded, or assisted in, founding companies that are currently worth several hundred millions of dollars. In addition, about 40 companies, mostly spin-offs of M.I.T., have been started, in part, through the efforts of the Technology Licensing Office during his tenure.

THE ROLE OF THE UNIVERSITY LICENSING OFFICE IN TRANSFERRING INTELLECTUAL PROPERTY TO INDUSTRY

By: John T. Preston

INTRODUCTION

Universities in the United States have a significant impact on business through the transfer of technology. This transfer of technology takes various forms, including faculty communications (such as lecturing and the publication of research results), faculty consulting activities, and the direct transfer of technology through the licensing of patents, copyrights and other intellectual property to industry.

Well-trained students and professional staff who leave the university to work in industry probably represent the universities' greatest contribution to industry. These persons stimulate creativity and bring new ideas and perspectives to industry.

Perhaps the most dramatic form of technology transfer from the university setting is the creation of new businesses. A recent study of MIT spin-off companies revealed that its personnel and technology were involved in six hundred and thirty six companies located in Massachusetts. In 1988, these companies employed over 200,000 Massachusetts residents, with annual revenues of $39.7 billion. Had all of these revenues been within Massachusetts, it would have amounted to about one-third of the Commonwealth's entire economy. These data do not include the jobs or companies created when MIT license agreements result in the transfer of inventions, an additional benefit to the Commonwealth.

In a regional economy, it is interesting to note that for every high technology job created, four or five low tech jobs are also created, magnifying the benefit of these companies.

MIT spin-off companies include Digital Equipment, Raytheon, Analog Devices, Lotus Development and various other large businesses. Many of these companies achieve tremendous growth rates. Such companies are often characterized by the following: a large financial investment was secured from a well known source of capital; the company management consisted of a team of talented entrepreneurs with diverse and complementary backgrounds; and the companies owned a core technology with broad applicability, numerous products, and

considerable growth potential. These companies seem to play an enormous role in stimulating the economy and creating jobs.

Background

MIT is a large research university with about 1000 professors, 3000 research scientists, 4500 graduate students and 4000 undergraduate students. The annual research budget for the MIT campus is about $300 million; in addition, the research budget at the MIT Lincoln Laboratory is about $400 million, and another $20 million at the Whitehead Institute, an affiliated biotechnology research organization. Approximately 80% of the on-campus research is government- sponsored.

The Technology Licensing Office ("TLO") at MIT is responsible for maintaining and licensing the intellectual property that arises from the $700 million expended on research at MIT.

The TLO operations are managed by professionals from various complementary business and technical backgrounds, and several are experienced in building businesses from embryonic technologies. I have some familiarity with this process, having founded or assisted in the creation of nine companies (plus forty MIT spin-offs through the TLO). As an aside, four of these nine businesses have failed--the remaining five companies are doing well, with a cumulative net worth greater than $100 million.

The TLO has a staff of fourteen people including seven professional staff, referred to as Technology Licensing Officers. Each has a technology background and several years of business experience. In fact, two of the seven professionals are former presidents of companies and entrepreneurs. These licensing officers have considerable latitude in negotiating licenses.

The TLO receives one or two inventions (or new software packages) daily. These are analyzed by TLO staff to identify inventions with strong commercial potential--these inventions are protected through the patent or copyright process. The TLO business analysis for commercially viable inventions results in about three patent applications filed each week.

The primary function of the licensing officers is to license these patented inventions--at present, the TLO licenses about two inventions per week. It has been in existence since 1932--the record number of license agreements prior to its present format, between 1932 and 1985, was 15 agreements in one year. MIT, Stanford and the University of California will each conclude more than 70 licenses this year. I estimate that these three schools, and the University of Wisconsin, will account for more than half of all US university license agreements and royalty income during the next year.

Based on 1988 data, Stanford and Wisconsin lead all US universities in royalty income, at $9 million each. MIT royalties were $6.2 million, including new equity (valued at the time of last trade); the University of California was approximately $5.4 million. The top seven universities are listed below:

1988 Licensing Activity

University	# of Lic.	Royalty in $Millions
Stanford	75	9.2
Univ. Wisc.	<20	9.0
MIT	92	6.2*

Univ. Calif. System	65	5.4
Mich. State	<5	3.3
Univ. Fla.	8	3.0
Columbia	<10	2.2
All Govt Labs	?	4.4

* Includes equity

These numbers are somewhat misleading because of single large winning inventions, and a change in the ranking will probably occur as these big patents expire. For example, at Stanford University, $3.6 million of its $9.2 million came from the Cohen/Boyer gene splicing patent which is shared with the University of California. At the University of California (all campuses), $3 million of its $5.4 million in license revenues came from the licensing of genetically engineered strawberries developed at UC Davis. At Michigan State University, all of its $3.3 million came from the licensing of cis-Platin, a highly effective and valuable anti-cancer agent. At the University of Florida, its $3 million came from the Gatoraid Trademark license. At the University of Wisconsin, most of the $9 million came from Vitamin D licenses.

An overall perspective of the licensing business is that all US Universities entered into about four hundred licensing agreements in 1988, resulting in about $45 million in royalty income. This yield, on a research base of thirteen to fourteen billion dollars, reflects a rather dismal performance. These results confirm that universities do not use licensing agreements as a primary mechanism to transfer technology. U.S. government laboratories are generating less royalty ($4.4 million in 1988) from a larger research base. Furthermore, $3.7 million of this amount came from inventions licensed by the National Institutes of Health, leaving all other government labs at just $700,000.

This is changing, as reflected in the considerable growth in licensing over the last ten years by both universities and government labs. In 1981, for example, US government laboratories signed only ten license agreements. In 1990, the laboratories signed ninety-five agreements, a considerable increase. MIT's performance (70 - 100 agreements/year) indicates enormous potential for growth in government labs and other universities.

Goals of MIT Technology Licensing Office

There are 4 major goals of MIT's Technology Licensing Office. The first goal is to bring about the efficient transfer of technology as a way of making the technology available to the public. To accomplish this end, MIT is willing to give away technology when it is in society's best interest. As mentioned above, MIT receives $700 million annually in research funds from the US government--MIT thus views the public trust and its obligations to society as very important. With some technologies, the public is better served if it is released to the public domain, especially so if the technology has a very low cost threshold to reach the market. Software is sometimes a good example of a low threshold technology and, in fact, one of the leading software packages, X-Windows, is licensed for free by MIT.

By way of contrast, if biomedical products are placed into the public domain, they may never reach the marketplace--the cost and regulatory hurdles to bring a new pharmaceutical to market are simply too high. For example, if someone invented aspirin today and patent protection was not sought, a company could not recover its costs of developing the technology. The cost of proceeding through the FDA may approach as much as $150 million--no company would spend this money if a competitor could subsequently follow the initial company and make the product without having to incur the research and regulatory expense.

The second goal is to manage conflicts of interests that are inherent in faculty-industry interactions. MIT has created a set of policies to manage and prevent conflict. This goal has equal priority to the first goal. In other words, technology transfer should not occur unless potential conflict is managed.

The third goal for MIT's licensing office is to make money for the institution and the scientist. In addition to providing motivation royalty sharing gives positive feedback.

The fourth goal is to generate good will both internally with MIT staff and externally with the licensees

MIT's Technology Transfer Philosophy

The TLO has undergone a radical philosophical transition over the last 5 years, resulting in a number improvements in the technology transfer process.

The first change was to move the marketing of inventions away from attorneys and instead hire technology-trained business people. These professionals are now MIT's catalyst for technology transfer. By contrast the lawyers concentrated on the protection of the intellectual property more than the transfer process.

The second philosophical change is that MIT is working with a greater number of small or start-up companies. When dealing with an embryonic technology, Fortune 500 companies are often not particularly well suited to license and develop the technology--rather, small start-up companies can be better suited to commercialize new and early stage technologies. This can be partially explained by examining the allocation and effectiveness of technology development funds within large and small companies. Large companies often have considerable funds available to scale-up a technology for manufacturing from the prototype stage--prior to the prototype stage, though, very little money is available to develop and prove the product concept, particularly when the product concept was not generated within the company. Small companies are more willing to "import" ideas and to use equity or venture capital to develop and prove the product concept, bridging the funding gap between concept and prototype. After bridging the gap small companies often develop partnerships with large companies to accelerate market penetration and obtain funds for scale-up. It should also be noted that a dollar spent by a small company for technology development usually accomplishes more than it would in a large company. This is explained below by the differences in passion.

About fifty percent of MIT's license agreements are with small companies, with fewer than 100 employees. Ten percent of the license agreements are with new companies, created around the technology and the remaining forty percent goes to large companies (typically Fortune 1000).

To provide further perspective of MIT's entrepreneurial tendencies I will share some data published by Venture Economics. Only twenty-three investments were made by major venture capital funds in 1988 for the purpose of beginning high tech and biotech companies in the twelve Northeast Atlantic States. Interestingly, eight of these twenty-three companies (and one-half of the funds invested) were MIT spin-offs through the Technology Licensing Office. This percentage suggests that other universities have not yet started to catalyze new company formation. The TLO helped create 40 companies in the last 4 years, cumulatively raising about $70 million for these companies. We estimate that eight hundred to nine hundred new jobs have been created in Massachusetts by these spin-offs, one of the few bright spots in an otherwise dismal economy.

Recent MIT start-up companies include some of the largest new ventures in the Boston area, when measured by the amount of first-round financing. These companies include American

Superconductor Corp, funded at $4.5 million, Immulogic Pharmaceutical Corp, funded at $3.25 million, and Oculon Pharmaceutical, funded at $5 million. MIT does not invest its funds--its role in the process is to evaluate the technology at MIT, translate the technology into a product concept, and then to locate private sector funds and management to support and develop the new companies.

To facilitate this new enterprise formation process (and licensing to existing companies), MIT shares the development risk with its licensees. If MIT charged a company acquiring the early stage technology a large up-front payment, the risk of failure is transferred completely to the new company. If a cash fee is deferred, if no fee is charged, or if the fee is taken as equity, without an initial license fee, the development risk is shared with the licensee. MIT typically requires an initial payment--technology is not licensed only for equity and/or royalties--but its up-front license fees are usually lower than it was when the office was managed by lawyers, and as compared with other licensing offices.

An additional reason for limiting the amount of the initial license fee (thus sharing in the risk and success of the start up company) is that by doing so, the probability that the company will succeed may be enhanced. For example, if a new company has $2 million in venture funding, and pays $1 million as an initial license payment, the likelihood that it will be able to develop the technology properly, and achieve its business goals has been reduced tremendously as it now only has a million dollars left to build the business. Success factors for new companies are important to consider because the licensor's reward is greatly impacted by the likelihood of success of the company. My view is that a licensor is better advised to devote time and effort increasing the probability of success of the licensee, rather than increasing the royalty rate. Stated differently, it is much more valuable to create a business with an eighty percent likelihood of success, and a two percent royalty rate, than to create a business with a twenty percent probability of success and an eight percent royalty rate.

IMPORTANT FACTORS FOR SUCCESS IN NEW COMPANY FORMATION

There are several important variables that impact the probability of success for any new start-up company. These variables include the quality of the technology (Qt), the quality of the management team developing the technology (Qm), and quality of the source of money or investors (Qinv).

When starting a new company, the probability of success (Ps), is proportional to the product of the variables, and although I do not want this to be taken too seriously, could be expressed by the following formula:

$$Ps = Qt \times Qm \times Qinv$$

The variables are ranked from zero to one, with one being the best score.

Quality of Technology (Qt)

Technology receives a high rating if the invention has the potential to create a number of new products ("product pipeline"; has a strong patent or copyright position; and has considerable market potential.

An invention that has the capacity to create many products greatly diffuses the risk of technology failure in a new start-up company, and offers more opportunities for success. Genentech, Inc. is a good example of having a viable product pipeline--its gene splicing technology can be used to generate many different products, e.g., TPA and Insulin. There are exceptions to this rule, of

course. Lotus Development Company, for example, had only a single product, yet was extremely successful. I would argue, though, that Genentech has a higher probability of success in the long term. Perhaps the problems that Lotus Development Company experienced with Jazz and Symphony (subsequent products) stems from the fact that its a core technology did not provide a big advantage to designing these products

Another critical factor for success relates to the need for a strong patent position, which provides a wider window of opportunity for a company to develop and commercialize it products without direct competition. A strong patent position provides a monopoly to the patent holder, keeping other companies at bay from the protected technology. The Japanese sometimes address a patent that they wish to have access to by filing "picket fence" patents. In effect, the Japanese company will file patents that represent small incremental innovations around the core technology they wish to acquire. If the incremental innovations represent the preferred way in which the base technology may be used commercially, a barrier to the effective use of the technology is created. They are then in a position to force cross-licensing of patents to acquire the core technology. This can be prevented by careful planning and a broad patent estate--if you have 20 patents, with 20 claims each, it would be difficult for someone to work around the patent estate, or to patent all the incremental improvements. This greatly enhances leverage of the owner of the core technology in attracting partners rather than competitors.

The market potential of the technology is obviously important. A technology with a billion dollar business potential will have a higher probability of success than one with a million dollar market.

Quality of the Management (Qm)

The quality of the receiving management is crucial to the success of the venture. Management gets high quality ratings if it maintains a healthy balance sheet; has a clearly focused strategy; and is realistic about marketing. A healthy balance sheet is the best way to assure that the financial community will be interested in making additional investments at later stages in the company's development. Almost every rapidly growing company will require additional funds as it prepares to produce products, or in biotechnology or pharmaceutical products, begins clinical trials of its products.

A clear strategy is essential because of the fluid nature of a start-up company--numerous paths that appear interesting will be presented, and must be filtered through a well- conceived strategic plan. Management that fails to do this will expend enormous energies on suboptimal efforts.

Good managers must be realistic about the market for their products. Much effort should go into the analysis of the market with a clear understanding of why products will or will not be purchased, and a clear understanding of how competitive products will respond.

For example, when the transistor was invented, the vacuum tube manufacturers redoubled their R&D and marketing efforts. As a result, vacuum tubes shrunk to half their size, half the power consumption and half the price within 5 years from the invention of the transistor. In fact, they were doing a great job of protecting their market until Texas Instruments developed an application for the transistor where vacuum tubes could not be easily used, i.e., hearing aids. The hearing aid sales enabled transistor manufacturers to reduce the price/performance ratio of the transistor sufficiently to compete with the vacuum tube in other businesses. A good counter example is the thirty year-old competition between silicon and gallium arsenide. GaAs is much faster than Si and from a fundamental viewpoint should displace Si. However, innovation in Si has been just fast enough to keep a better price/performance ratio than GaAs in the broad markets, leading to the joke that GaAs was, is, and always will be the material of the future. By anticipating the reaction of the

competition, and positioning the new technology properly in the market place, good managers can successfully commercialize new technologies to the marketplace.

Quality of the Investor (Qv)

There are a number of factors that influence the quality of the investor: first, the track record in building successful businesses; second, the network of connections with potential partners or customers; third, the level of personal involvement the investor is willing to devote to the business; and fourth, their access to money and long-term vision.

There are several examples of venture capitalists who have funded dozens of new companies over the last ten to twenty years, with only two or three failures, where failure is defined as a company in which the original investor failed to break even or is unlikely to break even. Clearly, the involvement of an investor with such a strong track record raises the probability of success.

Similarly, the investor's network of connections and ability to influence strategic partners impacts the probability of success. A venture capitalist with high- level contacts in industry can make a substantial differences in developing partnerships where such association could reasonably enhance the likelihood of success of the new technology development process. For example, Kleiner Perkins has assisted numerous such partnerships for companies it funded. One such example is the partnership between Genentech and Eli Lilly to make human insulin which helped establish Genentech in the early 1980s as the premiere biotech start-up.

Access to additional funds can determine whether a start-up company fails or succeeds. Federal Express, for example, went through five rounds of venture investment before finally achieving stability and outgrowing the need for venture funding. A large number of rounds of venture capital is usually "painful" for the start-up and indicates that the long term fundamentals look good, but the short term results are disappointing. In the case of Federal Express, Rothschild Ventures took the lead in all five rounds--the fact that Rothschild had access to large amounts of money was therefore a major determinant of success. Otherwise Federal Express might have failed for the wrong reason -- lack of cash.

Passion for Success (Pa)

The passion of the various players is a key determinant of success. Worded differently, any new business will encounter hundreds of barriers before it succeeds. People with no passion will use the first barrier as as excuse for failure, while people with high passion will do whatever it takes to overcome the barriers.

The formula is now modified as follows:

Ps = PatQt x PamQm x PainQinv,

where Pat is the passion of the technologists, Pam is the passion of the managers and Painv the passion of the investors. Note that in this overly harsh formula, any zeros guarantee failure while all one are read to guarantee success.

Should any of the three groups be indifferent about success, the future of the company will be greatly impacted. Some companies succeed despite low marks in one or more areas, but as competitive pressures increase, it becomes more important that the start-up company have dedicated personnel. People with high passion will achieve spectacular results, and do whatever is necessary to reach the goals. As a result, it is important to evaluate and modify, if possible, the

strength, determination and commitment (or "passion") of the technologists, the managers, and the investors.

There are many ways to kill passion, but greed takes first place. Greed in the form of equity distribution is probably the single largest barrier to creating companies. All players in a new company are trying to maximize their ownership. Often inventors feel they should own 100% of the company. These people push very hard for a stock price when they raise venture capital. This behavior typically drives them to raise money from secondary sources, (relatives, wealthy friends or unsophisticated investors). This lowers the quality of the investor (Qinv). Second, they are very stingy in incentive stock plans for their employees, which again attracts second rate players. Worse yet, in addition to getting second rate employees and investors, the passion of the employees and investors fades rapidly as they come to realize that the probability is small that they will make significant money from the overvalued stock they acquired. This means the employees will be unwilling to work long hard hours and the investors will not be willing to come forward when (not if) the company needs more money.

Greed can take many other forms. Within a large company there is no equity to be distributed, only credit for good performance. Managers that claim all the credit when anything good happens and dodge blame when problems arise are killing the passion of the employees under them.

Other killers of passion are destructive criticism. We have many groups dedicated to criticizing plans to prevent us from making mistakes. For example, the Food and Drug Administration is designed more to prevent a drug which does not perform to standards from reaching the general public than to facilitate getting new helpful drugs to market. Within companies committees and lawyers serve the watchdog function. These people serve an important function much like the brakes on your car, but often can have devastating effects on the early stages of any new business development. The psychology of these individuals is that they can only take credit for "preventing a negative event" rather than "facilitating a positive." Worded differently, they cannot get credit for the original idea, only finding its problems. A large dose of such criticism kills passion.

The Image of the Company (I)

The final complication to the formula is to add the image or credibility of the new business as a whole. Thus the formula is now:

$$Ps = PatQt \times PamQm \times PainvQinv \times I,$$

where I is the image. The image factor is the way the company is perceived by potential strategic partners, investors, customers, employees.... For example, a biotech company with a Nobel Laureate on its Board of Directors will have more credibility in presenting a joint venture plan to a large pharmaceutical company than a company with unknown scientists. Similarly, a computer company in partnership with IBM will have an easier time selling its next products than a company without such an endorsement. Also, a company deriving its technology from Stanford, Harvard, or MIT will have a higher image rating than technology from a lesser known university.

There are many examples of image influencing outcome. If a company has a high image, people will expect success and therefore want to invest, partner or work with the company, creating a success induced success syndrome. If a company or person has an adverse image, failure is expected (failure induced failure). Within one year of the introduction of Lotus 1-2-3, for example, other companies had developed competitive products, which based on their price/performance ratio should have eroded Lotus' lock on the business use of spreadsheets. Lotus, though, had built a superb image through its marketing campaign. This marketing effort was enormous compared to other software companies, and focused solely on business users.

Lotus' competitors were not able to overcome the momentum created by Lotus' marketing program. In fact, the image created by Lotus' marketing program was so strong that 1-2-3 became synonymous with spreadsheets. One venture capitalist, in 1985, defined the worst possible investment as a "1-2-3 clone."

Level of Investment

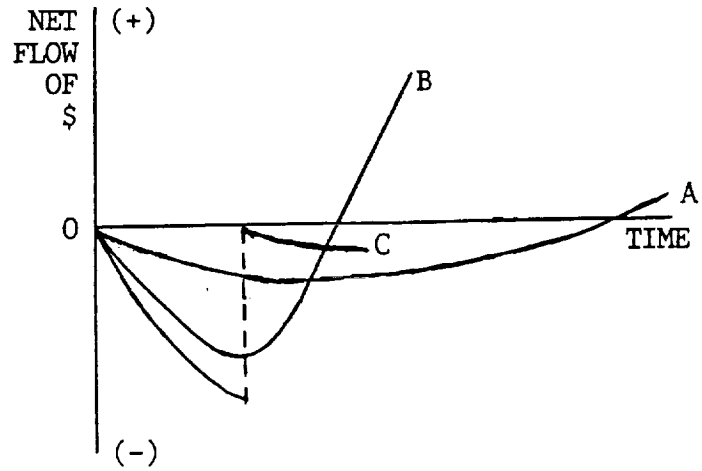
There are many different strategies for investing money in a new company. One end of the spectrum is typified by companies that adopt the minimalist approach. Namely, companies raise the minimum amount of money required to move the technology forward. Such companies may even try to "bootstrap" a start-up without raising capital. One benefit to this approach is that founders retain control and almost all ownership. Such companies are often attracted to and take advantage of the services, space and equipment made available by science parks and incubator facilities.

If money is raised, the investment is often too small to generate significant passion on the part of the investors. These minimalist companies are often not able to compete effectively, because technical and business developments move forward at a slow pace. Many of these companies also spend an inordinate amount of senior management time and effort in raising small amounts of capital needed to keep the company alive. This effort could have been devoted to developing the business had more funds been raised initially.

The other end of the spectrum (e.g., excessive initial capital) is often worse than the minimalist approach. The managers of these companies often lose the value of money typically pay high salaries and build lavish offices, and spend their weekends on their boats even when critical deadlines are imminent. I refer to this behavior as the "Taj Mahal syndrome." After spending large sums of money, these companies often frustrate investors by failing to show significant results. This frustration often leads the investors to cut off future investments and thus kill the company.

Somewhere between these two strategies is the optimal approach. Namely, sufficient resources are available for the company to develop its technology rapidly, but not so much that the managers loose the value of money.

The following chart demonstrates these three scenarios. It is interesting to note that passion in the optimal curve increases over time, while the minimalist companies tend to loose passion. The reason is that the employees and investors see the company moving toward a public offering while the employees in the minimalist companies see little hope for sale of their stock. Venture capitalists call such companies the "living dead."



Licensing to Larger Companies

Many factors discussed above relate directly to the creation of new businesses or product lines within existing companies. Using the formula from above, Qt and Qm have the same meaning. The Qinv term, though, refers to the Quality of the Sponsor within the company. Most internal operations within a large organization generally require someone at a high level, a sponsor or champion, to provide funds and guidance for the new venture.

The sponsor's role is analogous to the venture investor's role. Similar to the venture investor, the sponsor must have experience building businesses, and a strong network of connections, especially within the company. These connections are important to avoid political pressures within an organization that would discourage innovation and entrepreneurial behavior. Also, large companies often have internal markets or access to external markets that are valuable to the new business unit. The sponsor plays a key role in arranging for access to these internal opportunities. Unlike the venture investor, a sponsor must also be skilled at the internal politics of the organization.

Large companies have numerous advantages over start-up companies in developing new businesses. The advantages include access to markets, both internal and external, and greater access to resources than a start-up. The disadvantages include a reward structure that is not as conducive to the creation of passion, and a greater need for communication--this tends to makes decisions more deliberate and cumbersome.

The requirement for passion is greatest when the idea is extremely embryonic and opens new markets. In these cases a new start-up might have a greater probability of success over an existing company. If the technology is closer to an end product (eg. within 2 years), and if the product(s) are readily marketed by existing companies, the licensor might do better by licensing the technology to an existing company. In these later cases, the challenge is to generate passion within the large company and overcome company inertia that resists change and externally generated ideas.

Many large companies focus on short term performance (eg next quarter's earnings). This strategy is encouraged by the stock market which weighs quarterly results as more important than long term potential. It also drives management to behave along the minimalist curve (curve "A" in figure 1). In other words, a manager is not rewarded for investing in long term profit potential ("B" curve in figure 1); instead, if costs are reduced to the minimalist curve ("A"), the company's profit improves in the short term. I refer to such behavior as the "MBA Syndrome." Such managers can during a short period show increased profits and often get promoted or hired away before the long term disaster occurs. The irony is that if promoted, the manager has the opportunity and incentive to destroy a bigger piece of the company. The MBA Syndrome occurs in large U.S. companies for two reasons: 1) average U.S. job tenure is short (e.g. 3 years); and 2) the investors are speculators who care only about short term performance.

There are, fortunately, large companies that avoid this syndrome. Companies with large blocks of shares owned by one family are willing to invest for the long term. Family owned companies invest along the "B" curve because the family has no intention of selling its stock, instead, they plan to pass their shares on to their heirs. A number of publicly traded companies, such as Motorola, Corning and Ethyl have large blocks of shares held by a single family. Companies with family ownership of 10 percent or more of the outstanding shares which were also publically traded nearly doubled the performance of the Standard&Poors 500 companies over a four year

period (1984 - 1988), according to a study by Mark Cunningham of Alliance Capital . These somewhat incredible results are explained by the long term investment strategy of the owners. However, Cunningham's study becomes even more fantastic when the selection criteria includes active involvement of the family in managing the company. Cunningham has found that such selected family companies outperformed the S&P 500 by three and a half times during 1984-1988 and tenfold during the period 1968 to 1988.

Rewards to the Licensor

If the technology develops as expected, the university or licensor should expect a return equal to the royalty rate times the technology's realistic market potential times the probability of success.

However, there are several complications that will impact the licensor's rewards. For example, a poorly written license agreement could eliminate the licensor's rewards. One advantage in this regard is that universities can trade heavily on "good will." Companies will hesitate before alienating the university because the possibility of obtaining rights to future inventions may be jeopardized.

A significant factor limiting rewards to the university licensor is the level of hostility generated in negotiations. If the licensing company has grown to dislike the licensor because negotiations were one-sided, the licensee will view the royalty payments as a tax that should be avoided in any way possible. Energies will be expended, often subconsciously, to design around the patent or the agreement.

It is thus critical that the parties structure a well balanced agreement. The agreement is best written to provide for similarities between the winning scenarios for the licensee and licensor. In the case of a start-up, this creates strong incentive for the licensor to take equity in partial payment of the license. If the up-front payment has an equity component, the equity payment is not resented by the licensee as it does not remove resources from the technology and business. Also, subsequent design changes which may work around the patents do not impact the value of the equity, allowing the licensor a win in even the worst case.

Other Success Factors

Success factors for licenses are influenced by many factors other than those expressed above. For example, the quality of an invention is influenced by the industry which will use the invention. One could almost envision a parameter called "industry", ranked from zero to one, which describes the "adoptability" of patents in that industry. Certain industries, such as utilities or the automotive industry, are often not as receptive to externally generated technologies as other industries. If the technology has not been proven and established for many years, few people in these industries wish to take the risk of developing the invention. Other industries, such as the computer industry, have reduced the importance of inventions by extensive cross-licensing of patents. For many computer companies, the freedom to pursue a business strategy is a more dominant concern than using a patent to protect a monopoly. Also, the computer industry can more readily design around patents than most other industries.

Other industries, such as biotechnology and pharmaceuticals, where patents are more highly valued, are more difficult to design around.

The formula above could also be modified to reflect cultural differences. For example, both Japanese and European cultures tend to be more accepting of importing new technologies into large

firms, whereas in the US it is the small companies that are most supportive of importing new technologies.

Lastly, the role and significance of timing is crucial. For example, X-ray lithography has finally emerged as a commercially viable technology, just as MIT's fundamental patents are beginning to expire. The importance of timing is difficult to assess. It plays a key role in the development of markets for new technologies, and therefore a factor in assessing the quality of the invention.

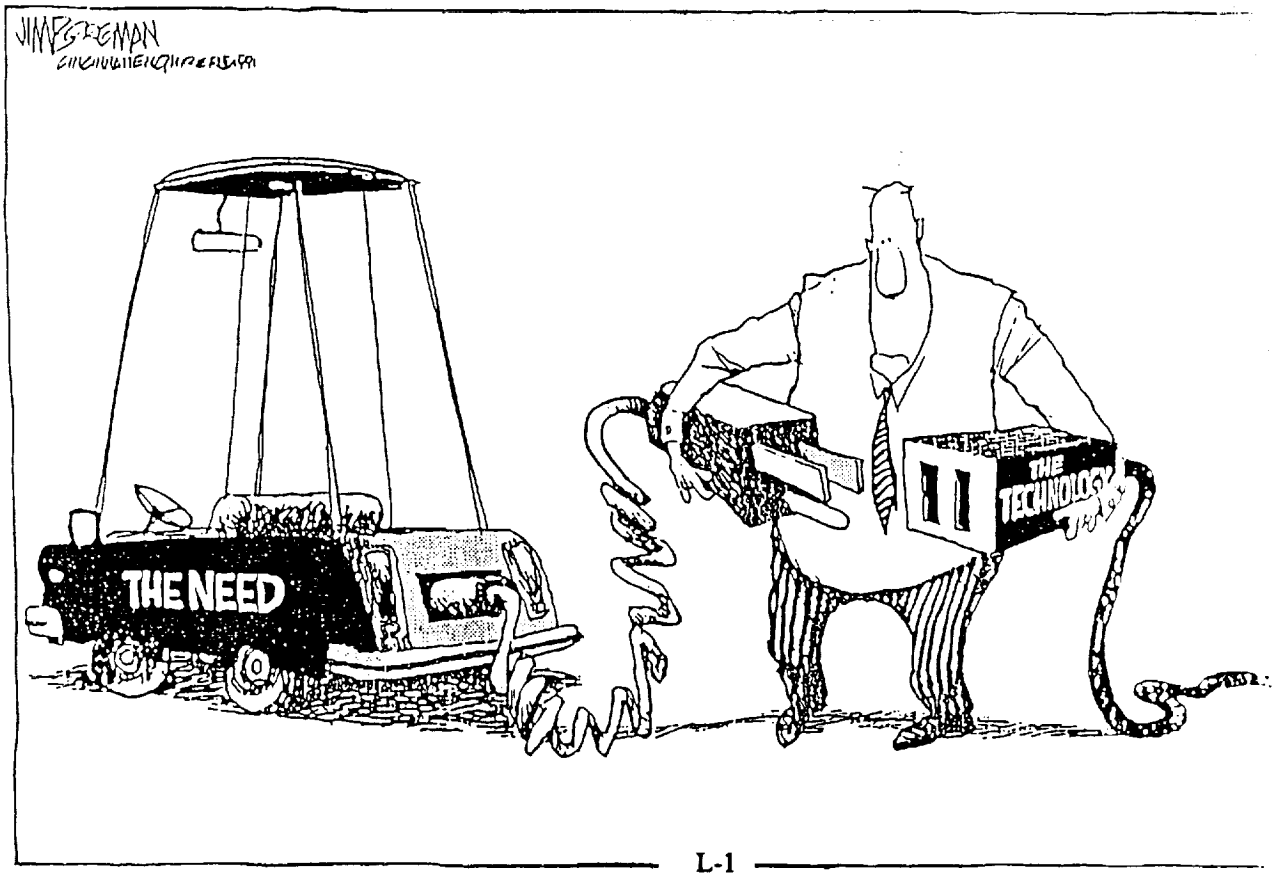
SUMMARY

Start-up companies and technology transfer to existing companies will continue to play a major role in economic development. The positive impact from new business creation can be increased by targeting appropriate technologies; finding strong managers and quality investors or sponsors; enhancing the image or credibility of the business; and finally, encouraging passionate behavior by the key players toward the success of the new business. These qualities, coupled with a well written, balanced agreement and good will on the part of both the licensee and licensor will greatly enhance the likelihood for success of the venture and rewards to the licensor.

TECHNOLOGY TRANSFER

FRANK E. PENARANDA

NASA HEADQUARTERS



Los Angeles Times - June 13, 1991

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

The Current Challenge

"If America is to maintain and strengthen our competitive position, we must continue not only to create new technologies but learn to more effectively translate those technologies into commercial products"

President George Bush
November 13,1990

CU-3298-6 2/7/92

NASA
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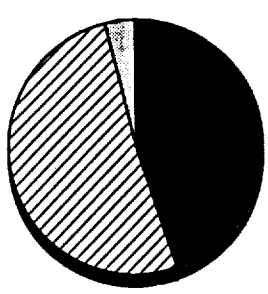
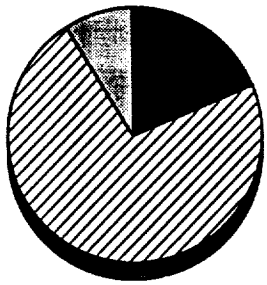
Office of Commercial Programs

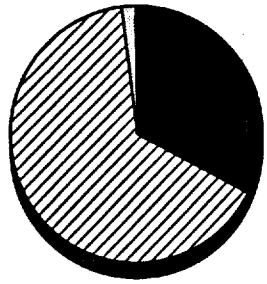
International Comparison of R & D Expenditures in 1989



United States
$111.1



Japan
$45.9



West Germany
$21.9

- Government
- Industry
- Other (R & D at nonprofit and higher education institutions)

Note: $ in Billions of Constant 1982 Dollars
Source: National Science Foundation

CU-3298-2 2/7/92

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

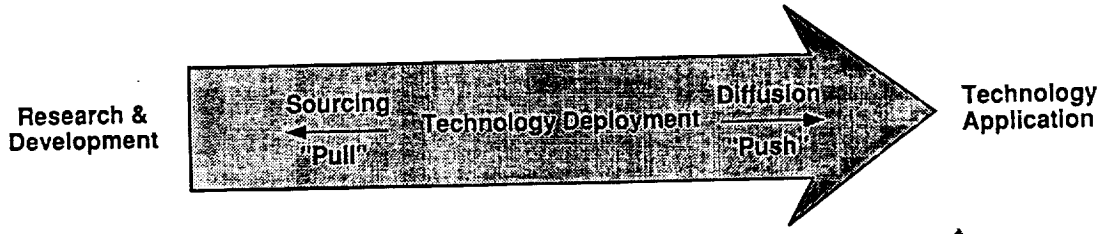
International Comparison of R & D Expenditures in 1989

	United States	Japan	West Germany
Billions of Constant 1982 Dollars	$111.1	$45.9	$21.9
Source of Funds:		*Percent*	
Government	45	19	33
Industry	51	72	65
Other	4	9	2

Source: National Science Foundation

CU-3298-3 2/7/92

Technology Transfer



Producers

- Federal R&D Agencies
  - Laboratories
  - Contractors
  - Universities

Intermediary Programs/ Organizations

- Federal Agency /TT Programs
- Federal Lab ORTAs
- NTTC/RTTCs
- State-Level Activities
  - Business/Technology Assistance
  - Incubators, Seed-Capital Funds, Research Parks

End-Users

- U.S. Private Sector
  - Individual Firms
  - Industry/Business Groups

Stakeholders

- Federal/State Agencies
- Federal/State Legislatures
- U.S. Industry/Business Communities
- U.S. taxpayers

CU-3256 10/16/91

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

NASA Technology Transfer Program

Two Basic Roles

- **Traditional Role:** Transfer NASA technology for secondary use throughout the U.S. private and public sectors
- **Emerging Role:** Develop the National Technology Transfer Network in cooperation with all Federal R&D agencies

CU-3298-7 2/7/92

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

NASA Technology Utilization Program Thrusts for FY 1992 and FY 1993

- Establish and operate a National Technology Transfer Network
  - Facilitate the transfer of all Federal technology to the private sector
  - Assist the Nation's industrial competitiveness objectives
- Streamline and expedite the identification, documentation and dissemination of NASA's emerging technologies
- Shorten the time between technology development and commercial applications
- Increase number of "cooperative agreements" and/or technology applications projects
- Emphasize and maximize economic benefits potential for NASA's technology applications projects

CP-4616-1 3/16/92

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

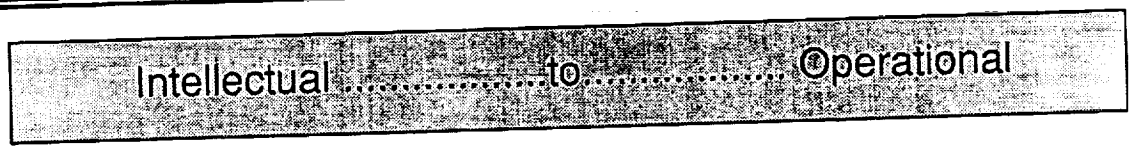
National Technology Transfer Network

- Core Structure
  - National Technology Transfer Center (NTTC)
  - Six Regional Technology Transfer Centers (RTTCs)
- Other Key Elements
  - Federal R&D Agencies
  - Federal R&D Labs and Centers
  - Federal Laboratory Consortium for Technology Transfer
  - State/Local Agencies and Programs
  - Business/Industry Groups and Associations

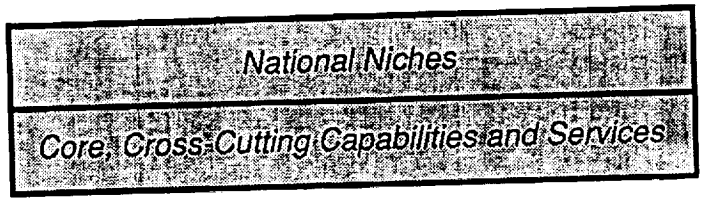
CU-3298-8 2/11/92

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

NTTC Roles



- Research/Analysis
  - Technology transfer issues
  - Industry technology needs
- Clearinghouse/Network "Hub"
- Outreach to Industry
- Training and education
- Network development



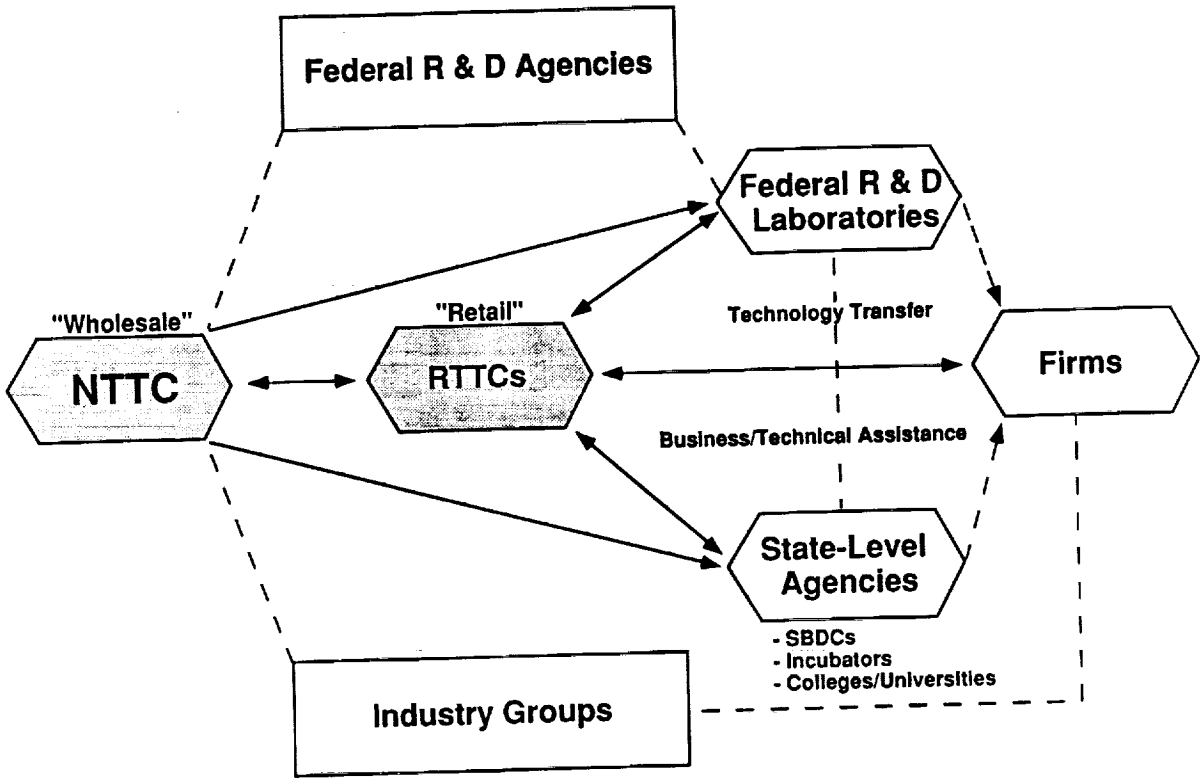
CU-3298-4 2/7/92

NASA
National Aeronautics and Space Administration
Office of Commercial Programs

RTTC Roles

- Link together Federal labs, state/local programs and the national network to serve the technology needs of each region's business and industry
- Provide value-added service to business and industrial clients:
  - Information Services involving computerized searches of Federal technology databases
  - Technical Services, including the assessment of technology requirements and potential solutions
  - Commercialization Services assisting the commercial application of Federal technologies
- Promote regional awareness of technology transfer resources and opportunities

CU-3298-5 2/7/92



CU-3255 11/18/91

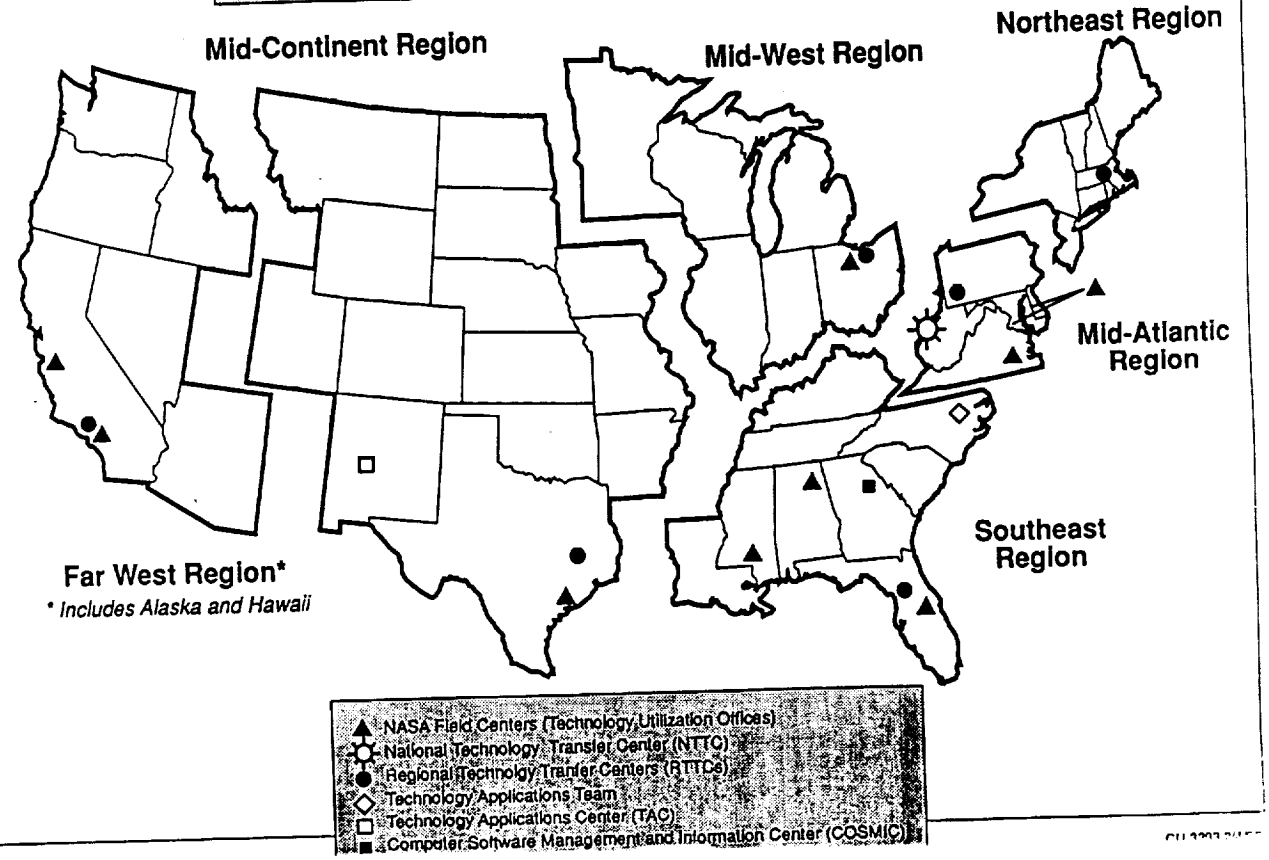
National Technology Transfer Network

* Includes Alaska and Hawaii

"Technology!... from the lab to the marketplace"

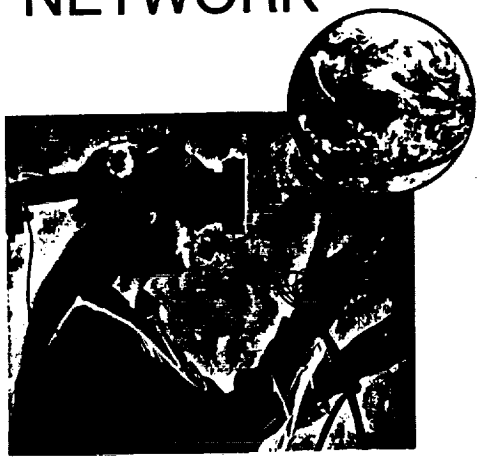
CU-3294 2/4/92

NASA Technology Transfer Network



* Includes Alaska and Hawaii

NATIONAL TECHNOLOGY TRANSFER NETWORK



"Technology . . . from the lab to the marketplace."

NATIONAL TECHNOLOGY TRANSFER CENTER

At the direction of Congress, NASA initiated in April 1991 a five-year development program to establish the NTTC as a national resource for Federal technology transfer.

The NTTC's principal mission is to assist all Federal agencies in executing the Federal-wide technology transfer mandate as a means of enhancing U.S. competitiveness. To this end, the NTTC serves as the national "hub" for the network, providing core capabilities and cross-cutting services that accelerate and expand the transfer of Federal technologies to the U.S. private sector.

The NTTC, now in its initial phase of development, is currently establishing key capabilities and services to:

- Serve as the national clearinghouse for Federal technology transfer, linking U.S. firms and industry with Federal agencies and laboratories, the RTTCs, and state and local agencies;
- Provide training and education services to government and industry to develop the individual skills and organizational approaches critical to technology transfer.

In addition, the NTTC conducts national outreach and promotional activities to improve U.S. private sector awareness of technology transfer resources and opportunities. Overall, NTTC activities in these and other areas complement and support private and public sector technology transfer efforts across the United States.

REGIONAL TECHNOLOGY TRANSFER CENTERS

The RTTCs, established in six regions spanning the United States, began operations in January 1992. The new centers, which replaced NASA's longstanding network of Industrial Applications Centers, reflect NASA's initiative to upgrade and restructure its technology transfer program in order to better serve U.S. business and industry in the 1990s and beyond.

The regional deployment, aligned with the six Federal Laboratory Consortium regions and covering all 50 states, allows the centers to work closely with a wide range of Federal, state and local programs in serving the technology and related business needs of the firms and industry in each region.

The RTTCs also utilize the NTTC and the national network to access technologies from throughout the Federal R&D base and link together additional capabilities and services from the NTTC and others across the United States to best meet their client's technology and related needs.

The RTTCs provide value-added services to meet the technology needs of individual business and industrial clients. These include:

- Information Services: computerized searches of Federal technology databases and other technology sources.
- Technical Services: assessment of technology requirements, analysis of technology applications, and engineering reports.
- Commercialization Services: technology brokering, business analyses and venture capital sourcing.

In addition to these core services, the RTTCs also conduct industry or technology based initiatives and activities addressing the particular needs and conditions of each region's industrial base and overall economy.

The surgeon is using a self-contained instrument, derived from NASA technology, thus offering greater freedom in the operating room (below).

"Working together to strengthen U.S. competitiveness. . ."

For further information, contact the National Technology Transfer Network.

NATIONAL TECHNOLOGY TRANSFER NETWORK

"If America is to maintain and strengthen our competitive position, we must continue not only to create new technologies but learn to more effectively translate those technologies into commercial products."

- President George Bush
November 13, 1990

PURPOSE AND OBJECTIVES

- The Federal R&D base -- involving over 600 laboratories and centers -- produces a robust supply of proven and promising technologies that have secondary applications throughout the commercial and industrial sectors.
- The purpose of the National Technology Transfer Network is to provide an effective, market-oriented means of deploying technologies from the Federal R&D base to meet the technology needs of the U.S. private sector.

Objectives of the network include:

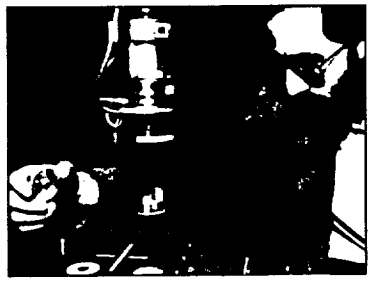
- Facilitate rapid access by U.S. firms and industry to the Federal R&D base and to the full range of technology transfer capabilities and services available throughout the United States; and,
- Foster cooperation and partnerships with Federal, state and local organizations and programs working to advance the technological competitiveness of U.S. firms and industry.

NETWORK ELEMENTS

The National Technology Transfer Center (NTTC) and the six Regional Technology Transfer Centers (RTTCs) form the core structure for the overall network. Other key elements are:

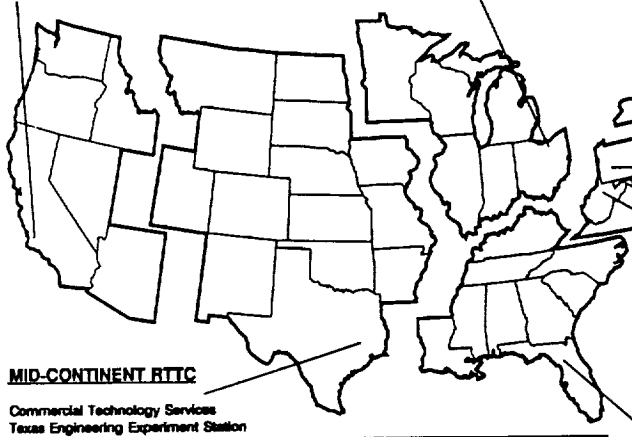
- Federal agency technology transfer programs and activities;
- Federal laboratories and centers;
- Federal Laboratory Consortium for Technology Transfer;
- State and local agencies and programs, including technology centers and business/technical assistance services; and,
- Business and industry consortia, associations, and communities.

Overall, the network provides a national framework for the public and private sectors to work together productively to enhance the economic competitiveness of the United States.



A researcher from Sandia National Laboratories demonstrates a robot using a new software program that enables a robot to "program itself."

NATIONAL TECHNOLOGY TRANSFER NETWORK



FAR WEST RTTC*

University of Southern California
3716 South Hope Street, Suite 200
Los Angeles, CA 90007-4344
(213) 743-8132

Mr. Robert L. Stark, Director

MID-WEST RTTC

Battelle Memorial Institute
Great Lakes Technology Transfer Center
25000 Great Northern Corporate Center
Cleveland, OH 44070
(216) 734-0094

Dr. Joseph W. Ray, Director

NORTHEAST RTTC

Center for Technology Commercialization
Massachusetts Technology Park
100 North Drive
Westborough, MA 01581
(508) 870-0042

Dr. William Gasko, Director

MID-ATLANTIC RTTC

University of Pittsburgh
823 William Pitt Union
Pittsburgh, PA 15260
(412) 648-7000

Ms. Lani S. Hummel, Director

NATIONAL TECHNOLOGY TRANSFER CENTER

Wheeling Jesuit College
316 Washington Avenue
Wheeling, WV 26003
(304) 243-2455

Mr. Lee W. Rivers, Executive Director

SOUTHEAST RTTC

Southern Technology Application Center
University of Florida, College of Engineering
Box 24, One Progress Boulevard
Alachua, FL 32615
(904) 462-3913 (local)
(800) 225-0308 (national)

Mr. J. Ronald Thornton, Director

MID-CONTINENT RTTC

Commercial Technology Services
Texas Engineering Experiment Station
The Texas A&M University System
310 Wisenbaker Engineering Research Center
College Station, TX 77843-3369
(409) 845-0538

Mr. Gary Sera, Director (acting)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of Commercial Programs
Technology Utilization Division
Code CU
Washington, D.C. 20546
(703) 557-8160

* Alaska and Hawaii included in Far West Region

NATIONAL TECHNOLOGY TRANSFER CENTER

MISSION

To serve as a hub
for the nationwide technology-transfer network
to expedite the movement
of federally developed technology
into the stream of commerce.

LEE W. RIVERS

NATIONAL TECHNOLOGY TRANSFER CENTER

PURPOSE

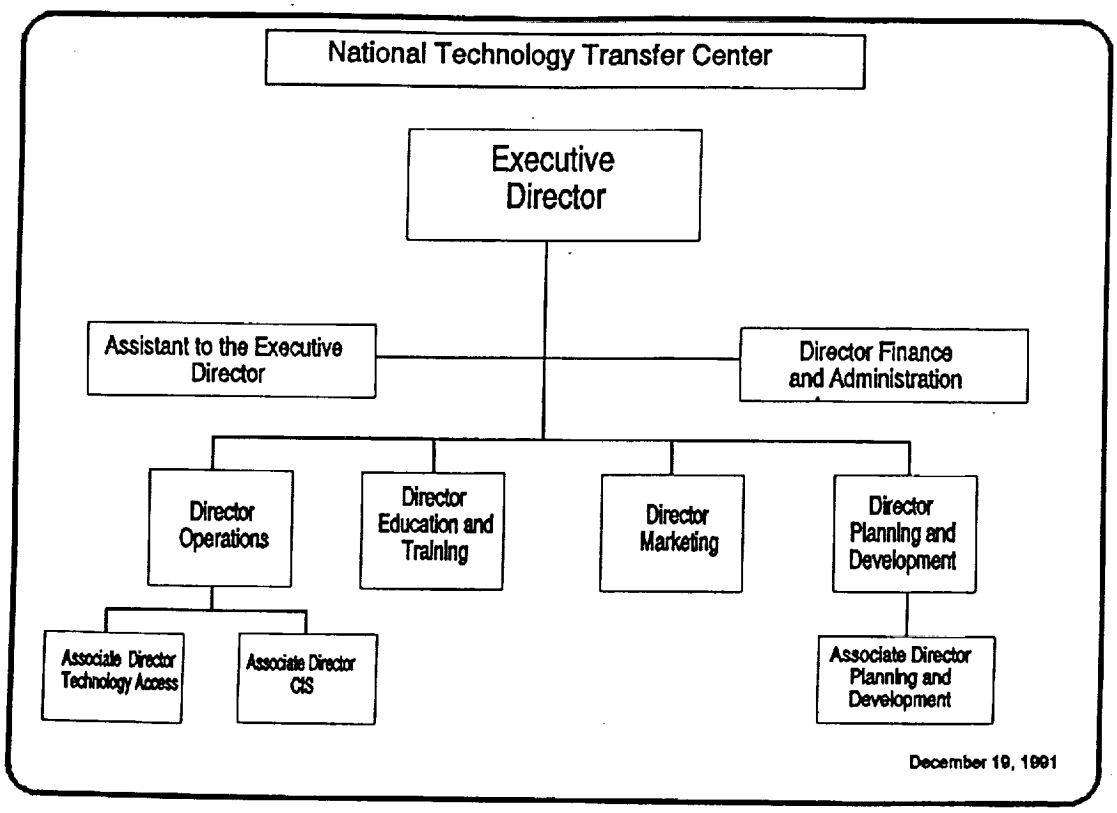
To enhance the competitiveness
of American industry.

OBJECTIVES

- To help American industry
  gain easy, rapid, and productive access
  to the most marketable federal technologies.
- To help the federal laboratories
  find appropriate private partners
  to develop and commercialize technologies.

ESTABLISHMENT CHRONOLOGY

- October 1989:
  Senate Appropriations Committee
  directed NASA
  to start process of establishing NTTC
  at Wheeling Jesuit College, Wheeling, WV.
- March 1990:
  College received planning grant.
- April 1991:
  NASA and college signed
  5-year cooperative agreement
  establishing NTTC.
- November 1991:
  Current executive director named.



NTTC WORKING GROUP

- Federal Laboratory Consortium
- Regional Technology Transfer Centers
- Agency Technology-Transfer Managers
- NTIS
- SBA/SBDC-National
- SBIR
- Technology-Transfer Partnerships & Programs
- Universities
- Economic-Development Groups
- Trade & Professional Associations

FUNCTIONS

GATEWAY. Linking
federal laboratories and
the nationwide technology-transfer network
with
American companies; trade and professional associations; entrepreneurs; venture capitalists and other investors; and state, local, and regional economic-development organizations.

EDUCATION & TRAINING. Helping government and industry understand technology transfer and develop individual and organizational approaches to it.

OUTREACH. Seeking out agencies, companies, and other organizations to help them improve their technology-transfer systems.

GATEWAY

- A full federal-technology database and indexing system combining existing and new sub-systems.
- An 800 telephone number for access by federal-technology users.
- A highly trained staff with technical and communication expertise for linking users with the nationwide technology-transfer network.
- Collaboration with FLC on the "Business Gold" technology alerting system.
- Follow-up to analyze and evaluate the effectiveness and impact of the technology transfers resulting from NTTC operations.

EDUCATION & TRAINING

- Undergraduate and MBA curricula for technology transfer and innovation management developed in collaboration with Wheeling Jesuit College.
- Seminars, conferences, and short courses for enhancing the skills of technology-transfer professionals and managers.
- Project to raise awareness and knowledge levels and to foster behaviorial changes in government and business executives and economic development professionals.

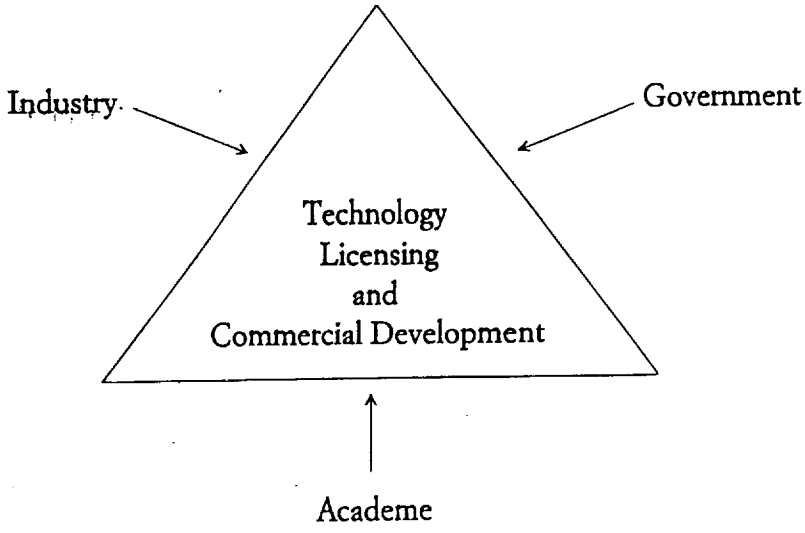
OUTREACH

- Participate in discussions with agencies and laboratories on fostering and managing technology transfer.
- Develop working relationships and agreements with trade and professional associations.
- Develop working relationships and agreements with technical, financial, and extension organizations.
- Facilitate linkages of regional, state, and local groups with the nationwide technology-transfer network.
- Assist in regional/state/local initiatives.
- Play advocate roll in economic-development issues.

ADVISORY COUNCILS

- Develop three councils involving innovation leaders in business, federal, and other-governmental communities.
- Purpose: To provide NTTC with a continuous flow of unbiased, forward-looking, sensitive expertise and criticism.

Three Views of the Elephant



INDUSTRY PERSPECTIVE

- o SPEED
- o QUALITY
- o EXCLUSIVITY
- o JUSTIFIABLE COST
- o COMPARATIVE ADVANTAGE
- o GLOBAL USE
- o CONFIDENTIALITY
- o WIN-WIN
- o TECHNICAL BACK-UP

GOVERNMENT PERSPECTIVE

- o AVOID PERSONAL RISK
- o QUANTITY OVER QUALITY
- o CONFLICTS OF INTEREST
- o NON-EXCLUSIVE
- o LITTLE SENSE OF VALUE
- o EQUAL ACCESS
- o DOMESTIC COMPANY BIAS
- o SMALL BUSINESS BIAS
- o COMPLEX DECISION-MAKING

ACADEMIC PERSPECTIVE

- o PUBLISHING COMES FIRST
- o CONFLICTS OF INTEREST
- o LITTLE SENSE OF VALUE
- o POOR BACK-UP
- o NOT HIGH PRIORITY
- o SCIENCE VS. TECHNOLOGY
- o EXCLUSIVITY (YES/NO)
- o MOVE SLOWLY
- o QUANTITY OVER QUALITY

THE TENTH PERSPECTIVE

"AS VIEWED BY THE NATION --- AND

ALL THREE SECTORS"

WE MUST MAKE IT WORK!

Technology Transfer From the Viewpoint of a NASA Prime Contractor

Technology Transfer Program

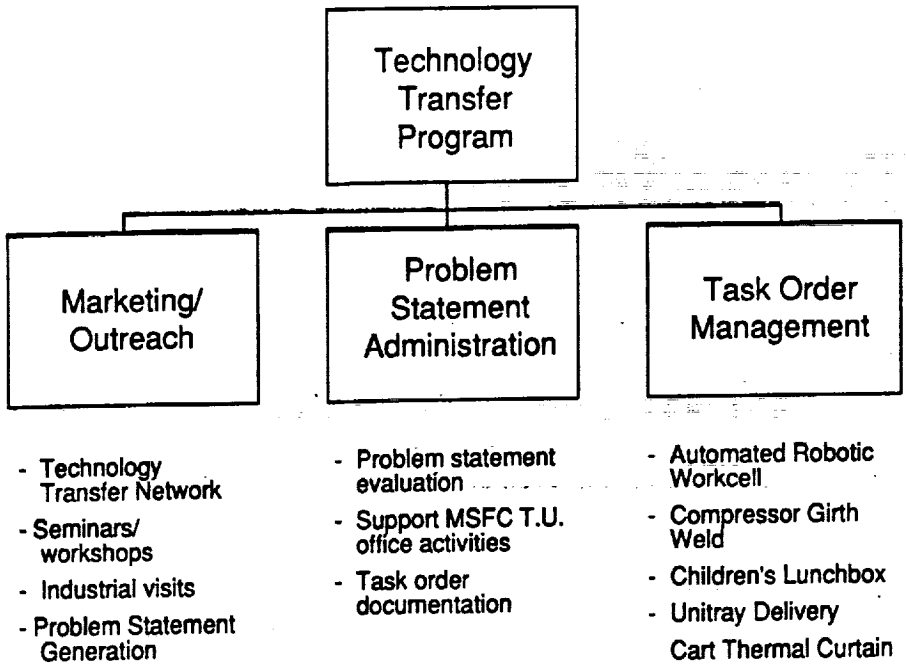
Manned Space Systems chartered October 1989 to develop and administer program

- Prime objectives
  - Support existing technology utilization program
  - Actively promote transfer of ET technology
  - Management of application engineering projects (Task Orders)
- Program seeded with $2M to cover administration and application projects (1989-1996)

NASA March Briefing/GD Persus Docs.

MARTIN MARIETTA
MANNED SPACE SYSTEMS

Technology Transfer Program

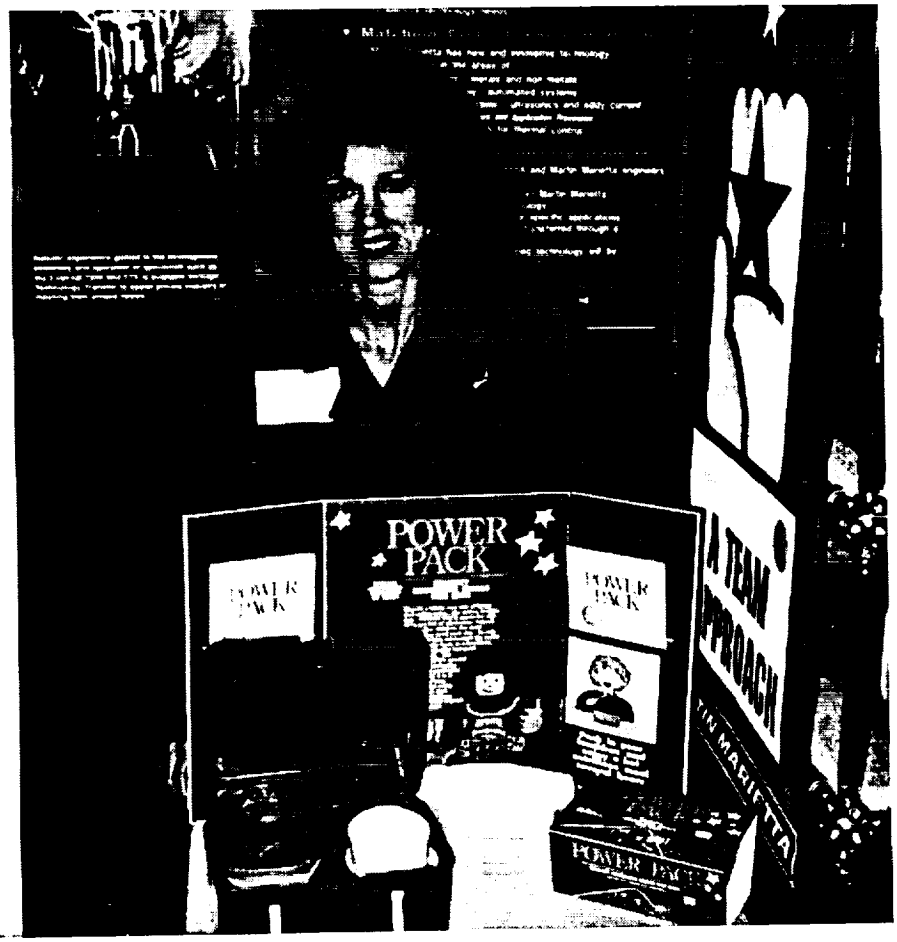


Technology Transfer Program Status

- Four technology projects have been successfully completed
  - Robotic workcell
  - Weld seam tracker
  - Children's lunchbox
  - Thermal curtain
- An average of 5 technical requests per month are being reviewed at Manned Space Systems
- Conducted 85 formal seminar presentations
- 33 requests for technology

Technology Transfer Program

- Support MSFC memorandum of understanding
  - Louisiana
  - Alabama
  - Mississippi
  - Tennessee
  - West Virginia
  - Georgia



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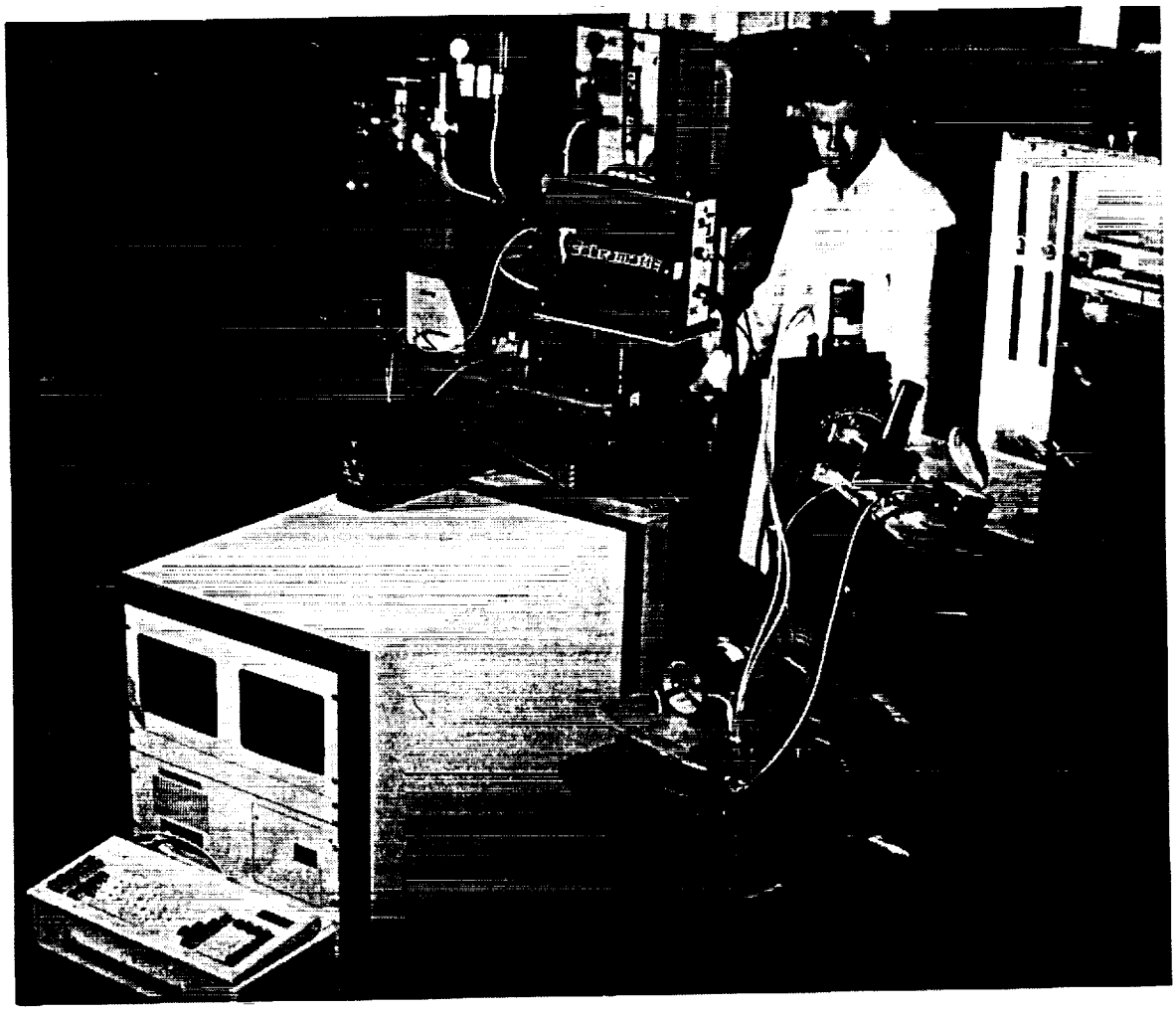


Technology Transfer and the Civil Space Workshop

NASA

Sandia National Laboratories
Laura R. Gilliom

3/18/92

Technology Transfer and the Civil Space Workshop

Sandia National Laboratories has identified technology transfer to U. S. industry as a laboratory mission which complements our national security mission and as a key component of the Laboratory's future. A number of technology transfer mechanisms -- such as CRADAs, licenses, work-for-others, and consortia -- are identified and specific examples are given. Sandia's experience with the Specialty Metals Processing Consortium is highlighted with a focus on the elements which have made it successful. A brief discussion of Sandia's potential interactions with NASA under the Space Exploration Initiative was included as an example of laboratory-to -NASA technology transfer.

The role of the national labs is changing as the national needs change

Declining importance	Increasing importance
Threat from "Evil Empire"	Threat from evil people
Nuclear weapons	High-Tech weapons
Go where we have never gone before	Get there! faster, cleaner, cheaper
Prolong life at any cost	Reduce health care costs
Large quantities of low-tech products	Custom products
Long product life cycle	Short product life cycles

4/1/91

Sandia's Technology Transfer Program

Mission focus :

- Enhance U. S. economic competitiveness
- Focus on market pull for rapid commercialization
- Apply lab strengths to problems of national importance
- Emphasize partnerships with industry and universities

The technology transfer mission complements Sandia's national security missions.

1/9/92

Recent/Ongoing Technology Transfer Successes

- Combustion Research Facility - User Facility
- Semiconductor Equipment Technology Center - SEMATECH WFO
- Specialty Metals Processing Consortium - Consortia Agreement
- SANDAC Computer - Honeywell Corp. - Direct Transfer via Contract
- Semiconductor Bridge Technology - SCB Inc. - Commercial License
- Microcellular Foam - Permacharge Inc. - License/CRADA

9/15/91

CRF - Industry collaborations increase U.S. competitiveness

General Motors	Flame chemistry codes, diagnostic techniques
Gas Research Institute	Natural gas combustion, pulse combustion
Exxon	Flame chemistry, soot formation, diesel technology
Altex	Turbulent reacting flows
AT&T	Flame-formed silica
EPRI	Coal combustion
John Deere	Rotary engine velocimetry, Industrial Fellow
Technor	Reduction of NOx from exhausts
Conoco	Coal combustion diagnostics
General Electric	Turbulent reacting flows
Cummins Engine	Diesel particulates, Industrial Fellow
Unocal	Engine knock diagnostics
Lennox Industries	Pulse Combustion, Industrial Fellow
Mobil	Diesel fuel auto-ignition
Ford, Chrysler	Fiber-optic spark plug technology
Combustion Engineering	Mineral- matter deposits

4/1/91

Semiconductor Equipment Technology Center (SETEC) Program Overview

Objective: Develop and apply tool design model and methodologies to enhance the reliability and operation of U.S. semiconductor manufacturing equipment

- Sponsored by SEMATECH
- Uses established facilities and expertise
- Transfers technology to member companies

4/1/91

Sandia Technology Transfer

SANDAC Computer

A high-performance, ruggedized, parallel processing computer weighing only seven pounds that can run on batteries while offering supercomputer-like computing power for such things as high-speed navigation, guidance, and control -- transferred via contract to Honeywell Avionics Division for production.

Silicon Bridge Ignitor

A microchip-sized explosive igniter that can ignite an explosive powder about 1000 times faster than traditional hot-wire igniters and requires much less energy -- licensed to SCB Technologies, Inc., based in Albuquerque, to develop SCB igniters for automotive air bags. The company has issued a sublicense for SCB air bag manufacture to Thiokol Corporations Tactical Operations Division in Elkton, Maryland.

Microcellular Foam

A low-density, porous material that is very uniform with a high surface area has been licensed to Permacharge Corporation, a small Albuquerque-based company, which will be using it in high-efficiency particulate air filters for use in hospitals, semiconductor and computer clean rooms, and other facilities requiring extremely particle-free environments.

9/18/91

CRADAs Approved

Company	Technology
Signetics Company	Microelectronics Quality Reliability Center (MQRC)
Motorola Inc.	Solvent Reduction Through Use of Self-Cleaning Soldering Process
National Semiconductor	Microelectronics Quality Reliability Center (MQRC)
Permacharge	Microcellular Foam Filtration Media Fabrication and Evaluation
Stellar Systems	Physical Security Technology Outdoor Perimeter Sensor
Vindicator Corp.	Physical Security Technology Taut Wire Fence
Dow Corning Corp.	Microengineering Materials Development Project
Watkins Johnson	Copper Chemical Vapor Deposition for Integrated Circuits
City of Albuquerque	Volatile Organic Monitor for Industrial Effluents
Pratt & Whitney	Intelligent Machining of Castings
Olin Speciality	Microelectronics Quality Reliability Center (MQRC)
LSI Logic	Microelectronics Quality Reliability Center (MQRC)
Schumacher	Copper Chemical Vapor Deposition for Integrated Circuits
BPLW Architects	Physical Security Technology
Sematech	Semiconductor Equipment Technology Center
Carpenter Technology	Joining Technology for Advanced Borated Stainless Steel
Pratt & Whitney	Intelligent Processing of Thin Section Welded Assemblies

1/27/92

Specialty Metals Processing Consortium

- Sandia has developed

  Advanced diagnostic and control techniques for forming high quality special metal alloys.
- The specialty metals industry affects microelectronics to jet engines.
- Products include high-strength, high-performance lightweight alloys.
- The consortium will help meet the challenge of foreign competition.

PARTICIPANTS:

Allegheny-Ludlum	Pratt & Whitney
Cartech	Special Metals
Cytemp	Teledyne Allvac
Garrett	Teledyne Wah Chang
Howmet	Wyman Gordon
INCO Alloys	

5/14/91

COST-SHARE CONSORTIA (SMPC MODEL)

Elements -

* Market pull: Industrial $
  Industry involvement in R&D program
* Well-defined technical agenda including short-term benefit to industry
* Catalyzed around existing lab facility and technical capability
* Flexible cooperative agreement
* Laboratory and industrial champions
* Involves small and medium-sized companies
* Involves both suppliers and end-users
* Pre-competitive technology development
* Threatened Industry

SMPC Program Rules

- **Work managed through Project Letter Agreements**
- **Stringent U.S. preference conditions set by SMPC**
- **Commercial-value information protected up to 3 years**
- **Sandia holds all intellectual property -- SMPC members get royalty-free rights under most situations.**

4/1/91

Summary
Technology Transfer at Sandia

- **Has been elevated to mission status**
- **Has new, more responsive mechanisms in place**
- **Focuses on strategic industry partnerships especially consortia aimed at dual use technologies**
- **Seeks to match capabilities at Sandia with industry/market needs**
- **Is actively soliciting industry participation**

5/14/91

Space Exploration Initiative

Supporting Technologies

○ 1) Heavy lift launch capability	● 8) Radiation effects issues
● 2) Nuclear thermal propulsion	● 9) Telerobotics
● 3) Nuclear electric surface power	◑ 10) Closed loop life support
◑ 4) EVA suit	○ 11) Human factors for long duration missions
◑ 5) Cryogenic fuel issues	● 12) Lightweight materials and manufacturing
◑ 6) Automated rendezvous and docking	● 13) Nuclear electric propulsion
○ 7) Zero-g countermeasures	○ 14) In situ resource utilization

Sandia participation: ● major ◑ significant ○ minor or none

SG-15/10-91 SANDIA NATIONAL LABORATORIES

TECHNOLOGY TRANSFER NEEDS & EXPERIENCES

THE NASA RESEARCH CENTER PERSPECTIVE

ANTHONY R. GROSS, CHIEF
ADVANCED SPACE TECHNOLOGY OFFICE
AMES RESEARCH CENTER

PRESENTED AT THE
ITP TECHNOLOGY TRANSFER WORKSHOP
MCLEAN, VA
MARCH 17 - 19, 1992

AGENDA

- INTRODUCTION
- MECHANISMS
- EXAMPLES
- ISSUES & CONCERNS
- CONCLUDING REMARKS

FUNCTIONS OF THE (NATIONAL AERONAUTICS AND SPACE) ADMINISTRATION

" (3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

from the NATIONAL AERONAUTICS AND SPACE ACT OF 1958, AS AMENDED

NASA AMES RESEARCH CENTER

INCENTIVES & BENEFITS

- Fulfills NASA Charter
- Contributes to National competitiveness
- Enhances NASA technology by expanding to new applications
  - Space Shuttle Main Engine (SSME)
  - Artificial Heart
- Facilitates NASA flight programs
  - Shuttle Thermal Protection System (TPS)
- Helps advocate NASA programs and budgets

NASA AMES RESEARCH CENTER

TECHNOLOGY TRANSFER MECHANISMS

- Formal
  - Reports, Publications & Presentations
    - Professional
    - NASA Tech Briefs
    - NASA Reports
    - NASA Spinoff Magazine
    - Ames Annual Report
  - On-Line/Electronic Systems
    - COSMIC
    - DIALOG
    - RECON
    - NASA SOFTLIB
    - NASABBS
  - Contractor Independent Research & Development (IR&D) Program
  - Small Business Innovative Research (SBIR) Program
  - ACSYNT - AirCraft SYNThesis Institute
- Informal
  - Personal contacts
  - Collaborations
  - Senior Manager Site Visits
- AMTECH - a unique program

Advanced Space Technology Office

ECONOMICS OF TECHNOLOGY COMMERCIALIZATION

FROM PERSPECTIVE OF EACH CO-ADVENTURER

	RESEARCH	DEVELOPMENT	COMMERCIALIZATION
GOVERNMENT	PRIMARY SPONSOR AND PARTICIPANT	STIMULATE DEVELOPMENT LEADING TO COMMERCIALIZATION	"CUSTOMER"
UNIVERSITY	SOLE PURPOSE FOR EXISTENCE: RESEARCH AND TEACHING	LIMITED PARTICIPATION	TECHNOLOGY LICENSING
INDUSTRY	PRIMARY FOCUS ON PRODUCT-ORIENTED RESEARCH; SOME GOVERNMENT RESEARCH	STRONG DEVELOPMENT EMPHASIS IN-HOUSE AND THROUGH NEW START-UPS	SOLE PURPOSE FOR EXISTENCE: CREATION OF WEALTH

SELECTED EXAMPLES

- Space Shuttle Main Engine (SSME)
  - Application of Computational Fluid Dynamics (CFD) to a problem of internal SSME redesign
  - NASA CFD technology transferred to Rocketdyne Corp.
  - Resulted in Rocketdyne/NASA-developed solution plus development of greatly enhanced Rocketdyne CFD capability

- Artificial Heart
  - Application of NASA CFD technology to modeling and design of an artificial heart
  - Transfer of NASA technology to the non-aerospace sector
  - Joint program with Penn State and Stanford Universities
  - Funded through the Ames Technology Utilization Office

CONCLUDING REMARKS

- Technology transfer is a key element in the successful and effective operation of a NASA research center

- Benefits accrue to both the Research Center and to the recipient organization

- Although there are many examples of successful technology transfer, both within the government and to the commercial sector, the process needs to be strengthened to effectively disseminate and utilize the increasing volume of NASA advanced technology

- Strong, consistent, and visable management support is necessary, on both sides of the technology transfer process, in order for it to be successful

omit

INSTRUCTIONS TO THE WORKING PANELS

JOHN C. MANKINS

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

WORKSHOP CONCEPTUAL FRAMEWORK

OAST

- **TECHNOLOGY TRANSFER IS A COMPLEX, MULTIDIMENSIONAL PROBLEM**

  WORKING HYPOTHESIS:

  — CORRECT SOLUTIONS WILL VARY SIGNIFICANTLY WITH SUBTLE CHANGES IN THE STATEMENT OF THE PROBLEM (I.E. CHARACTER OF THE SITUATION)

- **SYSTEMS APPROACH PROPOSED TO ANALYZE THE PROBLEM**

  APPROACH:

  — Construct a Systematic Framework for Discussion, Including Model(s)" Of The Different Dimensions Of The Transfer Problem

  — Review And Evaluate Individual Cases In The Context Of The Proposed Models (e.g., "Lessons Learned", Existing Programs, etc.)

  — Evaluate Proposed Model(s) Based On Participant Experience And Lessons Learned — Revise as Necessary

  — Assess Current Efforts, Programs, Impediments Against Model(s), Participant Judgment Regarding Efficacy Of Varying Approaches

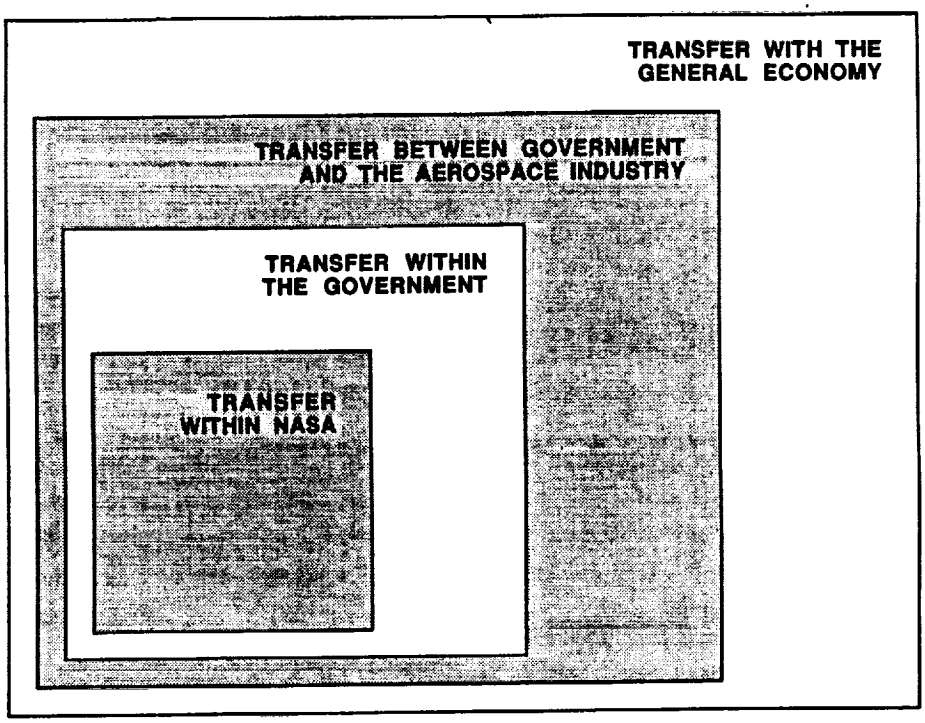
  — Identify Potential Additional Actions That Could Be Taken To Increase The Effectiveness Of Civil Space Technology Investmens

MARCH 17, 1992
JCM-7964

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Technology Transfer Arenas

OAST

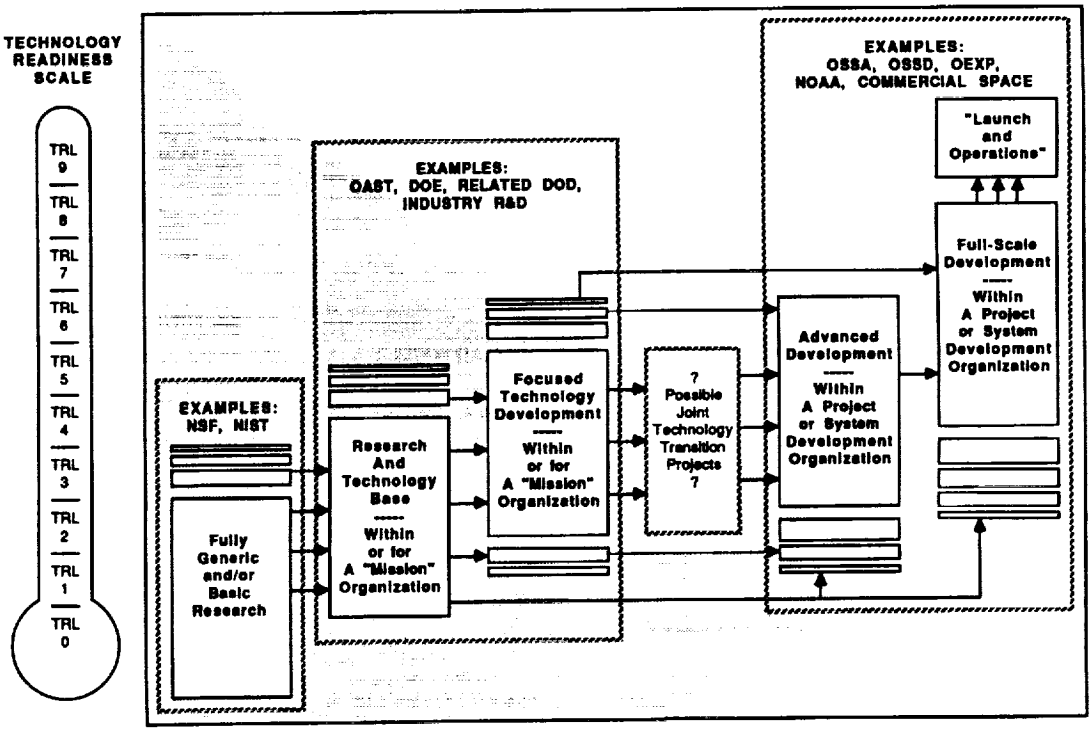


MARCH 17, 1992
JCM-7959

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Generic Technology Maturation Model

OAST



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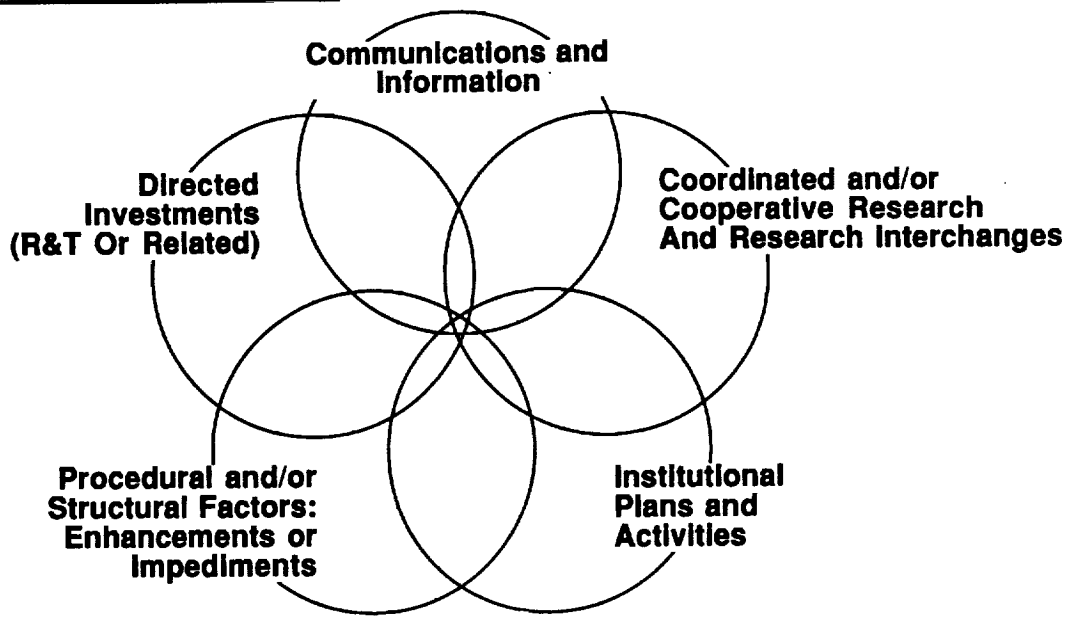
JCM-7971

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Technology Transfer Strategic Areas

OAST

Proposed Framework



MARCH 17, 1992
JCM-7970

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Working Panel "Chair" Role

OAST

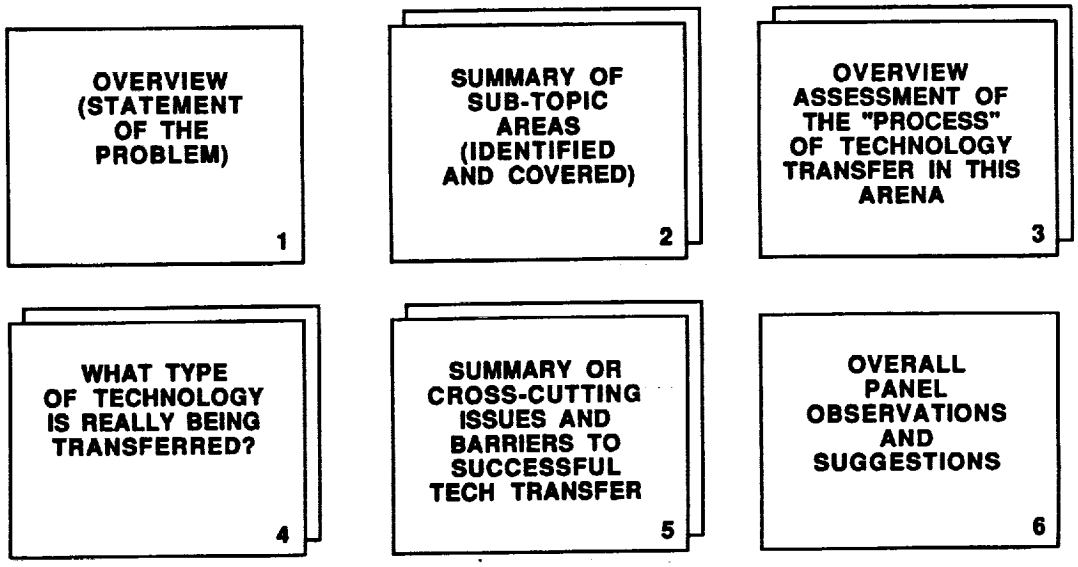
- GUIDE OVERALL WORKING PANEL DISCUSSION, WITH SUPPORT FROM RAPPORTEURS, COORDINATORS
- ASSURE THAT THE RIGHT SUB-TOPICS ARE COVERED
  - ALSO ASSURE THAT KEY ISSUES AND ALL PERSPECTIVES AT PANEL DISCUSSION ARE CAPTURED
- IDENTIFY OVERARCHING ISSUES AND THINK ABOUT OVERALL PROCESS IN THE ARENA
- RECORD WORKING PANEL DISCUSSION AND CONCLUSIONS (OVERALL)
  - I.E., PULL TOGETHER PANEL SUMMARY FOR WORKSHOP REPORT (PROVIDED TO THE COORDINATOR) AND PREPARE CHARTS FOR USE IN CLOSING PLENARY SESSION PRESENTATION
- PRESENT WORKING PANEL RESULTS OVERVIEW DURING THE THURSDAY MORNING PLENARY SESSION

MARCH 17, 1992
JCM-7954

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

"Panel Chair" Report Suggested Format

OAST



MARCH 17, 1992
JCM-7954a

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Working Panel "Sub-Topic Rapporteur" Role

OAST

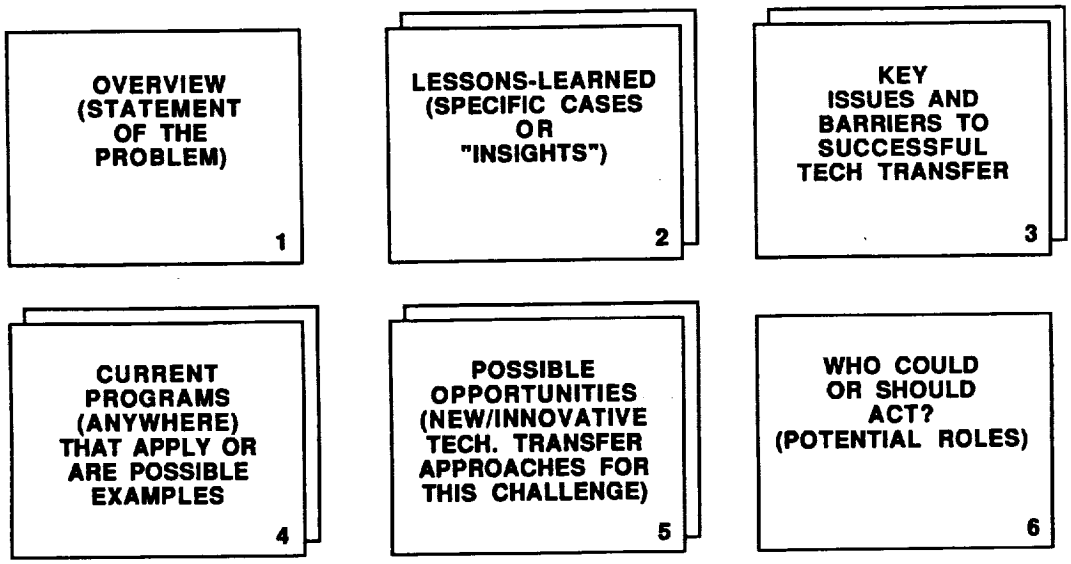
- SUPPORT THE WORKING PANEL CHAIR AS REQUIRED IN ASSEMBLING THE OVERALL REPORT FROM THE PANEL
- GUIDE WORKING PANEL DISCUSSION OF ONE OF THE SUB-TOPICS (AS ASSIGNED)
  - E.G., ASSURE KEY ISSUES AS WELL AS CURRENT TECHNOLOGY TRANSFER PROGRAMS ARE IDENTIFIED
- IDENTIFY TOPICS/ISSUES THAT MAY ARISE IN THE DISCUSSION OF OTHER SUB-TOPICS THAT BEAR HIS/HER SUBJECT
  - E.G., LOOK FOR CORRELATIONS ACROSS THE FULL COURSE OF THE WORKING PANEL DISCUSSION
- RECORD WORKING PANEL DISCUSSION AND CONCLUSIONS FOR THE SUB-TOPIC
  - I.E., PULL TOGETHER MATERIAL FOR WORKSHOP REPORT (WHICH ARE PROVIDED TO THE COORDINATOR) AND PREPARE CHARTS FOR USE IN CLOSING PLENARY SESSION PRESENTATION
- PRESENT WORKING PANEL RESULTS ON A PARTICULAR SUB-TOPIC DURING THE THURSDAY MORNING PLENARY SESSION

MARCH 17, 1992
JCM-7968

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

"Sub-Topic Rapporteur" Report Suggested Format

OAST



MARCH 17, 1992
JCM-7968

TECHNOLOGY TRANSFER AND THE CIVIL SPACE PROGRAM

Working Panel Coordinator Role

OAST

- SUPPORT THE WORKING PANEL CHAIR, SUB-TOPIC RAPPORTEURS, AND MEMBERS AS REQUIRED
- MAINTAIN WORKING PANEL ATTENDANCE RECORDS
- COLLECT ALL WORKING GROUP MATERIALS
  - E.G., PREPARED PRESENTATIONS, MATERIALS PREPARED DURING THE PANEL DISCUSSION
- TIMEKEEPER FOR THE WORKING PANEL DISCUSSION
  - E.G., BASED ON SUBTOPICS AGREED-TO AT BEGINNING OF PANEL, ASSURE EACH SUBJECT IS GIVEN SOME TIME IN DISCUSSION
- MANAGE "ISSUES TO BE CONSIDERED", ETC.
  - E.G., DISTRIBUTE AND COLLECT ITBC'S (OR OTHER FORMS) DURING THE COURSE OF THE PANEL DISCUSSION
- ASSURE WORKING PANEL DISCUSSION DOESN'T "STALL"
  - E.G., SEEK ASSISTANCE FOR A QUESTION OF PROTOCOL, OR USE "ITBC'S" TO FACILITATE TRANSITION TO NEW SUBJECT

MARCH 17, 1992
JCM-7968

OMIT

R. Working Panel #1: Tech Transfer Within NASA

Theodore R. Simpson
General Research Corporation

OMIT

The following participants of the workshop were members of this panel:

Individual	Organization
Acuna, Dr. Mario	Goddard Space Flight Center
Bott, Robert	McDonnell Douglas
Handley, Thomas	JPL
Hartman, Steven	NASA Headquarters
Hops, Larry	Idaho National Engr. Lab.
Plotkin, Dr. Henry	Goddard Space Flight Center
St. Cyr, Dr. William	Stennis Space Center
Simpson, Theodore	General Research Corporation
Spann, Robert	Johnson Space Center
Zombeck, Dr. Martin	Harvard/Smithsonian Center for Astrophysics

Dr. St. Cyr was the Chairman of the panel, Dr. Plotkin was the Rapporteur of Subtopic A, and Dr. Acuna was the Rapporteur of Subtopic B. Dr. Zombeck replaced Dr. Acuna on the last day of the conference. Mr. Simpson was the Facilitator for the panel.

The panel agreed to consider two subtopics:

A. The "classical problem: technology transfer within an organization (and across organization lines/codes), and

B. Space science/instrument technology, and the role of universities in the technology development/transfer process.

Dr. Plotkin made a presentation on *Technology Transfer Within the Goddard Space Flight Center* (his charts are in Section R1), and Dr. Acuna made a presentation on *Technology Transfer and Space Science Missions* (Section R2). This was followed by a general discussion, during which Mr. Hartman made a presentation on *Technology Coordination* (Section R3), and Mr. Handley made a presentation on *Technology Transfer* (Section R4).

Mr. Handley also wrote up two Issues To Be Considered (ITBCs):

1. How will Code S and Code R fund, manage, select, etc. the "technical transition projects" illustrated in the NASA Civil Space Technology Maturation Strategy -- see the figure on Page 14 of Section A.

2. As Code R sends more funds to its own centers, NASA needs a better technology transfer process between its centers.

Dr. Acuna wrote up one ITBC: Technology transfer should be a two-way street within NASA.

These three ITBCs are included with the other ITBCs in Section FF.

On the following morning, Drs. St. Cyr, Plotkin and Zombeck each made presentations on the panel's conclusions and recommendations at a plenary session (see Section R5 for their charts).

In assessing the group's feeling about technology transfer within NASA, Dr. St. Cyr concluded that:

1. It was a hit or miss situation, i.e., sometimes new technology was successfully transferred, but not always,

2. There was on NASA-wide tech transfer process in place,

3. There was no incentive for a manager to use new technology,

4. Project management usually tried to reduce any risk of failure, so that it would avoid using new technology unless required to do so, and

5. The RTOP process has no tech transfer objectives.

TECHNOLOGY TRANSFER

within the

NASA GODDARD SPACE FLIGHT CENTER

presented to

CIVIL SPACE TECHNOLOGY DEVELOPMENT

a workshop on

TECHNOLOGY TRANSFER AND EFFECTIVENESS

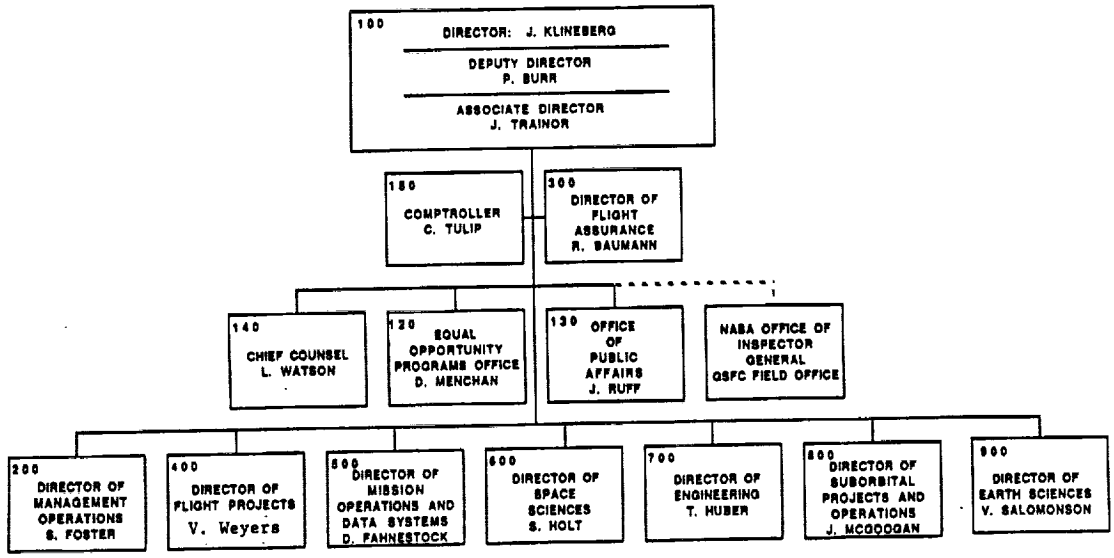
March 18, 1992

Henry H. Plotkin
Assistant Director of Engineering for
Development Projects

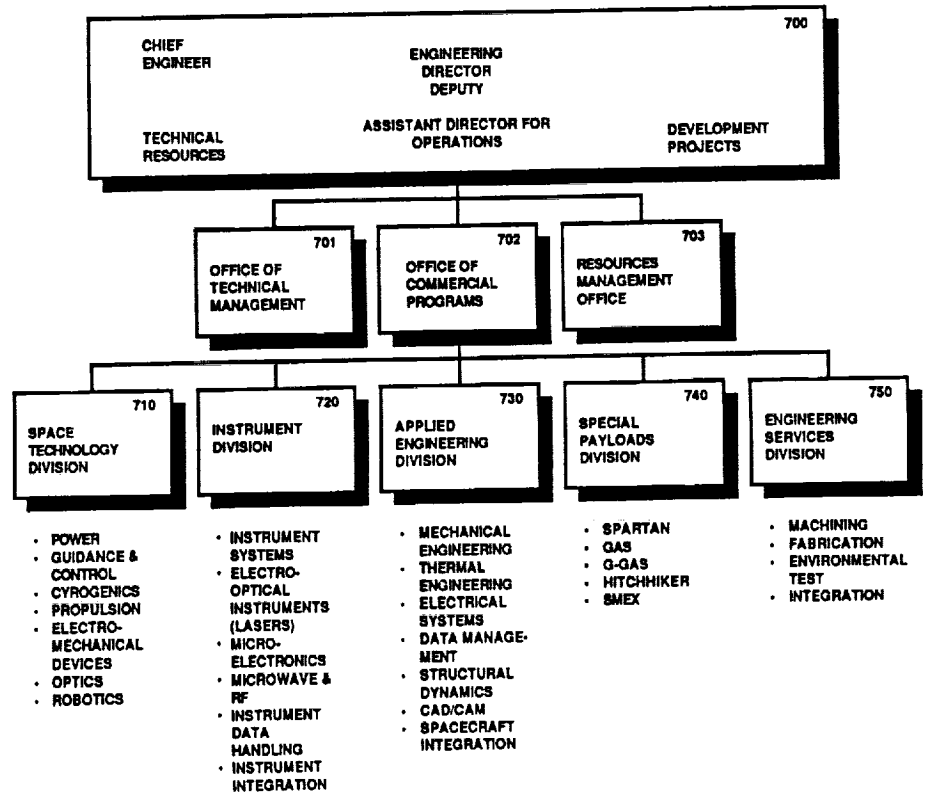
OBSTACLES TO TECHNOLOGY TRANSFER - I

- Goddard principal functions are:
  - Development, Flight, and operation of earth-orbiting spacecraft and instruments for earth and space sciences
  - Carrying out a comprehensive program in the earth and space science
  - Developing and operating the network for mission control and data acquisition
  - Conducting analysis, interpretation, and modelling, involving massive volumes of data
- Goddard has a relatively modest role in developing advanced technology directly relevant to our missions and where we have particularly strong skills.
- Goddard missions must incorporate beneficial new technology developed in-house, at other NASA centers, or outside NASA.

GODDARD SPACE FLIGHT CENTER



ENGINEERING DIRECTORATE



GSFC

AS00361-R

OBSTACLES TO TECHNOLOGY TRANSFER - II

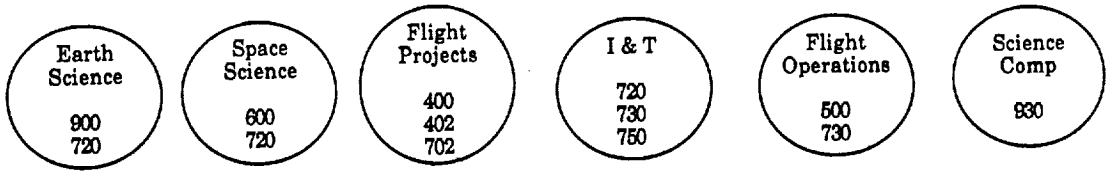
- Space Flight project manager has little incentive to incorporate new technology
  - Increased perceived risk and up-front costs are serious detriments
  - Objectives are to meet performance specs, not to exceed them or to reduce life-cycle costs
  - Reluctance to fly un-proven (i.e., in-flight) technology
- Scientists develop plans and algorithms based on existing technology: efficiencies and cost reduction are considered undesireable in light of the uncertainties of research.
  - The up-front cost of new technology may become cost-effective during later operational phases.

TECHNOLOGY TRANSFER IMPROVEMENT PROGRAM AT GSFC: Communication between Technology Developers and Users

- Establish committee of technologists to study strategic plans of User organizations: infer technology needs; performance goals expected to strain capabilities.
- Conduct an in-house Symposium/Workshop to present the on-going technology program (both in-house and NASA-wide) to the GSFC user community: products, delivery dates, expected benefits.
- Conduct (separate) meetings of technologist committee with key user points-of-contact: evaluate program with respect to user strategic vision. Recommend revisions, deletions augmentations.
- Repeat technology workshop annually: obtain feedback on relevance, quality, and utility.

TECHNOLOGY TRANSFER WORKSHOP

Technology Users



Technology Development

		Network and Operations Automation
		Flight Data Systems
Code	500	Scientific Computation
	600	Thermal Control
	700	Structural Dynamics
	900	Science Remote Sensing
		Telerobotics
		Space Communications
		Optics

USER FEEDBACK TO TECHNOLOGISTS: Joint Actions

- Feedback
  - Will the users accept new technology products if successful?
  - Which missions will benefit? When?
  - Should program be adjusted so as to be more relevant?
- Steps necessary to implement new technology
  - Demonstration in test beds, field experiments, aircraft, shuttle experiments
  - Plans for joint transfer process: Co-funding, off-line new technology in operational environment.
- Prepare individual "white papers" proposing specific actions: e.g., demonstrations.
  - Obtain Project concurrence for implementation
  - Enlist HQ support

TECHNOLOGY TRANSFER AND SPACE SCIENCE MISSIONS

DR. MARIO ACUNA

TECHNOLOGY TRANSFER WORKSHOP
SPACE SCIENCE MISSIONS

- PROJECT SCIENTIST ROLE WITHIN NASA:

  PROVIDE SCIENTIFIC LEADERSHIP FOR PROJECT

  PROVIDE SCIENCE GUIDANCE IN RESOURCE ALLOCATION AND TECHNICAL TRADEOFFS

  OVERSEE THE DEVELOPMENT AND IMPLEMENTATION OF A SYSTEM THAT ENSURES THE PROMPT ANALYSIS OF THE DATA AND DISSEMINATION OF RESULTS TO THE SCIENCE COMMUNITY AND PUBLIC AT LARGE.

  REPRESENT THE SCIENCE INVESTIGATIONS TO THE PROJECT OFFICE.

- ROLE OF UNIVERSITIES IN TECH. TRANSFER

MHA-1

TECHNOLOGY TRANSFER WORKSHOP
SPACE SCIENCE MISSIONS

- WHAT ARE THE TECHNOLOGY PROBLEMS IN SCIENCE TODAY ? - "FASTER, CHEAPER, MORE OFTEN" - WILL IT SOLVE THEM ?
- FUNDAMENTAL PROBLEM IS THE HIGH COST OF DOING SIMPLE THINGS, HIGH TECHNOLOGY NOT NEEDED:

  EMPHASIS IS ON "PROCESS" NOT PRODUCT. POOR ACCOUNTABILITY FOR PRODUCTIVITY. EXPENSIVE "SERVICE" STRUCTURES IN PLACE REGARDLESS OF NEED.

  POOR TECHNOLOGICAL RISK ASSESSMENT AND MANAGEMENT. DELEGATION OF RISK EVALUATION TO ORGANIZATIONS WITHOUT VESTED INTEREST IN PRODUCT. INEXPERIENCED WORK FORCE NOW IN PLACE. HAVE TO "REDISCOVER" PREVIOUS TECHNOLOGY.

  PROGRAM DEVELOPMENT CYCLE IS TOO LONG - HARDWARE IS CHEAP, INDECISIONS ARE EXPENSIVE.

MHA-3

TECHNOLOGY TRANSFER WORKSHOP
SPACE SCIENCE MISSIONS

- RIGID CONTRACTUAL ARRANGEMENTS THAT PRECLUDE CREATIVITY AND EFFECTIVE EXCHANGE OF IDEAS. MANAGEMENT AND ACCOUNTING OVERHEAD ARE KILLING THE SMALL, IMAGINATIVE AND PRODUCTIVE RESEARCH GROUPS.
- SCIENCE "YIELD" PER DOLLAR SPENT IS AT AN ALL-TIME LOW. 2-3 MISSIONS/YEAR IN 1966-76 TODAY: ONE MISSION EVERY 5-10 YEARS. TECHNOLOGY TRANSFER IS NOT THE DRIVER.
- HOW MUCH TECHNOLOGY IS TRANSFERRED FROM THE ACADEMIC SCIENCE ENVIRONMENT TO INDUSTRY AS A RESULT OF NASA SPONSORED SPACE RESEARCH? VERY HARD TO ESTIMATE - PROBABLY NOT MUCH. BUT SCIENCE NEEDS TEND TO ACT AS POWERFUL CATALYST FOR TRIGGERING RESEARCH AND DEVELOPMENT EFFORTS IN INDUSTRY.

MHA-4

TECHNOLOGY TRANSFER WORKSHOP
SPACE SCIENCE MISSIONS

- ROLE OF GOVERNMENT LABORATORIES IN RESEARCH:

  WHERE EXPERIENCE EXISTS, PROVIDE GUIDANCE TO INDUSTRY IN NON-TRADITIONAL" TECHNOLOGIES (I.E., RADIATION EFFECTS, MAGNETIC CLEANLINESS, EMC/EMI, ETC.)

  PROVIDE A RISK CONTROL/EXPOSURE ENVIRONMENT NOT AVAILABLE TO INDUSTRY (FACILITIES, DEVICES, ETC.)

- PROBLEMS OF CONFLICT OF INTEREST -
  DIRECT SOLUTION -

MHA-5

TECHNOLOGY TRANSFER WORKSHOP
SPACE SCIENCE MISSIONS

- TECHNOLOGY ISSUES ASSOCIATED WITH SCIENCE:

  SCIENCE IS FUNDAMENTALLY A NET TECHNOLOGY USER - ADAPTED TO RESEARCH GOALS AND NEEDS.

  IN SOME INSTANCES, TECHNOLOGY DRIVER, BUT IT IS RARE.

  "MARKET" IS SMALL AND UNPREDICTABLE, HIGH RISK HIGH VISIBILITY.

  ORGANIZATIONS INVOLVED ARE VERY DIVERSE AND REFLECT A VERY LARGE DYNAMIC RANGE.

- EXAMPLES FROM THE INTERNATIONAL SOLAR TERRESTRIAL PHYSICS PROGRAM: 2000 SCIENTISTS, EIGHT SPACECRAFT, USA, JAPAN, EUROPE, "FSU" INVOLVEMENT.

MHA-2

TECHNOLOGY COORDINATION

STEVEN HARTMAN

TECHNOLOGY COORDINATION PROCESS TO DATE

- ANNUAL TECHNOLOGY PRIORITIZATION SINCE 1987
- OAST LONG RANGE PLAN -- THRUSTS TIED TO OSSA STRATEGIC PLAN
- LIAISON ASSIGNED FROM OAST TO OSSA
- AUGUSTINE REPORT -- INTEGRATED TECHNOLOGY PLAN
- OSSA GRASS ROOTS TECHNOLOGY NEEDS PRIORITIZATION
- EXTERNAL REVIEW (OSSA PARTICIPATION) OF ITP
- OSSA/SSAAC WOODS HOLE 1991 RETREAT TO REVIEW OSSA MISSIONS
- INCREASED EFFECTIVENESS IN TECHNOLOGY INFORMATION EXCHANGE
- SSB/ASEB SPRING REVIEW OF OSSA TECHNOLOGY NEEDS CHART

TECHNOLOGY COORDINATION GOALS

- INJECT NEW TECHNOLOGY INTO OSSA NEXT-GENERATION OF MISSIONS
- MODIFY CURRENT OAST PROGRAM TO BE MORE RESPONSIVE TO OSSA NEAR-TERM NEEDS
- INSTITUTIONALIZE THE PROCESS FROM WHICH TECHNOLOGY REQUIREMENTS ARE INITIATED-- VIA THE INTEGRATED TECHNOLOGY PLAN
- INCREASE THE INTERCHANGE OF SCIENCE AND ENGINEERING PERSONNEL ON OSSA SCIENCE WORKING GROUPS AND OAST TECHNOLOGY WORKING GROUPS

How OAST Can Support OSSA

- FOCUSSED TECHNOLOGY DEVELOPMENT AIMED AT SPECIFIC MISSIONS IN THE OSSA STRATEGIC PLAN
- LONG-TERM, CORE TECHNOLOGY DEVELOPMENT TO ENABLE SMALL AND MODERATE MISSIONS
- INTEGRATED TECHNOLOGY GROUND & FLIGHT DEMONSTRATIONS
- BROADEN PARTICIPATION IN NEW INSTRUMENT TECHNOLOGY PROGRAMS TO INCLUDE A PEER SELECTED UNIVERSITY SCIENCE COMMUNITY
- STRONGER FEEDBACK OF OAST TECHNOLOGY PROGRESS AND MILESTONE ACCOMPLISHMENTS

How OSSA Can Support OAST

- ADHERE TO AN ANNUAL GRASSROOTS TECHNOLOGY NEEDS PROCESS
- ASSIST OAST TO SECURE RESOURCES THAT ARE DIRECTED TOWARD THE HIGHEST PRIORITY OSSA TECHNOLOGY NEEDS
- FORECAST START DATES FOR THE >1998 MISSION QUE
- HELP IDENTIFY FLIGHT EXPERIMENTS AND OPPORTUNITIES TO TEST CRITICAL INSTRUMENT TECHNOLOGIES

STEPS TO TECHNOLOGY TRANSFER

- SELECT A DISCRETE SET OF TECHNOLOGIES THAT ARE OF HIGH PRIORITY TO OSSA
- AA CONCURRENCE ON A TECHNOLOGY TRANSFER PLAN FOR EACH
- GROUND AND/OR FLIGHT DEMONSTRATION TECHNOLOGY PROJECTS FOR EACH
- DEVELOP A CO-FUNDING WEDGE BETWEEN THE PROGRAM OFFICES
- JOINT ASSOCIATE ADMINISTRATOR SEMI-ANNUAL REVIEW OF PROGRESS
- INSTITUTE A TECHNOLOGY TRANSFER TEAM OR PERSON RESPONSIBLE FOR:
  - PUSHING THE TECHNOLOGY TO THE APPROPRIATE READINESS LEVEL
  - MARKETING THE TECHNOLOGY FOR MISSION APPLICATIONS

Recommended Decision Rules

In Priority Order:

- **Complete** the Ongoing Program
- **Provide** Frequent Access to Space for Each Discipline Through New and Expanded Programs of "Small Innovative Missions"
- **Initiate** Mix of "Intermediate/Moderate Profile" Missions to Ensure a Continuous and Balanced Stream of Scientific Results
- **Initiate** "Flagship" Missions that Provide Scientific Leadership and have Broad Public Appeal
- **Invest** in the Future by Increasing the Research Base to Improve Program Vitality and by Developing Needed Future Technologies
- **Build and Utilize** Scientific Instrumentation for Space Station Freedom and **Conduct** a Spacelab Flight Program in a Manner Consistent with the SSF Development Schedule

SP
2/6

TECHNOLOGY TRANSFER

Tom Handley

JPL

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

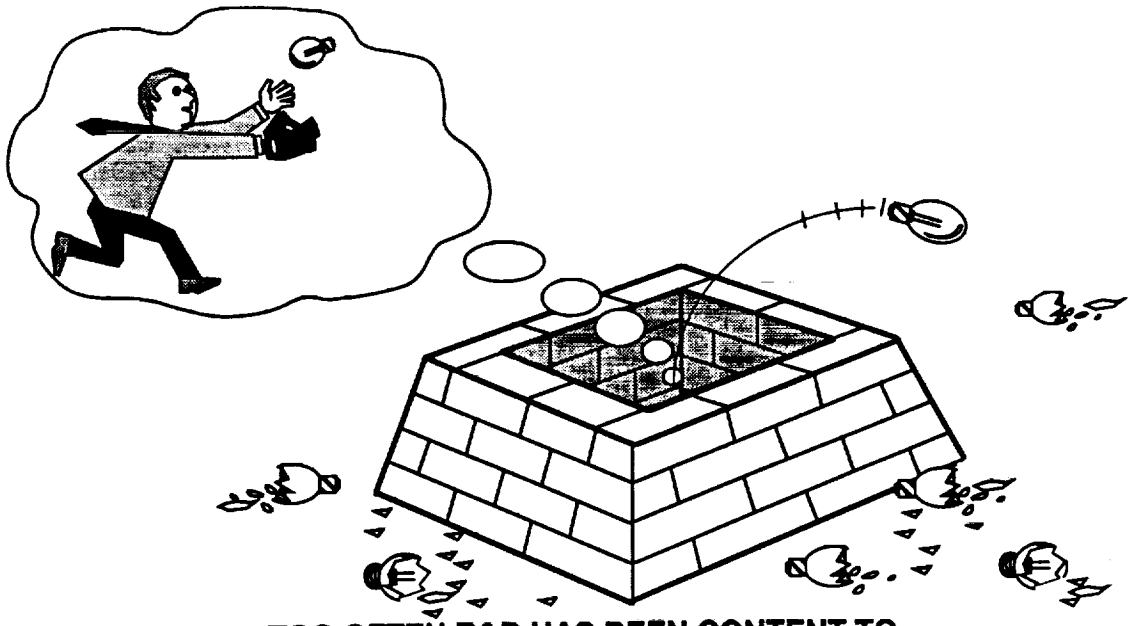
JPL

TECHNOLOGY TRANSFER DEFINITION

- THE TRANSFER OF ORGANIZED KNOWLEDGE TO A PROJECT OR PROGRAM FOR THE EVENTUAL PURPOSE OF PRODUCING NEW OR IMPROVED, PRODUCTS, PROCESSES OR SERVICES.

- TRANSFER WILL OCCUR THROUGH ONE, OR MORE, OF THE FOLLOWING MODES:
  - OCCASIONAL CONSULTING
  - DOCUMENTATION (REPORTS, ASSESSMENTS, PROGRAMS, OR DRAWINGS)
  - TRAINING (ON-THE-JOB, ON-SITE OR ELSEWHERE)
  - DEMONSTRATION (PROOF-OF-PRINCIPLE OR APPLICATION TO A REAL-WORLD PROBLEM)
  - COLLABORATIVE TECHNICAL WORK.

JPL TRADITIONAL TECHNOLOGY TRANSFER



TOO OFTEN R&D HAS BEEN CONTENT TO 'THROW ITS PRODUCT OVER THE WALL AND HOPE SOMEONE WILL CATCH IT.'

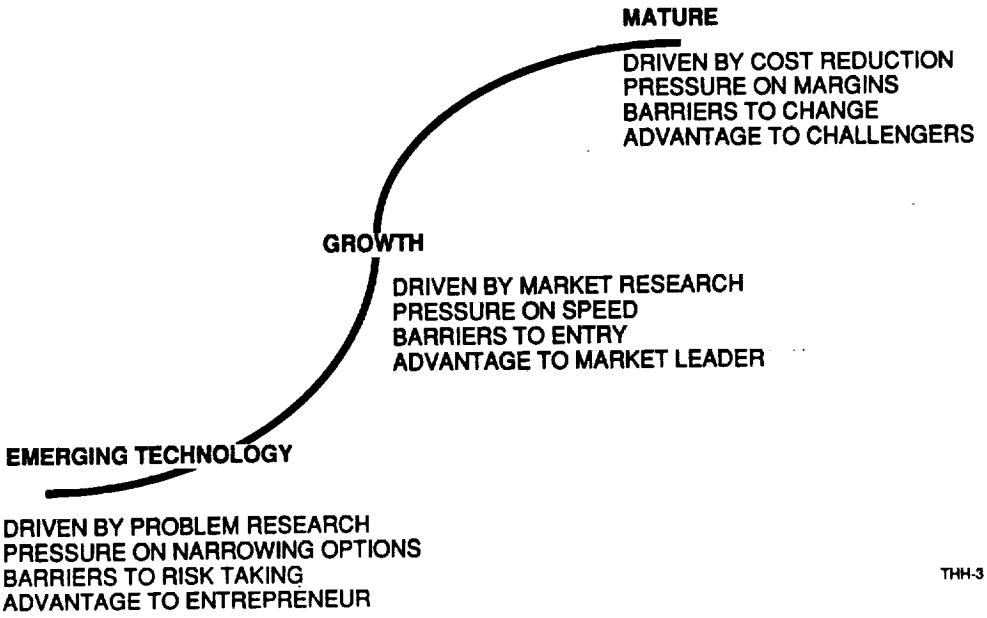
THH-2

JPL "BOTH SIDES OF THE FENCE"

ADVANCED DEVELOPMENT	IMPLEMENTATION OR PRODUCTION
• TECHNICAL MANAGEMENT WITH ASSISTANT ENGINEERS	• PRODUCT MANUFACTURING MANAGEMENT WITH SUSTAINING ENGINEERING CORE
• WORK PERFORMED BY SPECIALISTS AND TECHNOLOGISTS	• WORK DONE BY ENGINEERS AND TRAINED PERSONNEL
• FLEXIBLE OPERATIONS AND INTERACTION	• ORGANIZED PRODUCTION
• TIGHT CONTROL POSSIBLE	• MANUFACTURING TOLERANCE NECESSARY
• SMALL THROUGHPUT AND VOLUME	• LARGE THROUGHPUT AND VOLUME
• LOW INERTIA	• HIGH INERTIA
• DEDICATED ATTENTION	• LARGE BATCH "PHILOSOPHY"
• JUDGEMENT CRITERIA	• PASS/FAIL CRITERIA
• EXTENSIVE REWORK PRACTICAL	• REWORK DISRUPTIVE, UNINTERRUPTED FLOWS, STAGING DELAYS
• FLEXIBLE EQUIPMENT	• NARROW LATITUDE, SEVERAL SHIFT CONTINUOUS OPERATIONS SYSTEMS
• LITTLE DOCUMENTATION - DATA INTENSIVE	• EXTENSIVE DOCUMENTATION - DATA/ OPERATIONS INTENSIVE
• COST NOT PRIMARY	• COST PRIMARY
• CHANGES ROUTINE, EASILY IMPLEMENTED	• CHANGES DIFFICULT TO IMPLEMENT
• REAL-TIME ANALYSIS, TRACEABILITY, AND FEEDBACK	• NON-ROUTINE ANALYSIS DIFFICULT, FEEDBACK DELAY RESULTS IN LOSSES
• QA SEPARABLE FUNCTIONS	• QA NECESSARILY INTEGRAL

THH-4

JPL IMPLICATIONS OF TECHNOLOGY MATURITY



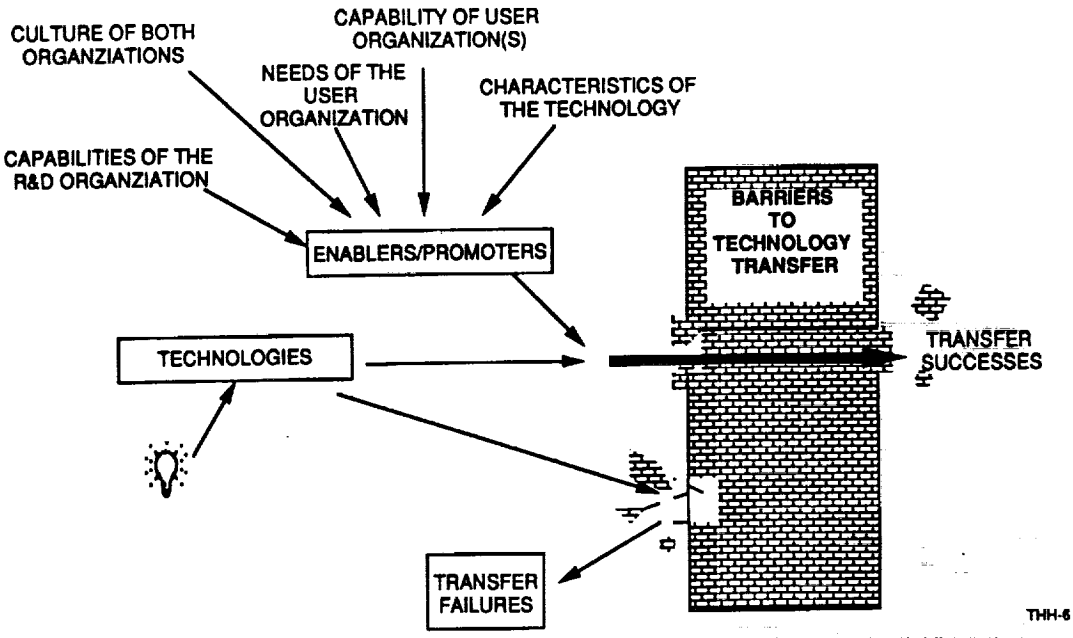
THH-3

JPL SIMPLIFIED LOOK AT BOTH SIDES

ISSUE	TECHNOLOGY OR ADVANCED DEVELOPMENT	IMPLEMENTATION OR PRODUCTION
• MANAGEMENT	• TECHNICALLY ORIENTED	• PRODUCT ORIENTED
• STAFFING	• TECHNOLOGIST AND SPECIALISTS	• ENGINEERS AND PRODUCTION PERSONNEL
• THROUGHPUT	• SMALL	• LARGE
• INERTIA	• LOW	• HIGH
• DOCUMENTATION	• MINIMAL	• EXTENSIVE
• COST	• NOT PRIMARY	• PRIMARY

THH-5

JPL TOMORROW'S TECHNOLOGY TRANSFER



JPL Barriers

- The user community lacks a process to identify common technology requirements

- The user community lacks a vehicle to exert the collective leverage to cause JPL/NASA to implement common design.

- Resources invested in existing systems and applications, and the attitude and culture of the work force make it difficult to evolve to new technologies.

- Current practices encourage a tactical approach to solving technical problems while ignoring key strategic (i.e. long term) issues.

- There are inadequate incentives fostering the insertion of new technology in to new missions. The linkage between technology payback and achieving missions goals is not strong.

- Fear of being unable to complete a mission (on-time, within budget, and meeting mission goals) using "newer" technology.

- There is no documented, coherent JPL/NASA vision for broad-based technology integration and the role of technology transfer in achieving that vision.

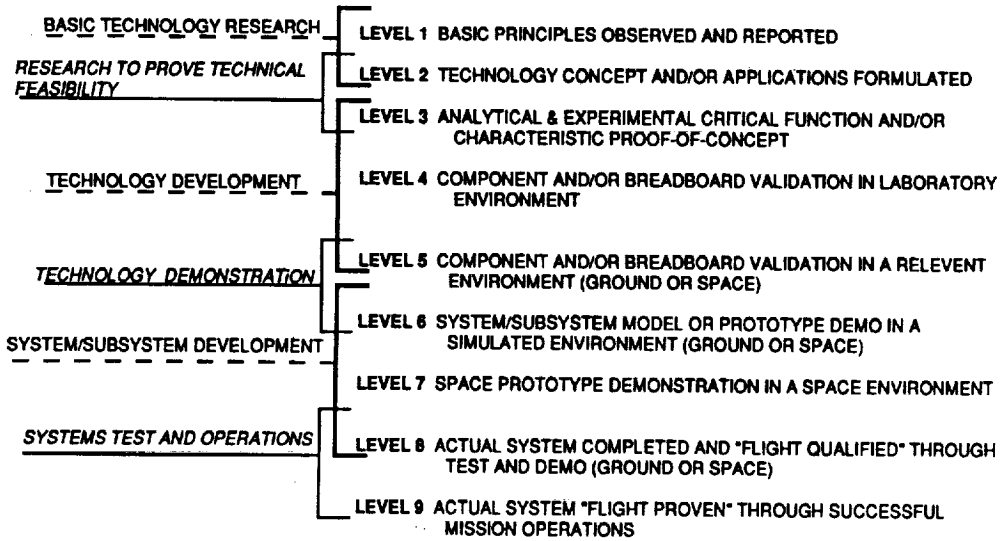
THH-6a

JPL Barriers (cont'd)

- There is no shared vision for developing a technology transfer process.
- Transfer is further complicated by the fact that oft times capabilities rather than specific products must be transferred.
- With today's projects, you cannot simultaneously accept a "fixed-priced" contract from Congress to develop a major undertaking and at the same time support technology development and the unavoidable attendant risks, i.e. cost uncertainty.
- Inadequate staffing by engineering. A common response to the suggestion for new technology is "We do not have anyone here who has the technical skills and knowledge to incorporate this technology into current projects."
- The perception that a technology is too complex will often lead the intended users to question the technology developers credibility.
- NASA does not develop serious plans beyond a five year new start horizon

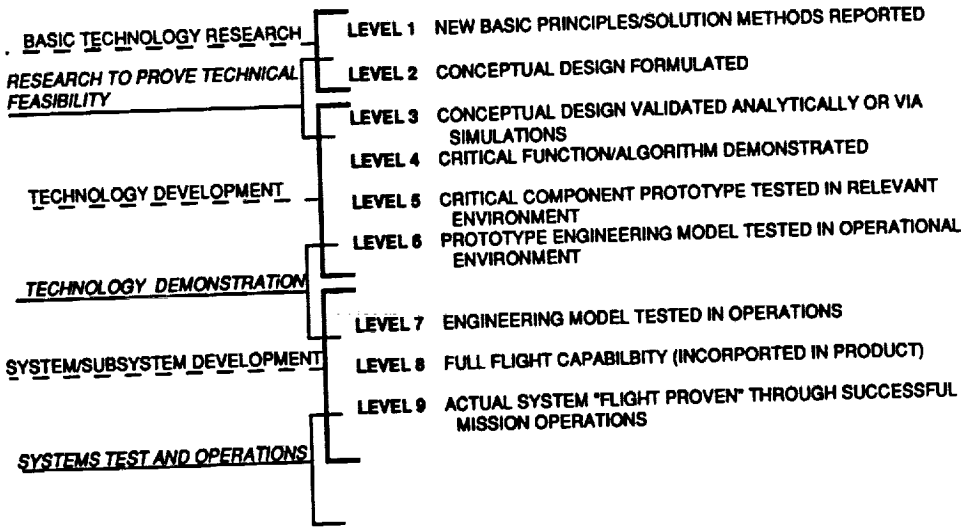
THH-6b

JPL TECHNOLOGY READINESS LEVELS



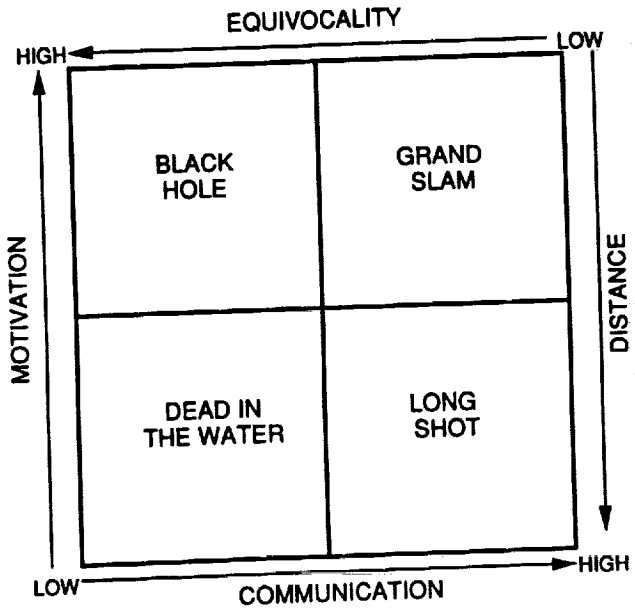
THH-7

JPL SOFTWARE TECHNOLOGY READINESS LEVELS (PROPOSED)



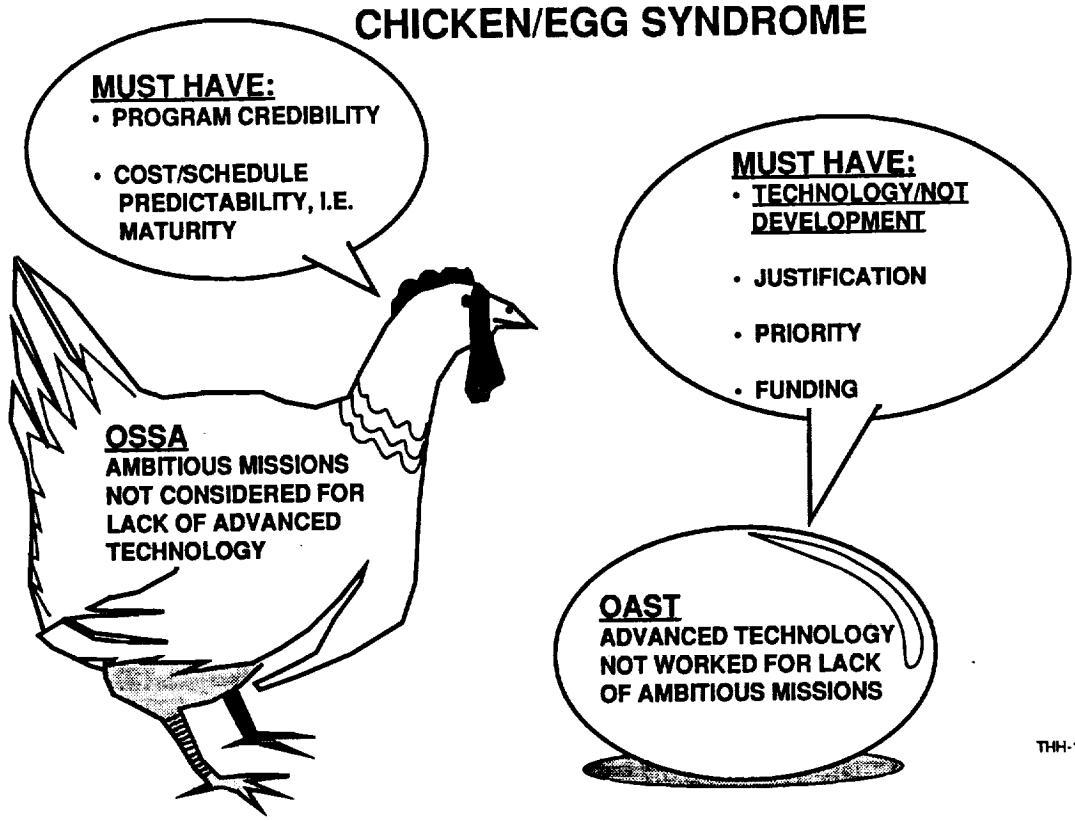
THH-8

JPL TECHNOLOGY TRANSFER MATRIX (FROM A STUDY)



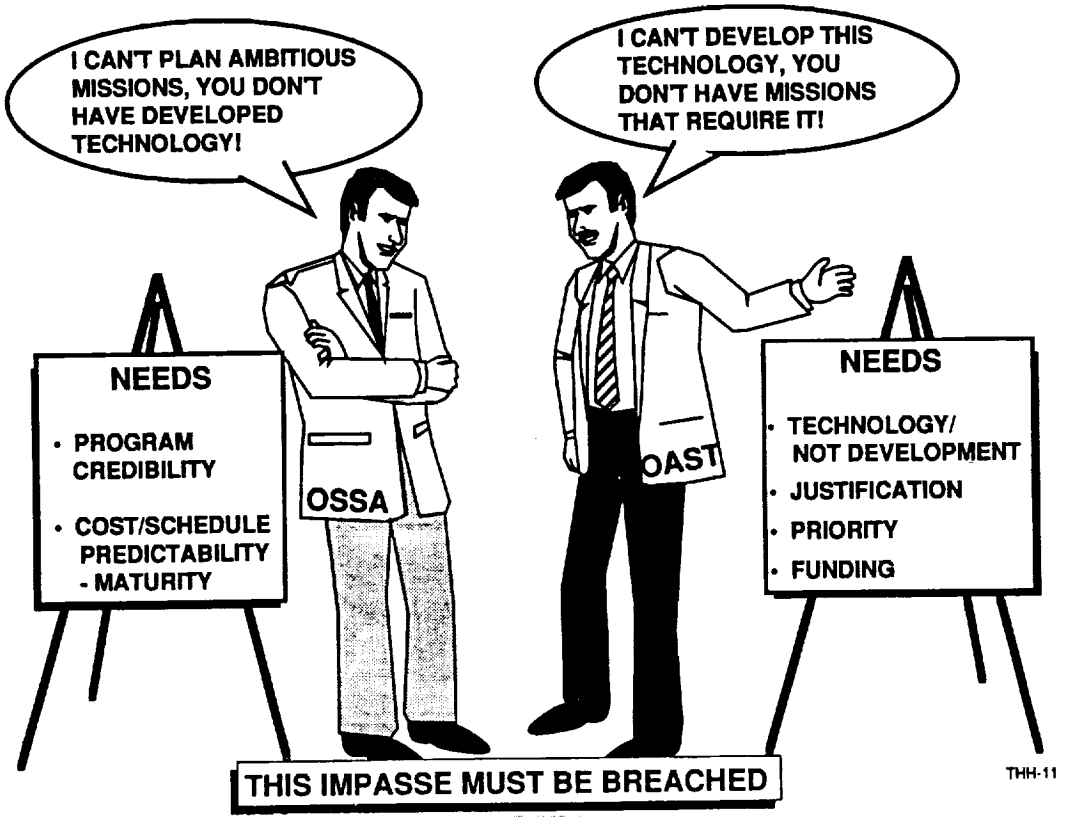
THH-9

JPL WHY? - PART OF THE ANSWER IS THE CHICKEN/EGG SYNDROME



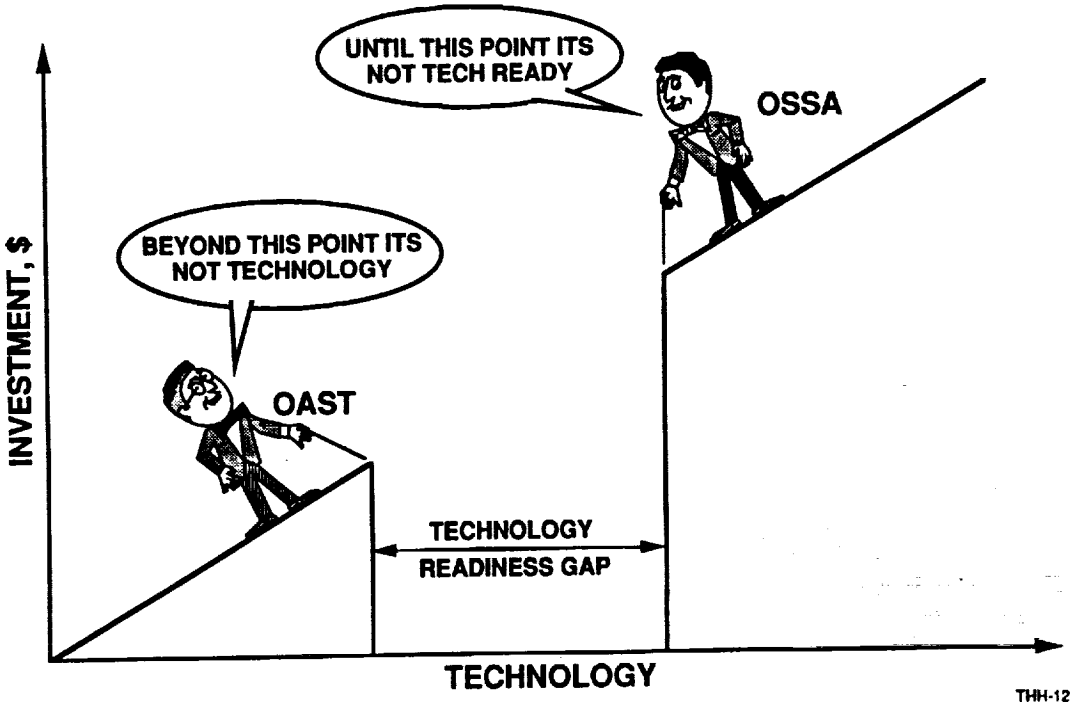
THH-10

JPL WHY? - MUTUALLY EXCLUSIVE PLANNING CRITERIA ARE PART OF THE ANSWER

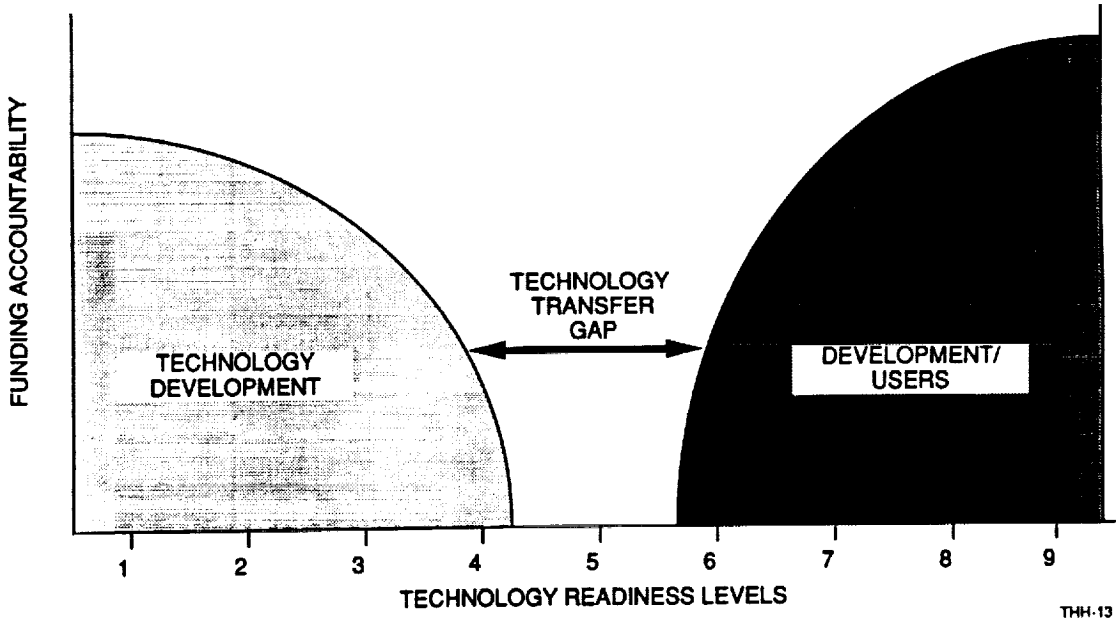


THH-11

JPL WHY? - DIFFERENT VIEWS OF TECHNOLOGY "READINESS" ARE ALSO A PROBLEM

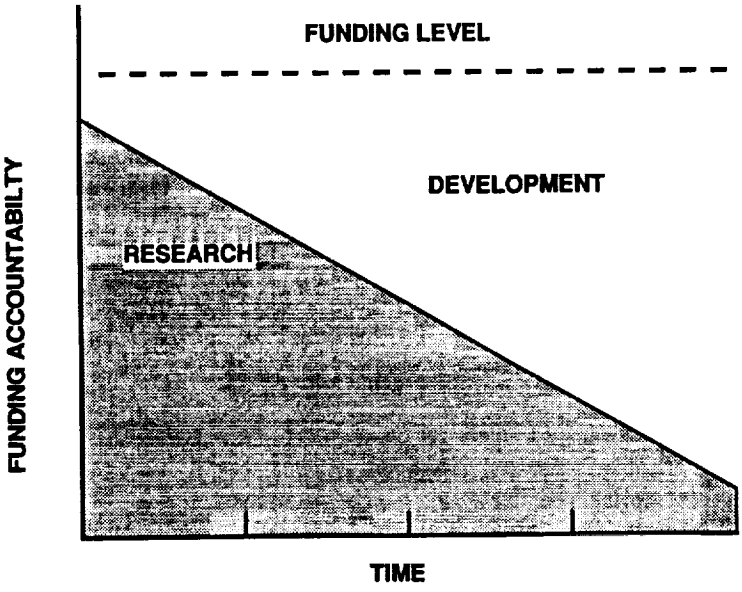


JPL TECHNOLOGY TRANSFER FUNDING GAP



JPL

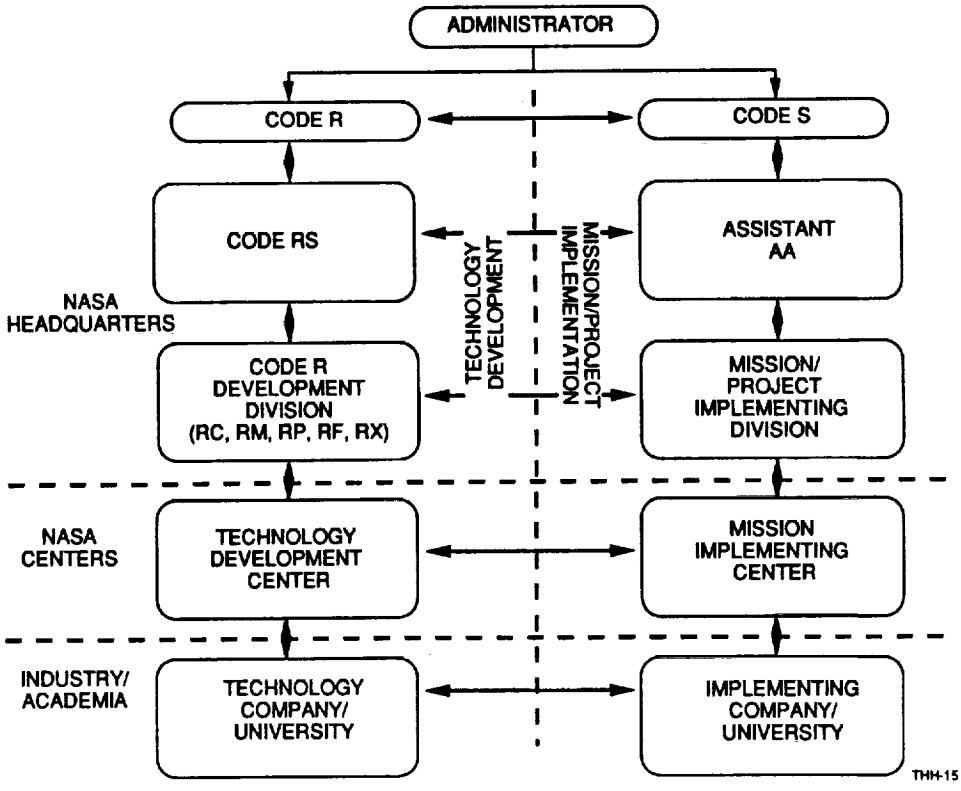
FUNDING PROFILE DURING TECHNOLOGY TRANSFER



THH-14

JPL

NASA TECHNOLOGY TRANSFER INTERFACES



THH-15

JPL

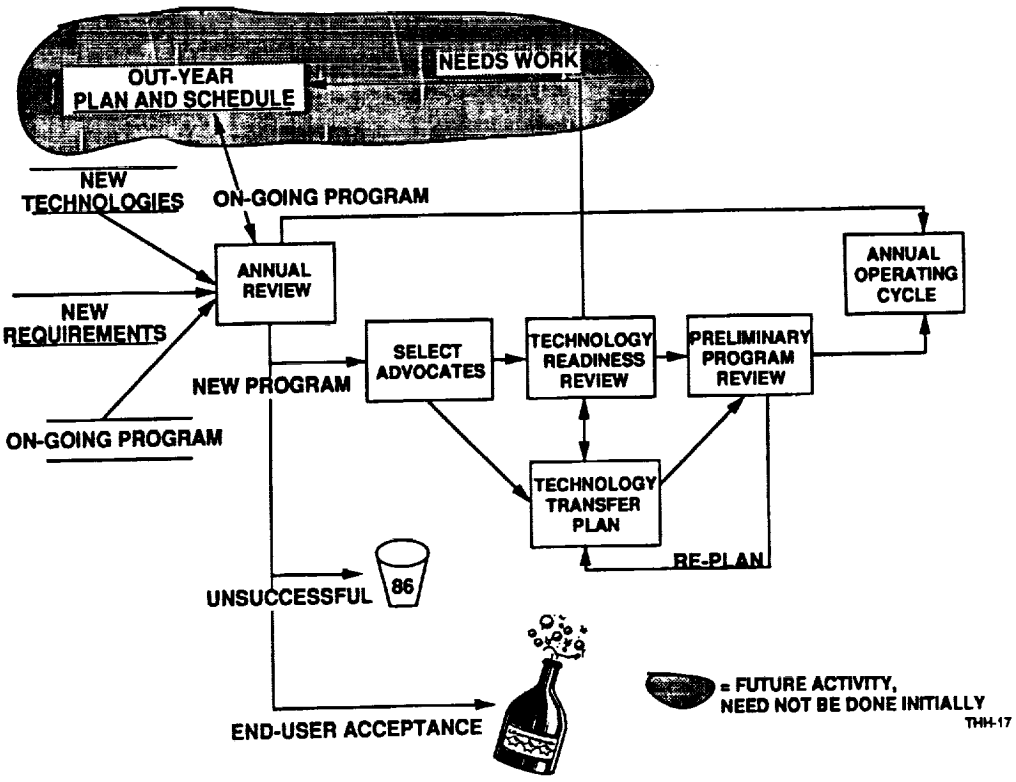
KEY FACTORS

- PLANNING
- USER INVOLVEMENT
- COMMUNICATIONS
- A PROCESS IS REQUIRED
- KNOWING AND ASKING THE RIGHT QUESTIONS
- RESPONSIBILITY AND ACCOUNTABILITY
- FUNDING

THH-16

JPL

TECHNOLOGY TRANSFER PROCESS



THH-17

JPL

THE DO'S

- TREAT THE TECHNOLOGY TRANSFER AS A PERSONAL COMMITMENT. IT IS PEOPLE THAT MAKE PARTNERSHIPS WORK
- ANTICIPATE THAT IT WILL TAKE UP MANAGEMENT TIME. IF YOU CAN NOT SPEND THE TIME, DO NOT START THE TRANSFER
- MUTUAL RESPECT AND TRUST ARE ESSENTIAL. IF YOU DO NOT TRUST THE PEOPLE YOU ARE WORKING WITH, FORGET IT
- REMEMBER THAT BOTH PARTNERS MUST GET SOMETHING OUT OF IT. MUTUAL BENEFIT IS VITAL. THIS WILL PROBABLY MEAN THAT YOU HAVE GOT TO GIVE SOMETHING UP. RECOGNIZE THIS AT THE OUTSET
- DO NOT PUT OFF RESOLVING UNPLEASANT OR CONTENTIOUS ISSUES UNTIL "LATER".

THH-18

JPL

THE DO'S (contd)

- RECOGNIZE THAT DURING THE COURSE OF THE TRANSFER/COLLABORATION, CIRCUMSTANCES AND MARKETS CHANGE. RECOGNIZE YOUR PARTNER'S PROBLEMS AND BE FLEXIBLE
- MAKE SURE THAT YOU AND YOUR PARTNER HAVE MUTUAL EXPECTATIONS OF THE TRANSFER AND ITS TIME SCALE
- GET TO KNOW YOUR OPPOSITE NUMBERS AT ALL LEVELS
- APPRECIATE THE CULTURAL DIFFERENCES. DO NOT EXPECT A PARTNER TO ACT OR RESPOND IDENTICALLY TO YOU
- RECOGNIZE YOUR PARTNER'S INTERESTS AND INDEPENDENCE

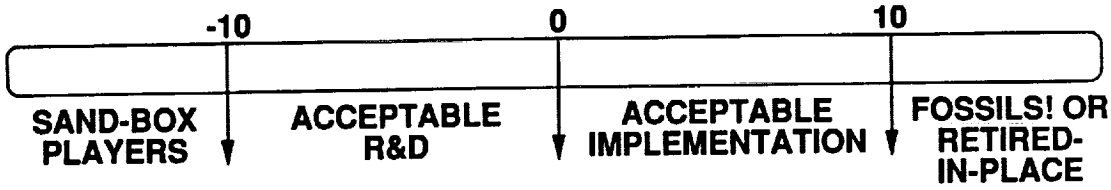
THH-19

MEASURE YOUR BOSS'S RDQ

THE RDQ (RESEARCH AND DEVELOPMENT QUOTIENT) WAS ORIGINALLY DEVELOPED BY WARREN LUSHBAUGH TO EVALUATE JPL ENGINEERS, GROUPS, SECTIONS, ALDs...

DEFINITION:

$$RDQ = 10 \log\left(\frac{\text{NUMBER OF "ATTA BOY" REQUIRED TO CANCEL}}{\text{A SINGLE "OH S..."}}\right)$$



WARNING: ADJUST YOUR OBJECTIVES TO YOUR BOSS'S RDQ

THH-20

Technology Transfer

JPL

Version 2.0
November 11, 1991

Table Of Contents

Figures and Tables

Acknowledgements

Over the course of this research effort, numerous individuals have provided valuable assistance either by reviewing the work in its various stages, or by giving information and advice. I would like particularly to thank the following individuals for their significant contribution

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Larry Preheim
Paul Robinson
Joe Statmen
Amy Walton
Bill Weber

I make no claim that the views expressed herein are necessarily held by them, and I assume full responsibility for any mistakes that may remain.

If you have comments, questions, etc, please contact me :

Tom Handley
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M/S 180-401
(818) 354-7009

1.0 Introduction

At its worst, traditional technology transfer is "tossing the good ideas over the wall to engineering" (see Figure 1). The ideas are not "caught" by the people on the other side; the results: missed opportunities; the technology developer is isolated from the intended user; the technology developer certainly does not know where the user is going; and the intended user does not know the new technology is coming. No wonder that these ideas are not "fielded" by the intended user.

At its best, technology transfer is the process by which both the intended user and technology developer get what they want and need. The user receives new or needed capabilities. The technologist receives recognition, continued funding, satisfaction or the like.

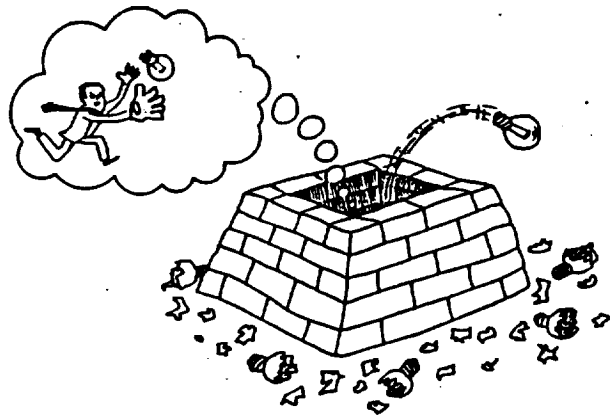

Figure 1 Traditional Technology Transfer

It may be said, that the Space Exploration Initiative (SEI) has a planning window of today through 2025, or ten years beyond initial long-term presence on Mars. Critical to the success of these long-lived programs is the ability to remain technologically viable during this extended development and mission-operations era. When the capabilities of terrestrially deployed systems are increasing by an order of magnitude every five to ten years, computers every three to four years, and detectors every two years, what does it mean to design systems for programs that require ten years to develop and have a life expectancy of up to 35 years? There are a number of obvious options: (1) Freeze the technology and stash a lifetime of spares, (2) plan for a complete replacement every five to seven years, (3) ignore the need for change and let the future take care of itself, or (4) plan to evolve the system. Only the fourth option suits the missions' purposes.

From a JPL point of view, these decadal missions map into the need to consistently and rapidly move the results of research and development into main stream mission development. For JPL survive and prosper, upgrading of technology must be a vital part of each mission. At present, JPL's technology utilization spans a dizzying range from 1970's to 1990's technology. These are all significant drivers leading to the realization that a more formal technology transfer process is needed at JPL.

This paper will discuss the requirements for a successful technology transfer program and what such a program would look like. In particular, this paper will address the issues associated with technology transfer in general, and within the JPL environment specifically.

The balance of the paper is in two Sections, i.e. Background and Technology Transfer. Section 2, Background, will (1) set the stage, (2) identify the Barriers to successful technology transfer; and (3) suggest Actions to address the Barriers either generally or specifically. Section 3, Technology Transfer, will present a process with its supporting management plan that are required to ensure a smooth transfer process.

If the reader is interested only in the process, the Background Section may be skipped ... thus, you may proceed directly to Section 3.

2.0 Background

Technology transfer may be defined as

> the transfer of organized knowledge to a project/program for the eventual purpose of producing new or improved, products, processes or services. Transfer will occur through one, or more, of the following modes: occasional consulting, documentation (reports, assessments, programs, or drawings), training (on-the-job, on-site or elsewhere) , demonstration (proof-of-principle or application to a real-world problem), and collaborative technical work.

Given this definition, it is obvious that technology transfer is absolutely dependent on person-to-person communications and is affected by all those things which encourage or inhibit communications, such as need, funding or confidence.

One important observation is that, in general, most "new" products are in fact improved versions of products that were available "last" year. They are based, not on a brand new idea from science, but on improving an existing product. And the process of repeated incremental improvement that produces these new versions of the product is inherently resistant to ideas from outside itself. Figure 2, details some of the implications of Technology Maturity. Thus, it is important to have a routine mechanism for inserting these technology improvements into the development cycle.

It does not take too many missed opportunities before both sides start losing interest in the whole process. Missed handoffs have the potential of large impacts on the projects. Thus, what we need are clear mechanisms (viz procedures, processes) with their associated management and cultural infrastructures, that enable reliable, consistent, and successful technology transfers.

Embedded within this mechanism is the recognition that the attributes, needs, etc for each of the organizations have different drivers e.g. cultural, motivation or rewards systems (see Figure 3). For example, in advanced development, documentation only need be adequate for individuals intimately involved in the technology, whereas, in implementation, documentation is paramount in the organizations ability to provide reproducible, standard products.

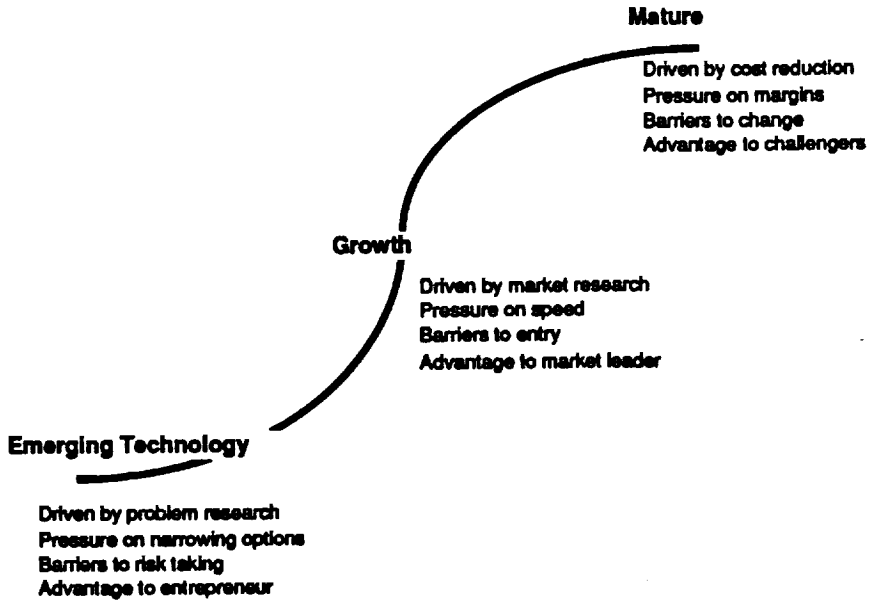

Figure 2 Implications of Technology Maturity

Advanced Development	Implementation or Production
• Technical Management with assistant engineers	• Product manufacturing management with sustaining engineering core
• Work performed by specialists and technologists	• Work done by engineers and trained personnel
• Flexible operations and interaction	• Organized production
• Tight control possible	• Manufacturing tolerance necessary
• Small throughput and volume	• Large throughput and volume
• Low inertia	• High inertia
• Dedicated attention	• Large batch "philosophy"
• Judgement criteria	• Pass/Fail criteria
• Extensive rework practical	• Rework disruptive, uninterrupted flows, staging delays
• Flexible equipment	• Narrow latitude, several shift continuous operations systems
• Little documentation - data intensive	• Extensive documentation - data/operations intensive
• Cost not primary	• Cost primary
• Changes routine, easily implemented	• Changes difficult to implement
• Real-time analysis, traceability, and feedback	• Non-routine analysis difficult, feedback delay results in losses
• QA separable functions	• QA necessarily integral

Figure 3 "Both sides of the fence"[1]

1 "Technology: Development to Production:, J. L. Abita, IEEE Transactions on Engineering Management, Vol EM-32, No. 3, August 1985, pp 129-131.

We may establish an alternative view of Figure 3 by observing the relationships as depicted in Figure 4. This view enables a view of categories of issues as they relate to advanced development or production.

Issue	Technology or Advanced Development	Implementation or Production
• Management	• Technically oriented	• Product oriented
• Staffing	• Technologist and specialists	• Engineers and production personnel
• Throughput	• Small	• Large
• Inertia	• Low	• High
• Documentation	• Minimal	• Extensive
• Cost	• Not primary	• Primary

Figure 4 Simplified Look at Both Sides

The technology transfer process of tomorrow (Figure 5) must provide the environment to enable the identification of new requirements, emerging technologies with their forecasts, and insight into organizational capabilities. Thus, as technology items are developed, another process (outside the normal research process) is required to assure that these items have a reasonable chance of transfer to the end user. The environment established by the process must support and be sensitive to all the drivers in each organization, viz. their needs, their technology characteristics, their production capabilities.

2.1 Technology Readiness Levels

NASA's standard Technology Readiness Levels are depicted in Figure 6. For technology related issues, levels 1 through 7 are used. The additional two levels (8 and 9) are presented for completeness, i.e. to show the full development cycle. The levels are annotated to show the higher level relationships among the activities. In general, technology transfer occurs at the Technology Demonstration Level.

These definitions of readiness levels are just one way to characterize the complex technology development cycle. One must remember that this taxonomy is for general reference. The levels are to provide common ground or a context for the technologists and target users to establish mutual understandings. These levels should not be used slavishly, without thought, for then, they become an additional barrier to successful technology transfer. For example, consider the readiness levels are reflected in figure 7. This characterization is attempting to better describe a software-intensive technology development, whereas the standard readiness levels are more systems and hardware oriented. Although I took the liberty to annotate the software readiness levels with the same cycle description, there do remain numerous questions as to their mapping the same way as the standard readiness levels.

Differences in technology transfer can and do occur based on the level in the system hierarchy, viz from components to full subsystems.

Additionally, technology at one end of the continuum may have a very narrow (or even single) target user, whereas at the other end, the technology may have broad, generic applicability.

Programs have the option of tackling key technology earlier if the technology is mainstream to their mission. Thus, these levels are used as guidelines in preparing for the eventual insertion of new technology into mainstream use.

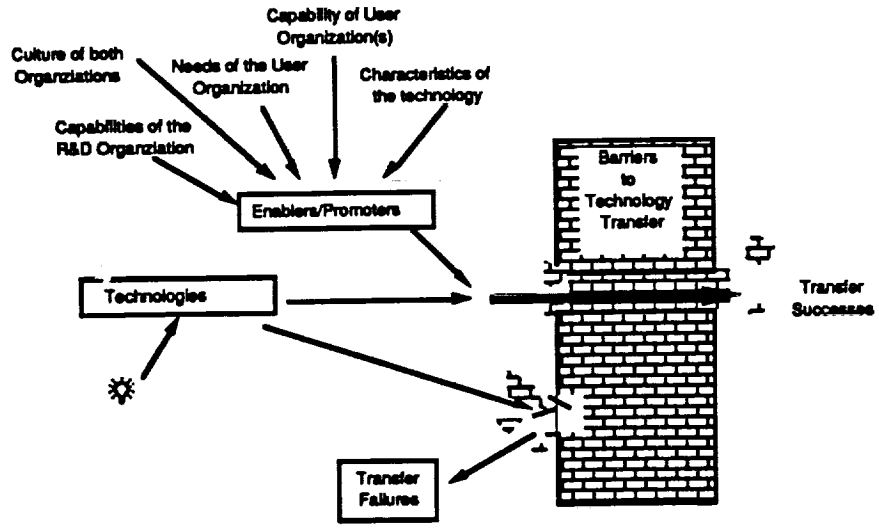

Figure 5 Technology Transfer - Tomorrow[2]

Technology Readiness Levels

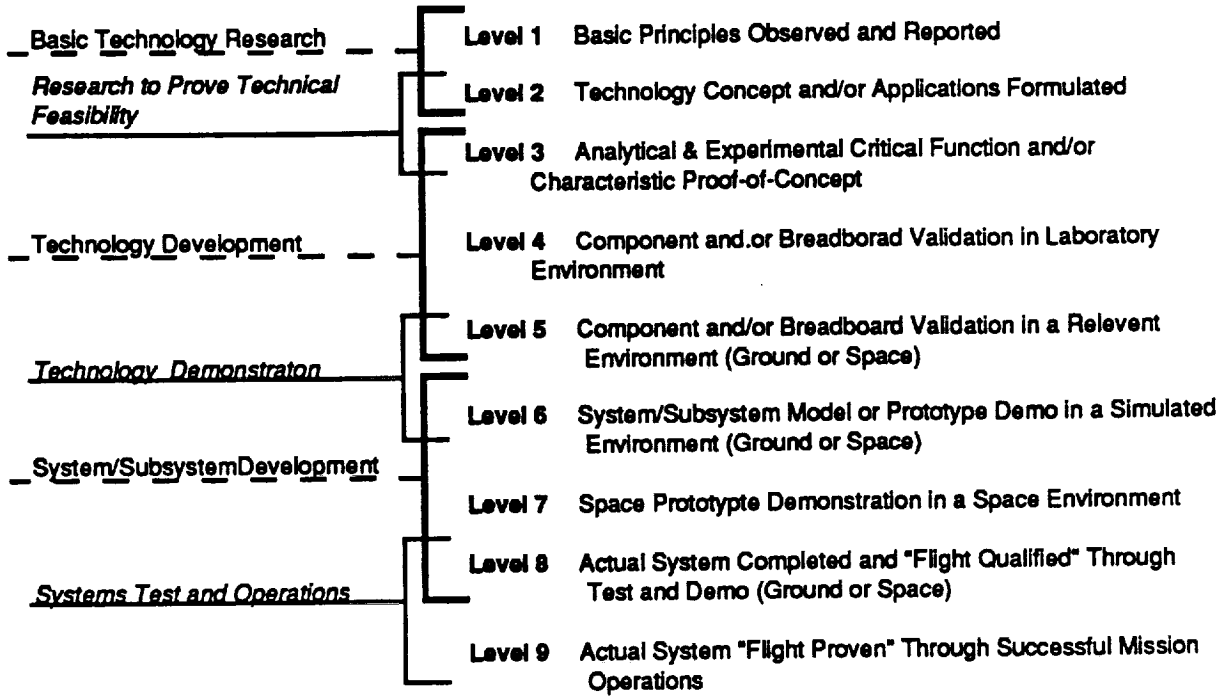

Figure 6 Technology Readiness Levels[3]

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2 "Transferring New Technologies From R&D to Manufacturing," W. E. Souder and V. Padmanabhan, Research • Technology Management, September-October 1989, pp 38-43.

3 See the Appendix for a narrative description of these levels.

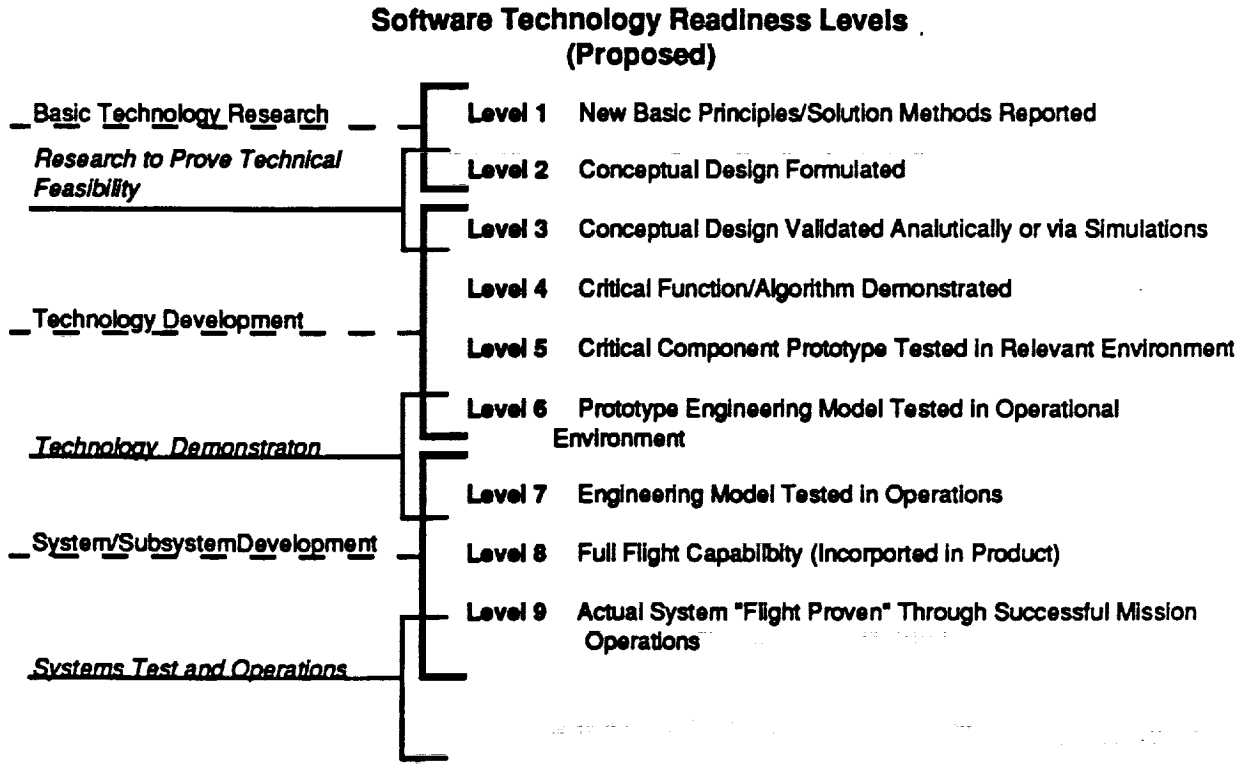

Figure 7 (Proposed) Software Technology Readiness Levels[4]

2.2 A Model for Technology Transfer[5]

A study at the Microelectronics and Computer Technology Corporation[6] focused on seven aspects of technology transfer: effectiveness of technology transfer at the consortium; effectiveness of various methods for technology transfer; importance of various factors in facilitating the technology transfer process; importance of barriers to technology transfer at both the consortium and the shareholder companies; agreement on who should set the research agenda; agreement on the type of research in which the consortium should be engaged; and agreement on ways that the consortium could improve the technology transfer process.

Based on this research four key variables emerged as especially critical in the technology transfer process: communication, motivation, distance, and technological "equivocality" (see Figure 8 Technology Transfer Matrix).

In Figure 8, each of the quadrants is discussed in the following:

---

4 "Technology readiness levels for Software", Robert C. Tausworthe, JPL IOM dated March 7, 1990.

5 "Accelerating Technology Transfer in R&D Consortia", R. W. Smilor and D. V. Givson, Research • Technology Management, January-February 1991, pp 44-49.

6 A major, for-profit, U.S R&D consortium that was established in 1983.

Communication - Both passive and active communications are involved in communications between technology developers and technology users. Passive communications have a broad sweep and are usually media-based. Here, greater care may be taken in packaging and producing a quality message.

Active links are direct, person-to-person interactions. They may range from teleconferences to *ad hoc* teams and onsite demonstrations. The benefits of active links center on the fact that they encourage interpersonal communications in terms of fast focused feedback, i.e. the researcher learns from the potential user and vice versa.

The fewer and more passive the links, the less likely the chance that technology will be successfully transferred. The higher or more active the communication links, the more likely the chance of technology transfer.

At JPL, communication is particularly important in that as large projects change their mission design or switch to an entirely different mission, the technology developers will be left with unnecessary or unneeded technology developments. This just leads to the need for clear, continuous communication. From this, it is also true that all this requires robustness to accommodate (or survive) change.

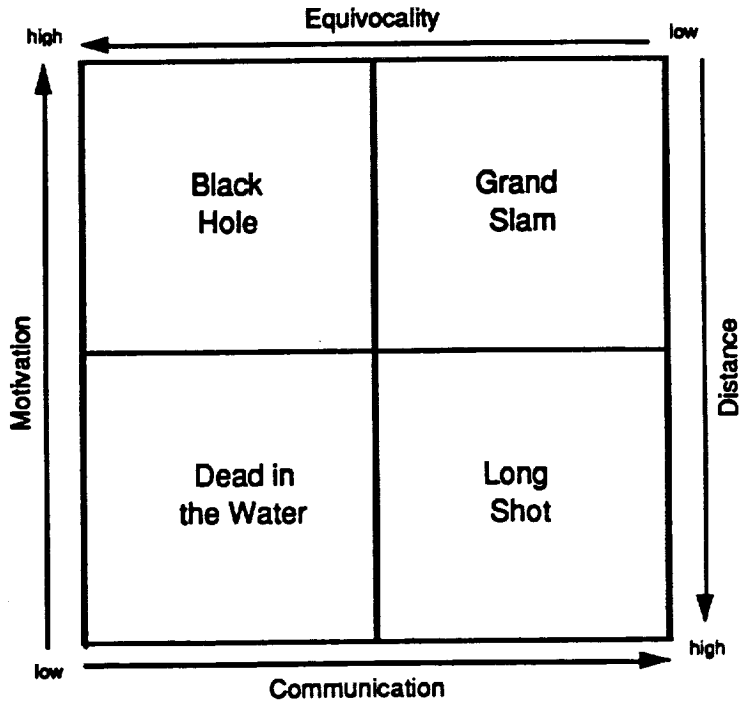

Figure 8 Technology Transfer Matrix

Distance - The second variable - distance - involves both geographical and cultural proximity or separation. Essentially, the result here is that the manager should endeavor to "co-locate" technology developers and their customers via promoting more active and direct communications links. (See Appendix A for additional information)

"Equivocality"[7] - This refers to the level of concreteness of the technology. Technology that is low in equivocality is fairly easy to understand, demonstrable and unambiguous. There is only one meaning to every individual involved in the technology transfer- the technology is understandable and its application clear. Of course, the higher the equivocality of the technology, the more difficult it is to educate the prospective users on the value or application of that technology. Clearly, this is part of the problem associated with communication.

Motivation - This involves incentives for and recognition of technology transfer. Motivation varies by importance of the technology transfer in the culture of an organization, the criteria by which the individual is evaluated, and the rewards established for those who engage in technology transfer activity.

Motivation means there is a definite answer to the question "What is in it for me?" when asked by the technology users and developers.

One can tell from the selection of the abscissa and ordinate axes labels that Motivation and Communication are the dominate factors in a successful technology transfer. As indicated above, perceptions of the maturity of the technology are directly related to the ability of the participants to communicate.

In the final analysis of this model, it would seem, at least from a JPL/NASA point of view, that one significant missing factor is cost or affordability. Fiscal considerations play a key role in both technology development and acceptance.

Technology transfer is "Dead in the Water" when there is low communication, low motivation, high distance, and high equivocality. The participants do not talk with each other because there are neither the incentives nor recognitions for those involved, because they are separated geographically, and because the technology is ambiguous and the application is uncertain!

What we want at JPL is the "Grand Slam." To achieve this we need high communication, high motivation, low distance, and low equivocality. In other words, because of highly interactive communication processes, because of a variety of incentives and recognition, and because the technology is unambiguous and its applications understood, successful technology transfer occurs. Of course, given JPL's relationship to NASA, all this must occur at NASA HQ also.

2.3 Barriers

Many of the barriers result from the fact that at any given time, no one is really focusing on what the next-step-after-this-version would be, that is to say: researchers are doing far-out exploratory work; a portion of development is producing the new systems required by the current missions; the balance of development is readying the next version for a continuing mission.

"Additionally, our factories and other workplaces have long been designed around management principles that prevent organizational flexibility and change. Harvard's Michael Porter describes it well: 'Change is an unnatural act, particularly in successful companies; powerful forces are at work to avoid and defeat it. Past approaches become institutionalized in standard operating procedures and management controls. Training emphasizes the one correct way to do anything; the construction of specialized, dedicated facilities solidifies past practice into

---

[7] Equivocality is defined to be - of doubtful advantage, or subject to interpretation.

expensive brick and mortar...' Such systems were simply not designed to react quickly, if at all, to rapidly changing conditions."[8]

Many would say that a fundamental problem in technology transfer is the lack of a way to bridge the technology transfer gap (Figure 9).

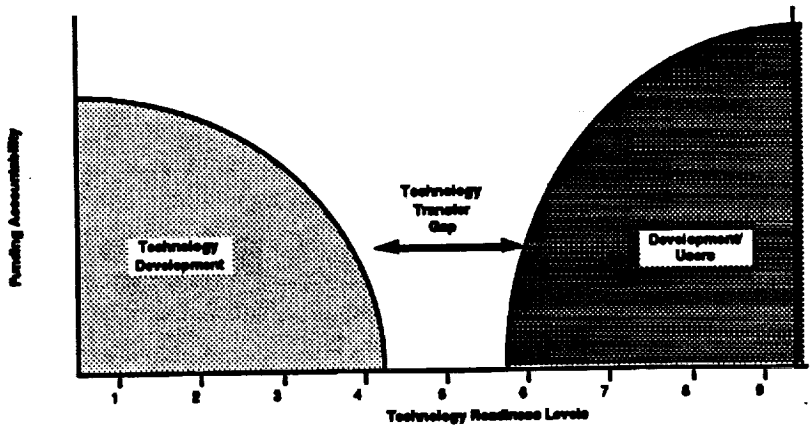

Figure 9 Technology Transfer Funding Gap

This gap is caused by two factors

(1) Historically, research is complete when a breadboard article has been validated. This validation, which occurs somewhere in readiness level 4, usually signals the termination of research funding (such as Code R).

(2) Unless the technology is fundamentally enabling to an endeavor, the flight project or consumer is usually hesitant to incorporate a new technology without the existence of an engineering model, at the very least. Additional confidence is built with the demonstration of the engineering model in an environment similar to the intended usage. Thus, users support (such as Code S) generally is not available until the technology reaches readiness level 6.

These two factors clearly indicate that each organization needs to recognize that co-accountability is the only way to affect the smooth insertion of this new technology in to mainstream usage. The Technology Transfer Plan is a vehicle to formalize this co-accountability and its eventual transfer to the using organization. In particular, the funding profile to bridge this gap is important (see Figure 10). The plan will document the transition funding profile required for successful handoff. Some of the issues facing technology transfer are beyond the scope of a single center. There needs to be a more complete technology transfer process that includes all the NASA centers and Codes S and R within NASA itself. Figure 11, NASA Technology Transfer Interfaces, depicts the needed interactions at various levels, i.e. starting with industry and academia through the Associate and Administrator level of NASA. Without explicit support within Code S for technology development/transfer activities, it will be difficult to insert new technology into on-going or new programs. This Code S funding

8 "Technology Development in the 1990s: Will Government Polices Help or Hinder?", Speech by Robert M. White, Under Secretary for Technology, U.S. Department of Commerce, to Council on Superconductivity for American Competitiveness, September 14, 1990.

coupled with "good faith" support from the target user and Code R support, will provide the basis for successful technology transfers.

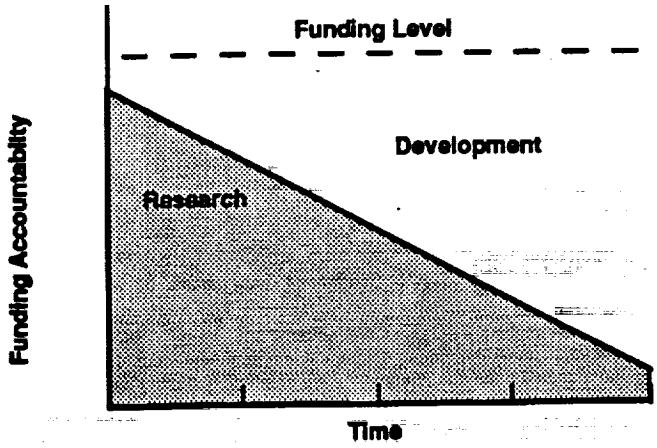

Figure 10 Funding Accountability

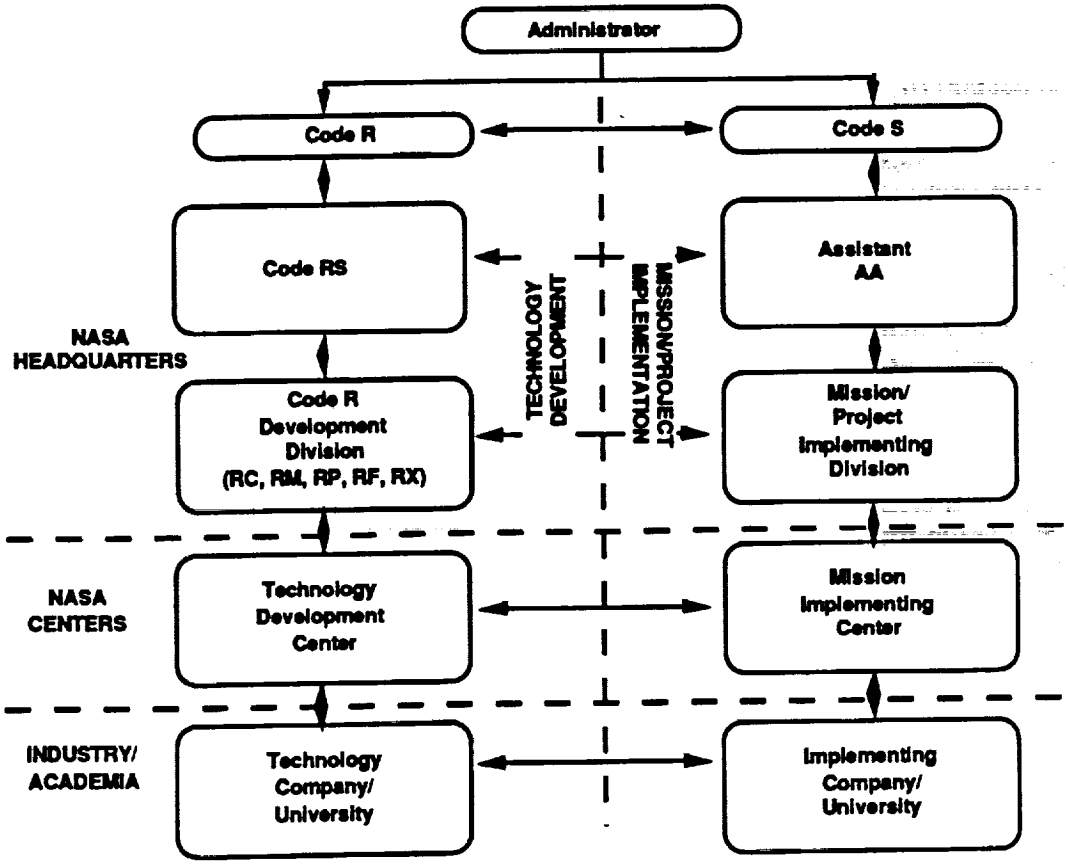

Figure 11 NASA Technology Transfer Interfaces[9]

9 Adapted from drawings and ideas of W. J. Weber III at NASA/JPL.

Yearly exchanges between each column (as illustrated by the horizontal doubled-ended lines) would enhance the ability to identify needs (e.g. Code S) and emerging technologies (e.g. Code R). As part of this exchange, more cohesive programs of technology development and transfer could be established.

The significant barriers having differing effects are the variables of communication, motivation or advocacy, risk or maturity of the technology, and organizational structure (distance). Figure 12 lists some of the specific barriers identified at JPL and suggests dominate areas of effect.

Barrier	Comm	Advoc	Mgnt	Risk
The user community lacks a process to identify common technology requirements	X	X	X	
The user community lacks a vehicle to exert the collective leverage to cause JPL/NASA to implement common design.	X		X	
Resources invested in existing systems and applications, and the attitude and culture of the work force make it difficult to evolve to new technologies.			X	
Current practices encourage a tactical approach to solving technical problems while ignoring key strategic (i.e. long term) issues.			X	X
There are inadequate incentives fostering the insertion of new technology in to new missions. The linkage between technology payback and achieving missions goals is not strong.	X	X	X	
Fear of being unable to complete a mission (on-time, within budget, and meeting mission goals) using "newer" technology.			X	X
There is no documented, coherent JPL/NASA vision for broad-based technology integration and the role of technology transfer in achieving that vision.			X	
There is no shared vision for developing a technology transfer process.	X		X	
Transfer is further complicated by the fact that oft times capabilities rather than specific products must be transferred.			X	X
With today's projects, you cannot simultaneously accept a "fixed-priced" contract from Congress to develop a major undertaking and at the same time support technology development and the unavoidable attendant risks, i.e. cost uncertainty.			X	X
Inadequate staffing by engineering. A common response to the suggestion for new technology is "We do not have anyone here who has the technical skills and knowledge to incorporate this technology into current projects."			X	X
The perception that a technology is too complex will often lead the intended users to question the technology developers credibility.	X	X	X	
NASA does not develop serious plans beyond a five year new start horizon		X	X	

Figure 12 Barriers

2.4 Case Studies At JPL

Understanding the current state-of-practice for technology transition at JPL is important. It is important to understand the attributes of recent efforts at JPL regardless of their success or not. These interviews included both specific insertion efforts and knowledgeable peoples' general understanding and views on technology transfer. The specific efforts at JPL included:

- Viterbi decoder for Voyager and Galileo
- Solid state power components e.g. switches, microprocessors

- Fiber Optic Rotation Sensor (FORS)
- Onboard processing for CRAF/CASSINI
- Rhenium engine, electric propulsion
- Optical communications.

These were selected because they are recent and there exists an adequate body of current knowledge in order to extract some similarities, principles or guidelines.

Without identifying the specific task or individual here are some of their insights (these are broadly grouped via

Involvement:

- Cannot underestimate the value of the advocates/champions. This should be done even to the extent of transferring someone with the technology.
- With advanced technology funding support via Code S, FPO, OSSI, etc, the first-use-of-technology-eats-the-cost syndrome may be broken.
- User involvement is key to the successful transfer of the technology. This enables a "buy-in" by everyone.
- Technologist do not understand the paradigm for technology transfer. User confidence is everything. Technologist should consider all potential end-users as from Missouri, i.e. "Show Me!".

Focus

- Some efforts have not been successful because the technologist became enamored with technology as an end result in itself, thereby losing sight of the needs of the project. They focused on the wrong problem from a flight project point of view.
- JPL has made the mistake of putting the technical person in-charge, where a task manager is really needed. The technical support is required. One choice is to possibly placed the technologist on staff as the chief scientist, chief engineer, etc.
- When discussing technology transfer, we really need to understand the drivers. Is the project in dire need (technology pull)? Is the technology ripe and there are clear applications (technology push)? Is it basic, enable technology, thereby causing the user to take the technology earlier than normal (pre-engineering model development)?
- The flight projects have to very conservative because of risk. Users are generally unwilling to accept risk in the bus; there is after all only one bus and if it fails, the entire mission fails. Thus, the users are interested in new bus technology only if: (1) it is mission enabling, i.e. the mission can not be accomplished without this technology; and/or (2) it is reasonably mature, having reached the engineering model stage and thus represents no more than moderate risk.
- Flight project should not be involved in technology development.
- Technical risks in the instruments are often acceptable: a given mission generally involves a range of task performed by multiple instruments, so a failure of any one instrument does not result in failure of the mission as a whole.
- Even if a reasonably mature new technology and an interested user find one another, a final hurdle remains: the cost of full and final flight development of the technology must almost invariably be borne by the first user. The fact that such funding must be provided during the trying early years of a flight program makes this last hurdle much more difficult.

Options for making the process a smooth one:

- Technology does not come in spurts like spacecraft do. We need a continuous program (here you may read "real budget") to develop the underlying technology for later

insertion. (Comments like this lead to the question of "Why do not OSSI and FPO establish technology programs like TDAs?").
- A significant portion of the Advanced Technology Development funding from Code S goes into advanced mission planning; more should go in to technology planning and technology insertion support (bridging funding).
- With advanced technology funding support via Code S, FPO, OSSI, etc, the first-use-of-technology-eats-the-cost syndrome may be broken.
- When considering technology transfer, industry's role should be considered, particularly since we do not usually build production units. Can synergistic relationships be established with institutions such as Draper Labs?
- If a new technology is to be attractive and ready for use on a given mission, its development process must usually start well before the mission itself emerges from the pre-project phase. Unfortunately, this implies a chicken-and-egg problem: the prospective user in not interested in immature technology, but without user interest, it is very difficult to advance a technology to an attractive level of maturity.

2.5 Actions

There is a broad spectrum of actions that may be taken to address the barriers to technology transfer. These include:

Involvement:
- Assign top level champions (bilateral championship). They will be the advocates of the technology to the two organizations, i.e. the technology developers and users. They will draft and get concurrence on the Technology Transfer Plan.
- Involve the end user in the early stages of technology development. This involvement may range from publication distribution and review participation, to engineering involvement in design. This is necessary if the technologists want the potential users to ultimately accept the technology rather than disregard it as yet another example of "a solution looking for a problem."
- Encourage the users to participate in developing the technology. Too often technology developers have been content to "throw their product over the wall and hope someone will catch it (Figure 1)."
- Demonstrate the technology to the end user community. Provide opportunities for users to meet collectively and share their experiences, requirements and needs.

Focus
- Apply the technology to a few representative problems before attempting to transfer it[10]. Thus, the recommendation is to (1) whet the user's appetite by trying the technology on one of his applications by the technology developer in the laboratory, then showing him how successful it was, (2) invite the user to work on the second application, and (3) finally, initiate the transfer process, by letting the user choose the next application and start providing the development pull and fiscal support. It is here that one may want to consider temporarily transferring a technology developer to the project development team.

Options for making the process a smooth one:
- Provide training by the technology developers. Often the technology developers lose interest after the readiness stage; they do not want to write the user's manual or to

10 Be willing to provide resources (people, time and money) to sell the technology.

think about features that may make it easier to use. Effective transfer requires these activities. Some accommodation must be formally made to effect this. Also, assisted by the technology developers, the consuming organizations need to provide formal training to the development engineers.

- Dedicate an engineer to monitor the transfer.
- Follow-up to determine the effectiveness of the transfer process. Never say "Good bye" -- feedback is important to the technology developers to fix immediate problems as well as considering improvements for the next round in the technology. The transfer process, itself, also needs calibration to enable improvement in the next round of technology transfer activities.
- Identify a host project. Given the "fixed-priced" mode of flight projects, what could help would be an arrangement whereby one or two targeted technology development activities would be taken on by a project with the up-front understanding that these areas would be excluded from the requirements of the "fixed-priced" constraints. Thus, a host project would be identified. This project would be the end-user for the technology in question.

The shotgun approach of overwhelming the barriers with actions/promoters can usually be replaced with a more efficient approach of eliminating barriers by matching them with specific actions. These actions will be codified via the Technology Transfer Process and its associated Technology Transfer Plans.

3.0 Technology Transfer

At this point, it is important to restate the definition of technology transfer:

> the transfer of organized knowledge to a project/program for the eventual purpose of producing new or improved, products, processes or services. Transfer will occur through one, or more, of the following modes: occasional consulting, documentation (reports, assessments, programs, or drawings), training (on-the-job, on-site or elsewhere) , demonstration (proof-of-principle or application to a real-world problem), and collaborative technical work.

Thus, again, given this definition and what has been dismissed previously, it is obvious that technology transfer is absolutely dependent on person-to-person communications and is affected by all those things which encourage or inhibit communications, such as need, funding or confidence. This communications must be between technology developers and the intended users, where users include not just the programmatic element, but the intended everyday utilizers of this technology. For without the ultimate end-users participation, the technology may be transferred, but not used (i.e. the transfer use not really consummated!).

We must overcome the general barriers associated with communications, motivation, technology readiness, and organization structure as described Sections 2.2. and the specific impediments as discussed in Section 2.3. Some of the significant factors concerning technology transfer from both the giving and the receiving perspectives include:

(1) Each transfer is really unique in the full sense of the word. The planning must address the ripeness of the technology (such as the needs of the receiving community or user; the complexity of the technology, that is to say is it a chip set or complete subsystem; and the maturity and skills of both organizations). Thus, application planning is one key to a successful technology transfer.

(2) User involvement is the next significant factor. Without the active sponsorship and support of the "host project", it is probably a case of "a solution looking for a problem."

(3) Since there are at least two organizations involved in the process, continuing, clear communication is essential. Open, working, active lines of communications are important to the continued ability to work out process and technical issues before they become too large to handle. Thus, communications is another key factor to a successful technology transfer.

(4) A process that encourages asking the right questions at the right time is next in our list of key factors. There are appropriate questions to be addressed at each stage (pre-transfer, planning, readiness review, and active transfer) of the transfer process. Often the process is complicated by not asking the appropriate questions.

(5) There is a real need to address the right questions at each step of the process. Knowing the questions and their logical location in the process is also key to the process.

(6) Often a transfer is attempted as a part-time activity or without clear lines of accountability. The results are slow or no decisions, lack of follow through which leads to frustration and ultimate failure. Clear lines of responsibility and accountability are the next keys to a successful technology transfer.

(7) Technology transfer becomes a funded activity. Funding is identified to bridge the gap between technology availability/demonstration and incorporation into a host project. With identified funding sources, technology comes of age in its own right.

As discussed above, technologies are "ready-for-transfer" at different stages in their development depending on the user's requirements, state-of-the art, etc. Thus, the process and documentation described in this section are only guidelines, and the reality is that each technology effort must be reviewed on its own merits. The appropriate level of technology readiness for transfer in any one case will depend on the needs and plans of the user organization to become involved in the development program and effect the technology transition into program and project activities.

3.1 The Process

The process should enable a "Grand Slam" (see Figure 8 and Section 2.2) and as such should provide for communications paths, motivation, and shortened communications distances.

Planning is the key to a successful technology transfer. Today, even if the technology developer and the intended user agree that the transfer is advantageous to each side, the lack of clear planning and understanding of the questions to be addressed, leads to, at the very least, a difficult time, and often to failure.

The Technology Transfer Process is depicted in Figure 13. This process addresses all the key factors described in the previous section:

- Planning

- User involvement
- Communications
- A process is required
- Knowing and asking the right questions
- Responsibility and accountability and
- Funding.

Each annual cycle starts with a review of inputs:

(1) the current program (on-going programs with their Technology Transfer Plan, and the current mission set),

(2) new requirements (input is based on future missions),

(3) new technologies (inputs consists of JPL thrusts, technology forecasts, and technology needs based on the future missions), and

(4) new out-year plan and schedule (inputs are all of the above).

The results of this review may be any of the following (based on the inputs)

- termination of an on-going program (destination the "86"-trash can).
- modification of an on-going program in the light of new missions, new requirements, and/or new technologies.
- standard continuation of current effort (probably with minor updates to the Technology Plan).
- initiation of a new technology transfer effort.
- end user acceptance of the technology!

A standard output each year is the forecast of upcoming technology transfer candidates on the 5 to 7 year horizon. This output provides a context and some continuity to the whole transfer as a set of activities.

The identification of a new candidate initiates a technology transfer cycle. After selection of accountable advocates (champions) two activities are started: writing the Technology Transfer Plan and preparation of a Technology Readiness Review. Besides the questions listed in Figures 14 and 15, the Technology Readiness Review will address issues such as:

- Basic concepts and technology associated with the transfer
- Mission requirements with derived requirements for this transfer
- State-of-practice contrasted with the state-of-art.

- Acceptance and success criteria for the receiver (host project).
- State of the technology development including proof-of-concept demonstrations, etc.
- Risk and affordability with respect to current technology and the needs of the intended users.
- Does the technology meet the needs of the intended receiver? What is paramount - performance? lifetime? reliability? mailability? ..other "-ilities"?
- Summary of accomplishments, identified issues and potential risks.

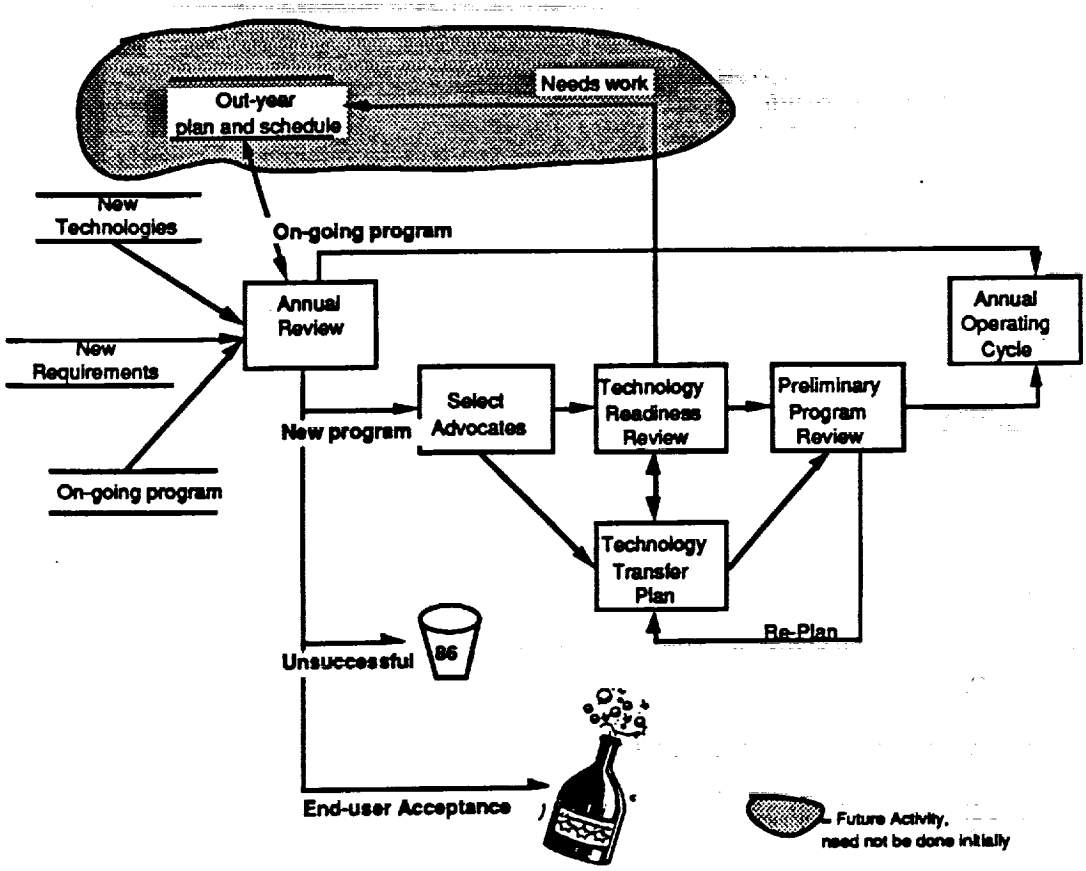

Figure 13 Technology Transfer Process

The result of the Readiness Review should be permission to proceed. It is here that any special consideration should be documented, i.e. the need to proceed while keeping a backup position in a viable state. Readiness does not just refer to the technology but also the the intended user. That is to say that the needs of the ultimate user and the technology match or that they will actually use the technology!

- What impact can this technology offer our program/project?
- What are the costs/risks associated with introducing this technology?
- Where does this technology rank in importance to our program/project needs?
- Is there a plan to receive the technology in a timely fashion?
- Are there adequate resources to receive and develop the technology?
- What will be done to upgrade the staff, if that is necessary?
- Is there a champion/advocate for this technology? Is that person at the right level?
- Have we done an adequate job of sharing the program/project opportunities with the research organization?
- Does the giver have an understanding of the timing of our needs?
- Have we agreed on what constitute a demonstration of technical feasibility?
- What has been the history of the relationships between these two organizations? If there is a history, what are the strengths upon which to capitalize?

Figure 14 Checklist for the Receivers[11]

- What does the technology promise?
- How do the promises related to the program/project needs?
- What are the costs/risks associated with developing the technology?
- How is industry using this technology?
- Is the technology familiar/unfamiliar to the receiver?
- Where does this technology rank in importance to the receiver?
- Is there adequate technical expertise to pick up the research?
- If not, is there any training or recruiting support we can provide?
- Is management in the project/program committed to the technology?
- Have we adequately marketed the technology?
- Do the researchers have a comprehensive understanding of the program/project's needs and opportunities?
- Are there adequate resources to research? To transfer the technology?
- What documentation does the receiver need? Has it be produced?
- Is there a plan to deliver the technology is a timely fashion?
- What is the proper hand-off of this technology?
- Have responsibilities been mutually delineated and accepted?
- Has the information exchange been thorough and timely?

Figure 15 Checklist for the Givers[12]

11 "A Study of the Factors Which Affect Technology Transfer in a Multilocation Multibusiness Unit Corporation", M. L. Ounjian and E. B. Carne, IEEE Transactions on Engineering Management, Vol EM-34, No. 3, August 1987, pp. 194-201.

12 Ibid.

3.2 The Plan

With the goals defined, the technology transfer advocates derive a detailed plan from a general ordered outline. This Technology Transfer Plan (see Figure 16 for the outline) is a management artifact. Its purpose is to establish ownership of the transfer of technology between peer organizations, i.e. a peer-to-peer process. This plan will also serve as a driver, check list, and guide, especially since each task description explicitly relates schedule and responsible person. In essence, this plan documents the effort, discipline, rigor, and order that are necessary to make it all come together.

The authors of the plan are the two advocates. Approval includes: advocates, program office(s), developing.organization(s).

4.0 Summary

The problems associated with technology transfer are complex. Some of the Do's for a successful collaboration and hence a successful technology transfer include:[13]

- Treat the technology transfer as a personal commitment. It is people that make partnerships work.
- Anticipate that it will take up management time. If you can not spend the time, do not start the transfer.
- Mutual respect and trust are essential. If you do not trust the people you are working with, forget it.
- Remember that both partners must get something out of it. Mutual benefit is vital. This will probably mean that you have got to give something up. Recognize this at the outset.
- Do not put off resolving unpleasant or contentious issues until "later".
- Recognize that during the course of the transfer/collaboration, circumstances and markets change. Recognize your partner's problems and be flexible.
- Make sure that you and your partner have mutual expectations of the transfer and its time scale.
- Get to know your opposite numbers at all levels.
- Appreciate the cultural differences. Do not expect a partner to act or respond identically to you.
- Recognize your partner's interests and independence.

Each technology transfer is unique, and as such, requires careful planning. At the least, this planning must detail (1) the technology to be transferred, (2) the readiness of this technology,

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13 "The Global Logic of Strategic Alliances", K. Ohmae, Harvard Business Review, vol 67, No. 2 (March/April), pp. 143-154.

(3) the needs of the intended users, (4) the process and schedule for the transfer, and (5) the acceptance criteria of the user (i.e. how do we know when the process has been successful?).

The basic dimensions of motivation - the organizations and individual, communications between the technology developers and intended users, organizational complexities, and maturity of technology, itself, provide a rich base of solutions. These dimensions lead to essential factors requiring attention are planning, user involvement, communications, a process, knowing and asking the appropriate questions, assigning responsibility and accountability and finally, recognition that little is accomplished without adequate funding.

The detailed solutions just compliment the key factors (listed above). These factors are embodied in the steps of the process that is described in Section 3.1.

Section #	Title	Description
1.0	Introduction	
1.1	Identification	Project name
1.2	Overview	Brief description of the Project. Brief statement of what this Technology does.
1.3	Document Scope	What this document addresses and how it relates to other documents
1.4	Controlling Documents	Documents that control this document
1.5	Applicable Documents	Documents referenced by this document
2.0	Organization and Responsibilities	The TTP shall provide definition of roles and responsibilities of personnel and their relationships. Show the project organization chart. Show an activity or product-oriented work breakdown structures with a mapping to the organization chart.
3.0	Polices and Constraints	
3.1	Project Polices	Polices to be applied to this work
3.2	Project Standards	Identify JPL and other standards that are to be used. Describe the milestone reviews. Specify the convening authority for each review.
4.0	Technical Approach	
4.1	Work Inputs	Describe all inputs from other organizational elements. Identify source, need date, acceptance criteria.
4.2	Technical Constraints	
4.3	Deliverables	Definition and scope of the work to be accomplished. Identify products to be delivered.
5.0	Methods, tools, and training	Identify the management methods to be applied for resource monitoring and control, configuration management, and product assurance. Include regularly scheduled development status reviews.
6.0	Metrics Reporting	Specify data to be reported to monitor work accomplished, resources consumed, products generated, and problems encountered for each phase of development.
Appendix A	Glossary	
Appendix B	Acronyms	
Appendix C	Budget	
Appendix D	Schedules	

Figure 16 Transfer Plan Outline

Appendices

Probability of Communication in Organizations

In Managing the Flow of Technology there were three charts depicting the Probabilities of communication between people under differing circumstances. These are reproduced here.

Figure 8.2 The Probability That Two People Will Communicate as a Function of the Distance Separating Them (100 Meters to 255 Kilometers)

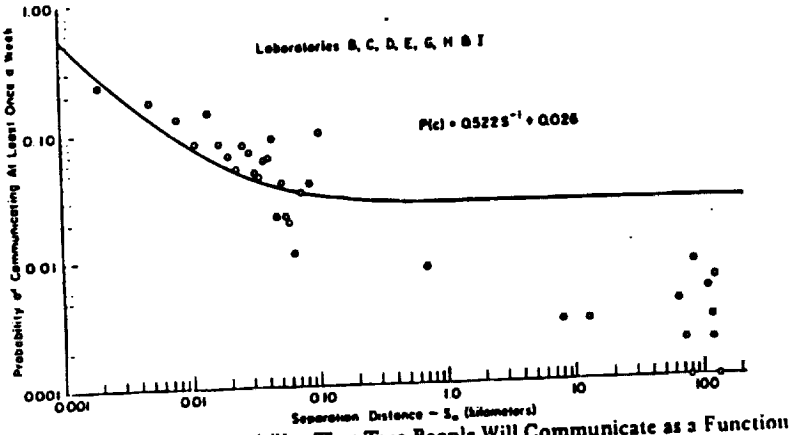


Figure 8.3 The Probability That Two People Will Communicate as a Function of the Distance Separating Them (0–100 meters)

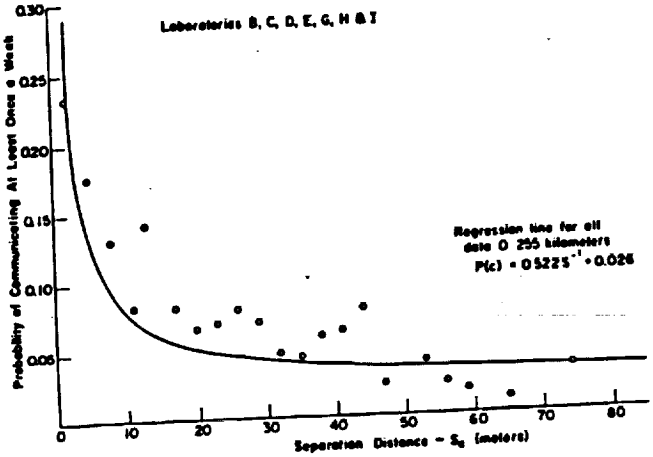
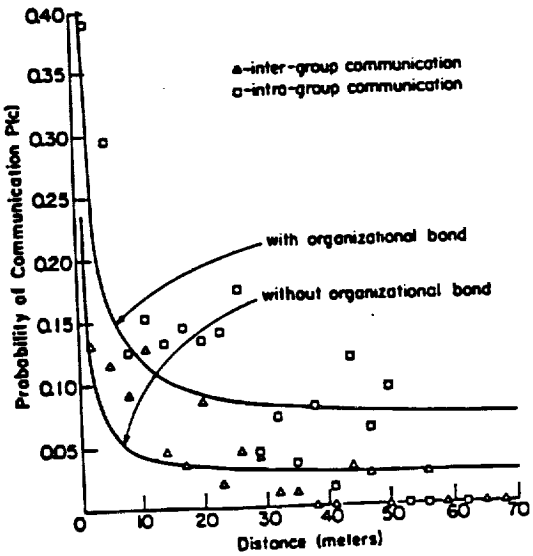


Figure 8.4 Probability of Communication as a Function of Distance—Controlling for Organizational Structure



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"Technology Transfer: How to make it work", H. Olken, Olken Publications, 2830 Kennedy Street Livermore, Ca. 94550, ISBN 0-934818-00-2

Technology Readiness Levels Descriptions

Level 1 Basic Principles Observed and Reported - Preliminary efforts are expended to identify the new technology and its applicability, and to provide a mathematical, empirical, or other supportive, basis to believe in the successful creation of the technology.

Level 2 Technology Concept and/or Application Formulated - Based upon preliminary work, the concept for the technology is evolved to specification of components, limits, and capabilities.

Level 3 Analytical and Experimental Critical Function and/or Characteristic Proof-of-Concept - The elements which make up the technology are constructed. In a piecewise fashion, each required function is created and tested.

Level 4 Component and/or Breadboard Validation in Laboratory Environment - Each element is integrated into a demonstration of the technology y. While limited in scope, application or performance, the breadboard serves to prove the feasibility of pursuing the development. The breadboard also helps to identify limitations, errors in components and, perhaps, flaws in the basic theory or empirical studies.

Level 5 Component and/or Breadboard Validation in a Relevant Environment (Ground or Space) - Following successful breadboarding, a prototype for the the technology is constructed and tested in the working environment. This level serves to affirm that the basic theories and motivations for the technology are correct.

Level 6 System/Subsystem Model or Prototype Demo in a Simulated Environment (Ground or Space) - Sometimes the prototype is transitioned into a ground qualified application of the technology. Tested in an operational environment, the proof-of-concept model is used to assure that no major technological flaws exist which might limit or jeopardize the operational use of the technology.

Level 7 System Prototype Demonstration in a Space Environment - When appropriate, the ground qualified unit is test during spaceflight. This is the ultimate check that the technology and its embodiment are correct for the intended function in the spacecraft application.

Level 8 Actual System Completed and "Flight Qualified" Through Test and Demon (Ground or Space) - Given correct operation during qualification, the embodiment of the technology is placed into operational status. Operational status primarily assures future users that there is little or nor manageable risk in applying the new technology and that the cost of implementation and operation/maintenance is reasonably understood.

Level 9 Actual System "Flight Proven" Through Successful Mission Operations - Common usage.

WORKING PANEL 1

TECHNOLOGY TRANSFER

WITHIN

NASA

WILLIAM ST. CYR

SUBTOPICS

A) THE "CLASSICAL" PROBLEM: TECHNOLOGY TRANSFER WITHIN AN ORGANIZATION (AND ACROSS ORGANIZATION LINES/CODES)

B) SPACE SCIENCE/INSTRUMENT TECHNOLOGY & THE ROLE OF UNIVERSITIES IN THE TECHNOLOGY DEVELOPMENT/TRANSFER PROCESS

ASSESMENT OF TECHNOLOGY TRANSFER PROCESS

- HIT & MISS
- NO INTERNAL RECOGNIZED/CONSISTENT TECHNOLOGY TRANSFER PROCESS IN PLACE
- NO MEASUREMENT/REWARD SYSTEM
- RISK AVERSION PROJECT MANAGEMENT
- RTOP PROCESS HAS NO TECH TRANSFER OBJECTIVES

TECHNOLOGY BEING TRANSFERED

- ROBOTICS
- ANALYTICAL TOOLS
- MODELING TECHNIQUES
- SENSORS
- ELECTRO-OPTICAL
- ADVANCEC MATERIALS
- SOFTWARE (HARWARE SPECIAL, ALGORITHMS, COSMIC)
- PERFORMANCE DATA

ISSUES AND BARRIERS

- COMMUNICATIONS
- TURF/PAROCIALISM/NIH
- PRIORITIES/WORK LOADS
- SENSITIVITY TO MISSION NEEDS/REQUIREMENTS
- RISK AVERSION
- LACK OF SYSTEMS ENGINEERING

OBSERVATIONS & SUGGESTIONS

- ITP PROCESS IS A GOOD BEGINNING; NEEDS VIGOROUS IMPLEMENTATION
- PROMOTE TECH TRANSFER WITHIN NASA AS AGGRESSIVELY AS TECH UTILIZATION OUTSIDE NASA
- TOP DOWN INPLEMENTATION (EG. METRIFICATION)
- NASA TO NASA TECH TRANSFER SHOW (EG. TECHNOLOGY 2000)
- ESTABLISH REWARD SYSTEM
- BUILD TECH TRANSFER INTO DEVELOPMENT PROCESS AT FRONT END OF PROGRAM (CONCURRENT PROCESS)
- SYSTEM ANALYSIS APPROACH FOR TECHNOLOGY INSERTION

STATEMENT OF PROBLEM:

TRANSFER WITHIN ORGANIZATION:

NASA TECHNOLOGIST TO (OPERATIONAL) MISSION APPLICATION

HENRY PLOTKIN

KEY ISSUES & BARRIERS

- DISINCENTIVES FOR RISK-TAKING, FOR TECHNOLOGY - INSERTION
  - — UP-FRONT COSTS
  - — NO REWARD FOR LIFECYCLE COST REDUCTION
- BENEFIT OF NEW TECHNOLOGY MUST BE MADE CLEAR TO USER
  - — SYSTEMS ANALYSIS/TRADE-OFF DURING PHASE A
  - — VALIDATED COST-ANALYSIS

TECHNOLOGY TRANSFER APPROACHES

- IMPROVE COMMUNICATIONS BETWEEN TECHNOLGIST AND USERS EARLY IN MISSION DEFINITION
- CREATE BUDGETARY INCENTIVES FOR NEW TECHNOLOGY
  - — ALLOWANCE (10%?) FOR NEW TECHNOLOGY TO EXCEED BASIC PERFORMANCE
  - — MINIMIZE LIFE-CYCLE COSTS
- ALLOW USE OF PARALLEL (OFF-LINE) NEW TECH IN OPERATIONAL ENVIRONMENT
- INCREASE BUDGET FOR "BRIDGING" ACTIVITIES
  - — TEST BEDS
  - — FLIGHT DEMONSTRATIONS
    - GAS CANS
    - CHEAP S/C
- ESTABLISH RESPONSIBILITY (&ACCOUNTABILITY) FOR TRANSFER

PROBLEM: INSUFFICIENT INTERACTION BETWEEN CODE R SENSOR DEVELOPMENT PROGRAM AND CODE S

CURRENT PROGRAM: SENSOR WORKING GROUP REVIEWS PROGRAM STTUS, ACCOMPLISHMENTS, FUTURE PLANS. USER ORGANIZATIONS INVITED TO ATTEND.

BARRIERS: NOT ALL USER CODES HAVE ATTENDED: AS A RESULT, PERSEPTION PERSISTS THAT

A) SENSOR TECHNOLOGY PROGRAM MAY NOT OPTIMUM

B) CODE S MAY NOT ACCEPT THE NEW TECHNOLOGY

APPROACH: ENHANCE CODE S ATTENCANCE

ACTOR: CODE R & CODE S

SUB-TOPIC

SPACE SCIENCE INSTRUMENT TECHNOLOGY AND THE ROLE OF UNIVERSITIES IN THE TECHNOLOGY DEVELOP/TRANSFER PROCESS

MARIO ACUNA & MARTIN ZOMBECK

The reward is the transfer --
the publication

CURRENT SPACE PROGRAMS

- FUNDAMENTAL PROBLEM IS THE HIGH COST OF DOING SIMPLE THINGS - OFTEN HIGH TECHNOLOGY IS NOT NEEDED
- PROGRAM DEVELOPMENT CYCLE IS TOO LONG - OFTEN TWO GENERATION OF GRADUATE STUDENTS

LESSONS - LEARNED

- IMAGE RESTORATION TECHNIQUES - HST
- GRAZING INCIDENCE X-RAY MIRROR DEVELOPMENT - AXAF
- DEVELOPMENT OF METROLOGY TECHNIGUES FOR HIGH PERFORMANCE MIRRORS - SURFACE FINISH AND SURFACE CONTOUR
- IUE - mission operations development
- undergraduate and graduate student programs
- microcalorimeter development

BARRIERS TO DEVELOPMENT/TRANSFER

- INTELLECTUAL PROPERTY RIGHTS

  COMPETITION FOR FUNDING FOR INFREQUENT OPPORTUNITIES FOR SCIENTIFIC INVESTIGATIONS IN SPACE

- FUNDING IS USUALLY TIED TO A SPECIFIC FLIGHT PROGRAM

APPROACHES

- NASA ISSUES AO'S FOR SCIENTIFIC INVESTIGATIONS - ALL POTENTIAL RESPONDERS SHOULD BE GIVEN DESCRIPTION OF RELEVANT TECHNOLOGY
- UNIVERSITIES SHOULD HAVE OPPORTUNITY TO PARTICIPATE IN NEW TECHNOLOGY DEVELOPMENT AT NASA CENTERS - HELP TO DEFINE DIRECTION OF DEVELOPMENT
- UNIVERSITIES SHOULD BE ENCOURAGED TO USE NASA FACILITIES - LABORATORY, TEST, COMPUTER FACILITIES AS A NATIONAL RESOURCE
- THROUGH VISITING PROFESSOR PROGRAM NEW TECHNOLOGY IS DISSEMINATED TO THE CLASSROOM
- FACILITATE CLOSER INTERACTION BETWEEN UNIVERSITY AND NASA SCIENTISTS AND TECHNOLOGISTS BEYOND CONFERENCES

S. Working Panel #2: Technology Transfer Within the Government

Carissa Bryce Christensen
Princeton Synergetics, Inc.

The following participants in the workshop were members of this panel:

Individual	Organization
Christensen, Ms. Carissa Bryce	Princeton Synergetics, Inc.
Connolly, Dr. Denis	Lewis Research Center
Dula, Mr. Alex	Johnson Space Center
Freese, Dr. Kenneth	Los Alamos National Lab.
Holcomb, Mr. Lee	NASA Headquarters
Neeland, Dr. Roger	Department of Transportation
Reck, Mr. Gregory	NASA Headquarters
Russell, Col. John	Phillips Laboratory
Schneider, Mr. Stanley	NOAA

Col. Russell was the Chairman of the panel. No subtopic Rapporteurs were selected. Ms. Christensen was the Facilitator for the panel. The suggested subtopics for the panel were:

A. Transfer from non-NASA U.S. government technology developers to NASA space missions/programs.

B. Transfer from NASA to other U.S. government civil space mission programs.

The panel felt that the major issues associated with these subtopics were essentially the same for non-NASA and civil space transfer, and so the subtopics were not addressed separately. The panel also felt that the limitation of subtopic B to civil space was inappropriate, because DOD is an important potential user and in some cases provider of NASA technology.

Two presentations were made to the panel. Mr. Dula opened the panel discussion with a presentation entitled *Roles/Value of Early Strategic Planning Within the Space Exploration Initiative (SEI) to Facilitate Later Technology Transfer To and From Industry.* (Mr. Dula also provided the panel with a handout entitled Exploration Technology Prioritization. See section EE.) On Wednesday afternoon, Mr. Schneider presented *NOAA Satellite Programs and Technology Requirements*, highlighting the relationship between NOAA and NASA in the past and present, and identifying possible future interactions.

The panel discussion addressed the following major issues:

- DOD/NASA cooperation.
- Alternative mechanisms for interagency communication and interactions.
- Current technology transfer relationship among federal research agencies, and strategies for improving this transfer.
- Technology transfer mechanisms appropriate to intragovernment transfer.
- The importance of industry as a technology transfer conduit.
- Measures of merit.

Dr. Neeland provided an ITBC regarding the coordination of test facility construction and upgrade between industry and government.

The panel's discussion is directly reflected in its conclusions and recommendations, which were presented by Col. Russell to the plenary session on Thursday. The briefing charts used in the plenary session were for the most part developed as the relevant discussion occurred (see Section S.3 for these charts).

Conclusions and Recommendations

The conclusions and recommendations of the panel, as covered in the plenary session presentation, are summarized below.

Feasibility and desirability of DOD/NASA cooperation

The panel found that, while obstacles to cooperation (such as security concerns) existed for advanced development and technology applications research, cooperation could realistically take place between NASA and DOD at the basic research and (to some degree) focused technology levels. An enabling factor was that research be non-classified. The group also noted that technology was typically developed to different levels of maturity by different agencies.

Alternative mechanisms for interagency communication and interactions

The panel discussed the Space Technology Interagency Group (STIG) and its recent revitalization, and the DOD Joint Directorate of Laboratories (JDL). In particular, the structural commonalities between the Directorate of Space and Missile Technologies of JDL and STIG were identified as important factors for successful communication and interaction.

Technology transfer relationships among federal research agencies and strategies for improving transfer

Major federal agencies transferring technology to and from one another were identified, and recommendations for the success of such transfer were developed. These recommendations were: use the planning process to identify areas of commonality (and combine resources when appropriate); develop and (keep current) joint roadmaps of research and development plans and programs; recognize and act on the critical importance of communications (of which STIG is an example); and, include industrial partners early in the process.

Technology transfer mechanisms appropriate to intragovernment transfer

Important technology transfer mechanisms were categorized by the five strategic areas (communications and information; coordinated and/or cooperative research and research interchanges; institutional plans and activities; directed investments; and procedural and/or structural factors) identified early in the workshop. Important mechanisms and issues identified included facility utilization policies that permit sharing of facilities and particularly associated expenses; databases, strategic joint planning, and generally improved communications; structural mechanisms facilitating interactions between agencies (such as the JDL/STIG relationship; staff interchanges, prevention of flow down impediments, and personnel policies that encourage transfer.

Importance of industry as a technology transfer conduit

The panel agreed that industry plays an important role in intragovernment technology transfer, because of the large proportion of technology research performed by industry under government contract. The panel felt that this mechanism may not always work, in part because of the disconnect between industry R&D institutions and industry system design institutions (even within the same firm).

Need for measures of merit, and appropriate terms

The panel discussed the importance of evaluating the effectiveness of technology transfer efforts, and in particular the need to assess research as it occurs in terms of both its scientific quality and its applicability to potential user needs.

Summary

The panel concluded in general that some useful mechanisms (such as STIG) are in place, and that in some cases these mechanisms need to mature before they can be fully evaluated. However, the panel found that significant culture shifts may be necessary for enhancement of technology transfer to occur.

Roles/Value of Early Strategic Planning Within the Space Exploration Initiative (SEI) to Facilitate Later Technology Transfer To and From Industry

Alex S. Dula, Jr.
NASA/JSC Exploration Programs Office

Dula:afu:3/11/92

NASA

Agenda

EXPLORATION PROGRAMS OFFICE

- **Background**
- **Purpose**
- **Approach**
- **Conclusions**

Dula:afu:3/11/92

NASA

Background

EXPLORATION PROGRAMS OFFICE

- NASA has been actively planning missions to return to the moon to stay and to explore Mars for the last four years
- Recently, the SEI Program has initiated an approach based on three strategic themes:
  - The approach will be evolutionary
  - The program must be economically viable
  - Management and organizational structure to yield low-cost, highly reliable, and successful programs
- Near-term strategy is to start small and use a management structure that will deliver on time and within budget
- NASA's Office of Exploration has been determining technology needs for SEI that will be satisfied by the technology development community

Dula:sfu:3/11/92

NASA

Purpose

EXPLORATION PROGRAMS OFFICE

Assess and develop technologies that will support the SEI Program needs and allow transition to the private sector for commercial exploitation in the future.

Dula:sfu:3/11/92

NASA

Approach

EXPLORATION PROGRAMS OFFICE

- First unmanned missions will involve no new technology initiatives in order to accomplished in the near-term
- Prioritization criteria were developed to define the critical technology areas that needed advancement for the planned missions
- One of the criteria used was transportability/spin-off to the commercial sector
- Technology needs for the First Lunar Outpost (FLO) (1992-1995 timeframe) have been identified and transmitted to NASA Code R for input into the Integrated Technology Plan (ITP)
- Technology needs for the permanent lunar base and initial manned Mars missions (timeframe 1995+) have also been identified and inputted to Code R
- Strategic planning involves defining those technologies that SEI will need but also can be synergistically needed and used by the commercial sector in the future.
- Planning needs to occur now to define the best way to work together to set the stage for later technology transfer by involving industry in the process

Dula:afu:3/11/92

NASA

Conclusions

EXPLORATION PROGRAMS OFFICE

- By working with industry, NASA's technology needs for the future can be defined to support technology transfer to industry at a later date and in a manner that will improve our competiveness in the world economic market
- The SEI will require the cooperative effort of many government agencies to help develop the technologies to allow the United States to lead the way in the 21st Century for space exploration. colonization, and exploitation

Dula:afu 3/11/92

NOAA SATELLITE PROGRAMS AND TECHNOLOGY REQUIREMENTS

STANLEY R. SCHNEIDER
CHIEF
ADVANCED SYSTEMS PLANNING DIVISION
NOAA/NESDIS

CIVIL SPACE TECHNOLOGY TRANSFER WORKSHOP
MCLEAN, VIRGINIA
MARCH 17 - 19, 1992

NOAA'S SPACE PHILOSOPHY

PRESENT

- Maintain 2 GOES operating systems
- Maintain 2 POLAR operating systems
- NOAA will continue to be the source of environmental observations for global change studies for the 1990's
  - Snow cover
  - Ice Analysis
  - Sea Surface Temperature
  - Earth Radiation Budget
  - Vegetation Index
  - Ozone
  - Advanced Microwave Soundings
  - Improved Ozone Measurements
- Europeans to provide morning polar-orbiting worldwide satellite service in late 1990's

NESDIS FY 1993 BUDGET SUMMARY

(Dollars In Thousands)

	FY 1992	FY 1993	INC/DEC
SATELLITE OBSERVING SYSTEMS			
Polar Orbiting System	130,289	216,553	+ $ 86,264
Geostationary System	118,000	128,896	+ 10,896
Landsat Commercialization	2,000	0	- 2,000
Landsat Operations	7,560	0	- 7,560
Environmental Observing Services	52,943	52,943	0
SUBTOTAL	$310,792	$398,392	+ $87,600
ENVIRONMENTAL DATA MANAGEMENT SYSTEM	$34,028	$39,596	+ 5,568
TOTAL NESDIS	$344,820	$437,988	+ $ 93,168

2/5/92

LANDSAT

LANDSAT PROGRAM STATUS

- o LANDSAT 4, 5 CONTINUE TO OPERATE
- o LANDSAT - 6 LAUNCH SCHEDULED FOR JANUARY 22, 1993 WITH ETM
- o ADMINISTRATION COMMITTED TO CONTINUITY OF LANDSAT TYPE DATA
  - DETAILS BEING WORKED WITH NASA AND DOD

GOES

WHY GOES?

Warnings to Public -- Detect, Track and Characterize

HURRICANES
SEVERE OR POSSIBLY TORNADIC STORMS
FLASH FLOOD PRODUCING WEATHER SYSTEMS

Imagery for Weather Forecasting

Direct National and International Users
Value Added Companies for Media and other Agencies

Winds for Aviation and NWS Numerical Models

Environmental Data Collection - Platforms including Buoys, Rainguages.

HISTORY OF GEOSTATIONARY SATELLITES

SATELLITES	*LAUNCHED*	*MISSION-INSTRUMENTATION*
SMS-1	May 1974	Proved Geostationary imaging feasible
SMS-2	February 1975	Both SMS's had VISSR, DCS, SEM
GOES-1	October 1975	First NOAA funded
GOES-2	June 1977	Basic VISSR, DCS, SEM instruments
GOES-3	June 1978	Instrumented like GOES-1 & -2
GOES-4	September 1980	First VAS sounder instrument added
GOES-5	May 1981	First Stepable Lamp Voltage
GOES-6	April 1983	Additional incandescent bulbs added
GOES-7	February 1987	LED and SAR experiment added

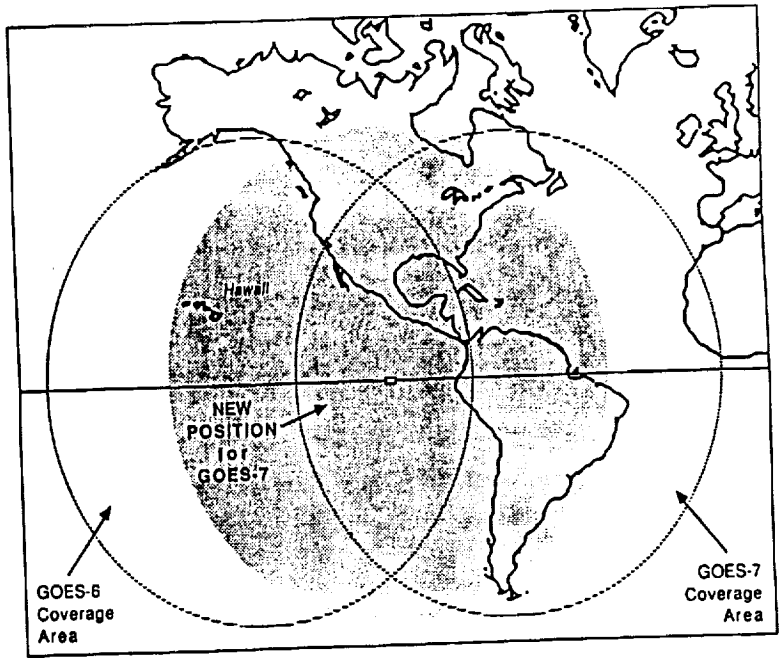
(VISSR - Visible and Infrared Spin Scan Radiometer)
(DCS - Data Collection System)
(SEM - Space Environmental Monitor) (VAS - VISSR Atmospheric Sounder)
(SAR - Search and Rescue Experiment) (LED - Light Emitting Diode)

GOES PROGRAM

- NORMALLY A 2 GOES PROGRAM
  - -- (75°W AND 135°W)
  - -- GOES - 7 CURRENTLY AT CENTRAL LOCATION
- LAUNCH NEW GOES IN ANTICIPATION OF A GOES FAILURE
- 5 YEAR DESIGN LIFE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE



CURRENT GOES INSTRUMENTS

Remote Sensing

VAS - Visible/Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder

SEM - Space Environment Monitor
- -- High Energy Particles
- -- Solar X - Rays
- -- Earth's Geomagnetic Field

Communications

Direct Broadcast (Western hemisphere and U. S. private sector)

WEFAX - Weather Facsimile

DCS - Data Collection System - 6000 platforms

SAR - Search and Rescue experiment

IMPROVED GOES CAPABILITIES

GOES - 7	GOES I - M
● Earth location accuracy 10 Km	● Earth location accuracy 2-4 Km
● IR Resolution - 8 Km	● IR Resolution - 4 Km *Improved Tracking & Detection of Severe Storms/Flash Floods*
● Sounder Resolution - 14 Km	● Sounder Resolution - 8 Km 7 more channels
● Images or Soundings	● Simultaneous Imaging/Sounding
● Limited "Small Picture" repetitive viewing	● Can take "Small Picture" view of a Severe Storm every 5 minutes

GEOSTATIONARY SATELLITE FUTURE

- o GOES - I 1993
- o GOES - J 1994
- o GOES - K 1998
- o GOES - L 1999
- o GOES - M 2003
- o GOES I-M LAUNCH USING COMMERCIAL LAUNCH SERVICES (ATLAS CENTAUR)

POES

WHY POLAR ORBITERS?

ESSENTIAL Global Temperature and Humidity Vertical Profiles

Input to NWS numerical models to describe current state of the atmosphere - Input to initialize model with quantitative temperature and humidity data

Worldwide Imagery Coverage

Cloud/frontal/snow cover inputs to numerical models
Warnings of tropical cyclones and volcanic eruptions

Shipping/Fishing

Sea surface temperature
Ice analysis

Global Warming - Worldwide monitoring of ozone, vegetation index

Flying/Boating - Search and Rescue

HISTORY OF TIROS R & D SATELLITES

SATELLITES	LAUNCHED	MISSION - APPLICATIONS
TIROS - I	April 1, 1960	Proved TV operation in space feasible
TIROS - II	November 1960	First ice floes observed-First IRRAD
TIROS - III	July 1961	First hurricane observed
TIROS - IV	February 1962	First international use of data
TIROS - V	June 1962	Broader image coverage
TIROS - VI	September 1962	Hurricane watch program begun
TIROS - VII	June 1963	Supported Indian Ocean Experiment
TIROS - VIII	December 1963	Direct Readout APT system
TIROS - IX	January 1965	Daily global coverage
TIROS - X	July 1965	Near Polar orbit - sun synchronous

(APT - Automatic Picture Transmission)
(IRRAD - Infrared radiometer)

HISTORY OF ESSA OPERATIONAL SATELLITES

SATELLITES	LAUNCHED	MISSION - INSTRUMENTATION
ESSA-1	February 1966	First Global Operational Satellite
ESSA-2	February 1966	First Global Operational APT
ESSA-3	October 1966	First Global Operational AVCS/LRIR
ESSA-4	January 1967	APT Operational Satellite
ESSA-5	April 1967	AVCS Operational Satellite
ESSA-6	November 1967	APT Operational Satellite
ESSA-7	August 1968	First AVCS with S-Band
ESSA-8	September 1968	APT Operational Satellite
ESSA-9	February 1969	First AVCS with dual S-Band

(APT - Automatic Picture Transmission)
(AVCS - Advanced Videcon Camera System)
(LRIR - Low Resolution Infrared)

HISTORY OF ITOS/NOAA SATELLITES

SATELLITES	LAUNCHED	MISSION - INSTRUMENTATION
ITOS-1	January 1970	First SR & Solar Proton Flat Plate First Three Axis Stabilization
NOAA-1	December 1970	Configured like ITOS-1
NOAA-2	October 1972	First VHRR & VTPR
NOAA-3	November 1973	First Direct Readout VTPR
NOAA-4	November 1974	Configured like NOAA-3
NOAA-5	July 1976	Configured like NOAA-3

(SR - Scanning Radiometer)
(VHRR - Very High Resolution Radiometer)
(VTPR - Vertical Temperature Profile Radiometer)

HISTORY OF TIROS-N/NOAA SATELLITES

SATELLITES	LAUNCHED	MISSION - INSTRUMENTATION
TIROS-N	October 1978	First AVHRR,HIRS/2,MSU,SSU,DCS,SEM
NOAA-6	June 1979	Configured like TIROS-N
NOAA-7	June 1981	Increased AVHRR channels from 4 to 5
NOAA-8	March 1983	First Search and Rescue Payload
NOAA-9	December 1984	First SBUV/2 & ERBE Instruments
NOAA-10	September 1986	Configured like NOAA-9
NOAA-11	September 1988	First Capable of 0-80 Degree Sun Angle
NOAA-12	May 1991	First "Re-cycled" Satellite

(ERBE - Earth Radiation Budget Experiment)
(AVHRR - Advanced Very High Resolution Radiometer)
(SBUV - Solar Backscatter UltraViolet) *(MSU - Microwave Sounding Unit)*
(DCS - Data Collection System) *(HIRS - High Resolution Infrared Sounder)*
(SEM - Space Environmental Monitor) *(SSU - Stratospheric Sounding Unit)*

POLAR METSAT

PLANNING LAUNCH SCHEDULE

SATELLITE NAME	PROJECTED LAUNCH DATE	NEED DATE
I	SEP 1992(31)	-
J(AM)	DEC 1993(31)	MAR 1993
K	APR 1995(31)	JUN 1994
L(AM)	JUL 1996(31)*	OCT 1995
M	NOV 1997(31)	JAN 1997
N	JUN 2000(31)	MAY 1998
O	JAN 2002(36)**	DEC 2000
P	JAN 2005(36)	JUL 2002
Q	JAN 2008(36)	JUL 2005

CURRENT POLAR - ORBITING SATELLITE INSTRUMENTS

Remote Sensing

AVHRR - Advanced Very High Resolution Radiometer
-- 1 Km and 4 Km Imagery

HIRS - High Resolution Infrared Sounder
SSU - Stratospheric Sounding Unit — *Sounder*
MSU - Microwave Sounding Unit

SEM - Space Environment Monitor
-- MEPED Moderate Energy Particle and Electron Detector
-- TED Total Energy Detector

* ERBE - Earth Radiation Budget Experiment
SBUV - Solar Backscatter Ultraviolet - Ozone

**CARRIED ONLY ON NOAA 9 AND 10*

Communications

Direct Broadcast - 120 + Countries depend on this data
DCS - Data Collection System (ARGOS) - 2000 Platforms
SARSAT - Search and Rescue > 1400 lives saved

INTERNATIONAL INSTRUMENTS ON NOAA SATELLITES

Stratospheric Sounding Unit (SSU)	United Kingdom
Advanced Microwave Sounding Unit - B	United Kingdom
ARGOS Data Collection System	France
Search and Rescue	Canada, France

NOAA K, L, M, UPGRADES

* AMSU - A, B, REPLACES SSU AND MSU
* AVHRR GAINS 1.6 UM CHANNEL
* INCREASED CAPACITY FOR ARGOS DATA COLLECTION AND LOCATION SYSTEM

POLAR ENVIRONMENTAL SATELLITE FUTURE PROGRAM

- AGREEMENT IN PRINCIPLE BETWEEN U.S. AND EUROPE (ESA & EUMETSAT) FOR EUROPE TO ASSUME RESPONSIBILITY FOR MORNING MISSION, AND NOAA TO CONTINUE AFTERNOON MISSION.
- NOAA TO PROVIDE OPERATIONAL METEOROLOGICAL FLIGHT INSTRUMENTS TO EUROPE (EUMETSAT).
- FIRST LAUNCH OF MORNING SEGMENT OPERATIONAL EUROPEAN SPACECRAFT, POEM-1, NEAR END OF DECADE (1998).
- EUROPE TO PROVIDE HIGH LATITUDE GROUND STATION TO READ OUT DATA FROM BOTH SATELLITES (IN ADDITION TO FAIRBANKS/WALLOPS).
- DATA EXCHANGED IN TIMELY WAY (LESS THAN 2 HOURS) BETWEEN EUROPE AND U.S.
- NOAA TO ACQUIRE EOS PROTOTYPE OPERATIONAL INSTRUMENT DATA IN NEAR REAL TIME FROM WHITE SANDS

POLAR ENVIRONMENTAL SATELLITE
FUTURE PROGRAM (CONTINUED)

- BASELINE JOINT PROGRAM WITH EUROPE (EUMETSAT)
  - EUROPE AM MISSION (POEM-1 AND FOLLOW-ON)

    (10:00 AM, LST, DESCENDING NODE)
  - U.S. PM MISSION (NOAA O,P,Q)

    (1:45 PM, LST, ASCENDING NODE)
- U.S. SUPPLIED OPERATIONAL COMMON INTERFACE INSTRUMENTS (CII) FLOWN ON BOTH U.S. & EUROPEAN MISSIONS.
  - COMPETITIVE PHASE B STUDIES FEB 92 - MAY 93
  - PHASE C/D BEGIN MID 1993

NOAA O,P,Q SPACECRAFT

- PHASE A STUDIES COMPLETED THE FIRST QUARTER OF 1992
- INCREASED LIFETIME REQUIREMENT AS COMPARED TO NOAA K,L,M
- ORBITAL DRIFT LIMITED TO +/- TEN MINUTES OVER THREE YEARS
- STUDIES INCLUDE POSSIBLE ACCOMMODATION OF NASA PROTOTYPE OPERATIONAL INSTRUMENTS: AIRS, ALT, CERES, HIRDLS, MIMR, SCATT
- COMPETITIVE PHASE B CONTRACTS START FIRST QUARTER CY 1993
- PHASE C/D START CY 1995

EUROPEAN POLAR PROGRAM PLANNING

- o ESA
  - POEM-1 SPACECRAFT (MID 1998)
  - ARIANE 5 LAUNCH
- o EUMETSAT
  - PAYLOAD INTERFACES
  - AMSU-B/MHS INSTRUMENTS
  - SPACECRAFT SUBSYSTEMS
- QUARTERLY NOAA/NASA-GSFC/ESA/EUMETSAT COORDINATION MEETINGS
- SEMI-ANNUAL EOS-ICWG MEETING (U.S./EUROPE/CANADA/JAPAN)

UPGRADED DATA HANDLING AND COMMUNICATIONS SERVICES FOR NOAA O,P,Q AND OPNL POEM-1 METEOROLOGICAL PAYLOAD

- o ALL HIGH RESOLUTION (1KM) IMAGER DATA STORED AND PLAYED BACK
- o HRPT DATA RATE INCREASED TO 3.0 - 3.5 MBPS
- o 100 MBPS RECORDED PLAYBACK RATE FOR GLOBAL DATA
- o ANALOG APT REPLACED WITH DIGITAL LRPT

IMAGER

OLD		NEW
AVHRR/3	NAME	VIRSR
6	NO. OF SPECTRAL CHANNELS	7
5	NO. OF SIMULTANEOUS CHANNELS	7
10 (11 EFF)	RESOLUTION (BITS)	12
1.1	RESOLUTION (KM)	1.1
0.12	NEDT (CH. 4-7)	0.10
	IN-ORBIT CALIBRATION (%)	
1 NONE	INFRA-RED VISIBLE	1 3
ANTI-SUN TO SUN	SCAN DIRECTION	SUN TO ANTI-SUN
$\pm$57.0	SCAN COVERAGE (DEG)	$\pm$57.0
6	SCAN RATE (SCANS PER SEC.)	~6

INFRA-RED SOUNDER

OLD		NEW
HIRS/3	NAME	IRTS
20	NO. OF SPECTRAL CHANNELS	20
12	RESOLUTION (BITS)	12
21	RESOLUTION AT NADIR (KM)	19.5
2	IN-ORBIT CALIBRATION (%)	2
SUN TO ANTI-SUN	SCAN DIRECTION	SUN TO ANTI-SUN
$\pm$49.5	SCAN COVERAGE (DEG)	$\pm$49.5
6.4	SCAN-TIME (SECS)	8 INC. CALIB.

MICROWAVE TEMPERATURE SOUNDER

OLD		NEW
AMSU-A	NAME	MTS
15	NO. OF SPECTRAL CHANNELS	21
45	MAX SOUNDING ALTITUDE (KM)	73
14	RESOLUTION (BITS)	14
45	RESOLUTION AT NADIR (KM)	45
2	IN-ORBIT CALIBRATION (%)	2
SUN TO ANTI-SUN	SCAN DIRECTION	SUN TO ANTI-SUN
$\pm$48.3	SCAN COVERAGE (DEG)	$\pm$48.3
8 INC. CALIB.	SCAN TIME (SECS)	8 INC. CALIB.

MICROWAVE SOUNDER (WATER VAPOR & PRECIPITATION)

OLD		NEW
AMSU-B	NAME	MHS
5	NO. OF SPECTRAL CHANNELS	5
14	RESOLUTION (BITS)	14
15	RESOLUTION AT NADIR (KM)	15
2	IN-ORBIT CALIBRATION (%)	2
SUN TO ANTI-SUN	SCAN DIRECTION	SUN TO ANTI-SUN
8/3	SCAN TIME (SECS)	8/3
$\pm$49.0	SCAN COVERAGE (DEG)	$\pm$49.0

OZONE MONITOR

OLD		NEW
SBUV	NAME	SBUV
12	NO. OF SPECTRAL CHANNELS	12
14	RESOLUTION (BITS)	14
165	RESOLUTION (KM)	165
DIFFUSER PLATE + REFLECTANCE/ TRANSMITTANCE	IN-ORBIT CALIBRATION	DIFFUSER PLATE + REFLECTANCE/ TRANSMITTANCE

OZONE MAPPER

OLD		NEW
NONE	NAME	TOMS
	NO. OF SPECTRAL CHANNELS	6
	RESOLUTION (BITS)	14
	RESOLUTION AT NADIR (KM)	45
	SNR	>30 MIN. SCENE RADIANCE
	IN-ORBIT CALIBRATION	DIFFUSER PLATE + REFLECTANCE
	SCAN DIRECTION	ANTI-SUN TO SUN
	SCAN COVERAGE (DEG)	$\pm$51.0
	SCAN TIME (SECS)	8.0

NOAA'S SPACE BASED OBSERVATIONS

FUTURE

- NOAA will be an IMPORTER of satellite data by end of the decade.

NOAA WILL:

-- Negotiate for access to all foreign and non-NOAA remote sensing platforms with needed data
-- Provide information to users in Near-Real time
-- Depend on "Free and Open" exchange of data

- To achieve this: NOAA plans to Improve ground capabilities including communications, workstations, directories, scientific and technical infrastructure to Support real-time access to environmental information

NOAA'S ROLE IN "MISSION TO PLANET EARTH"

NOAA will be provided access, in near real time, to prototype operational sensor data from the Earth Observing System (EOS) platforms. The following EOS instruments will be designed with standardized interfaces to allow for possible flight on future NOAA spacecraft.

HiRDLS - Ozone Limb Scanner
MIMR - Passive Microwave Imager
CERES - Earth Radiation Budget Sensor
AIRS - Atmospheric Infrared Sounder
Scatterometer
Altimeter

FOREIGN SATELLITE DATA ACQUISITION ACTIVITIES

- NOAA SUPPORTING LAUNCH OF JERS-1 (NET FEBRUARY 11)
- SIGNING OF ERS-1 DATA MOU BETWEEN NOAA/ESA SCHEDULED FOR FEBRUARY 26
- NOAA TO DISTRIBUTE CANADIAN RADARSAT DATA TO U.S. USERS
- NOAA NEGOTIATING WITH NASA AND JAPAN/NASDA FOR OPERATIONAL ACCESS TO ADEOS SCATTEROMETER AND OCEAN COLOR DATA

SATELLITE OBSERVATION SYSTEMS FOR THE CLIMATE AND GLOBAL CHANGE ERA

(1990 TO 2010)

SENSOR GENERIC TYPE	NOAA-10 TO NOAA-J	DMSP	ERS-1 ERS-2	UARS	JERS-1	TOPEX	SEA WIFS	NOAA-K TO NOAA-N	RADAR SAT	GEOSAT FO	ADEOS	TRMM	EPOP/ POEM	EOS	JEOS	NOAA* CPO
(LAUNCH / SERVICE PERIOD)	86-93	90+	91-97	91	92	92	93	94-01	94	95+	95	96	97+	98+	99	01-08
VISIBLE/INFRARED IMAGER	X	X	X		X			X			X	X	X	X	X	X
MICROWAVE IMAGER		X										X	X	X	X	
ALTIMETER			X			X				X			X	X		
SCATTEROMETER			X								X		X	X		
OCEAN COLOR SENSOR							X				X		X	X	X	
RADAR (SYNTHETIC AND REAL APERTURE)			X		X				X			X	X	X	X	
IR/MICROWAVE SOUNDERS	X	X	X			X		X				X	X	X		X
WIND SOUNDERS				X										X	X	
EARTH RADIATION BUDGET INST.											X		X	X		
TRACE GASES & OZONE	X			X				X			X		X	X		X
SPACE ENVIRONMENT MONITOR	X	X		X				X					X	X		X

NON-NOAA DATA SOURCE OF INTEREST

NOT MANIFESTED ON NOAA SATELLITES

* MAY HAVE PAYLOAD GROWTH CAPABILITY

WORKING PANEL #2

TECHNOLOGY TRANSFER WITHIN THE GOVERNMENT

COL. JOHN RUSSELL

TECHNOLOGY TRANSFER WITHIN THE GOVERNMENT

CHARTER

TO EXAMINE TECHNOLOGY TRANSFER WITHIN THE U.S. GOVERNMENT

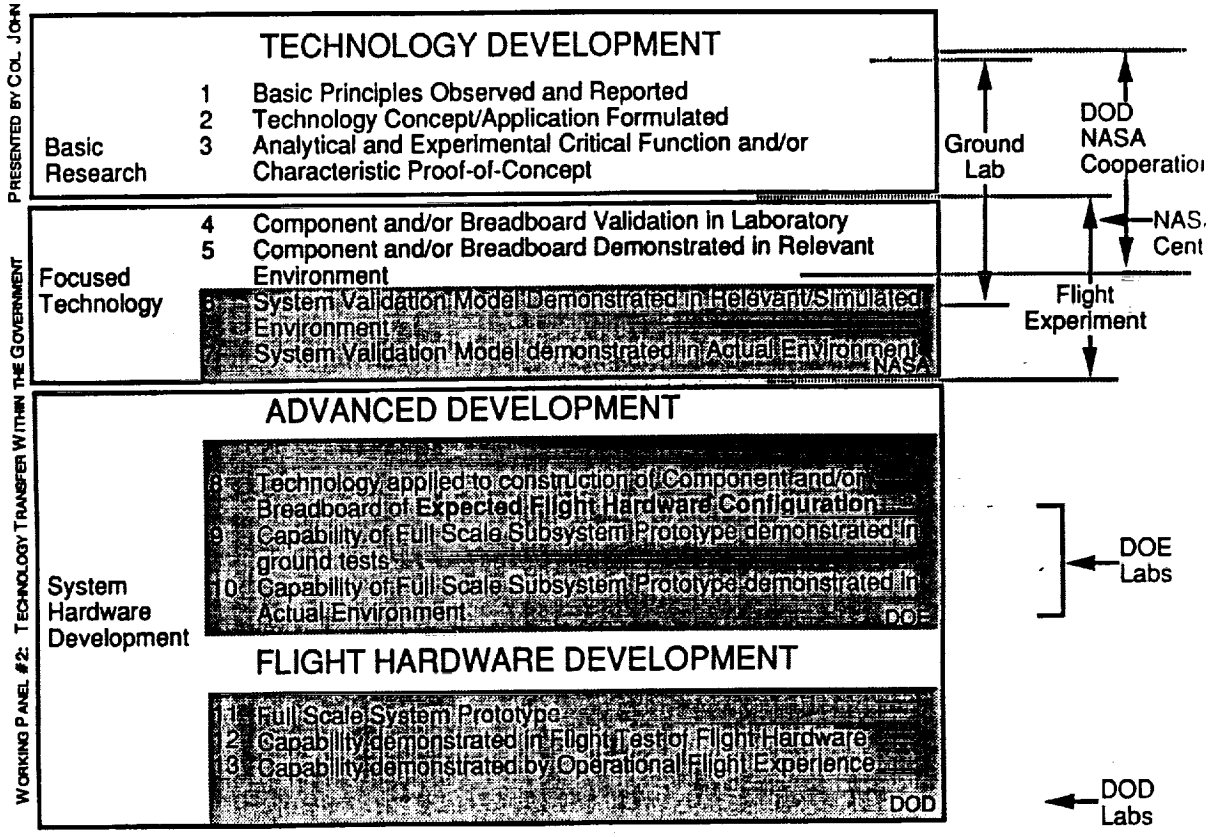
SUBTOPICS

A TRANSFER FROM NON-NASA US GOVERNMENT TECHNOLOGY DEVELOPERS TO NASA SPACE MISSIONS/PROGRAMS

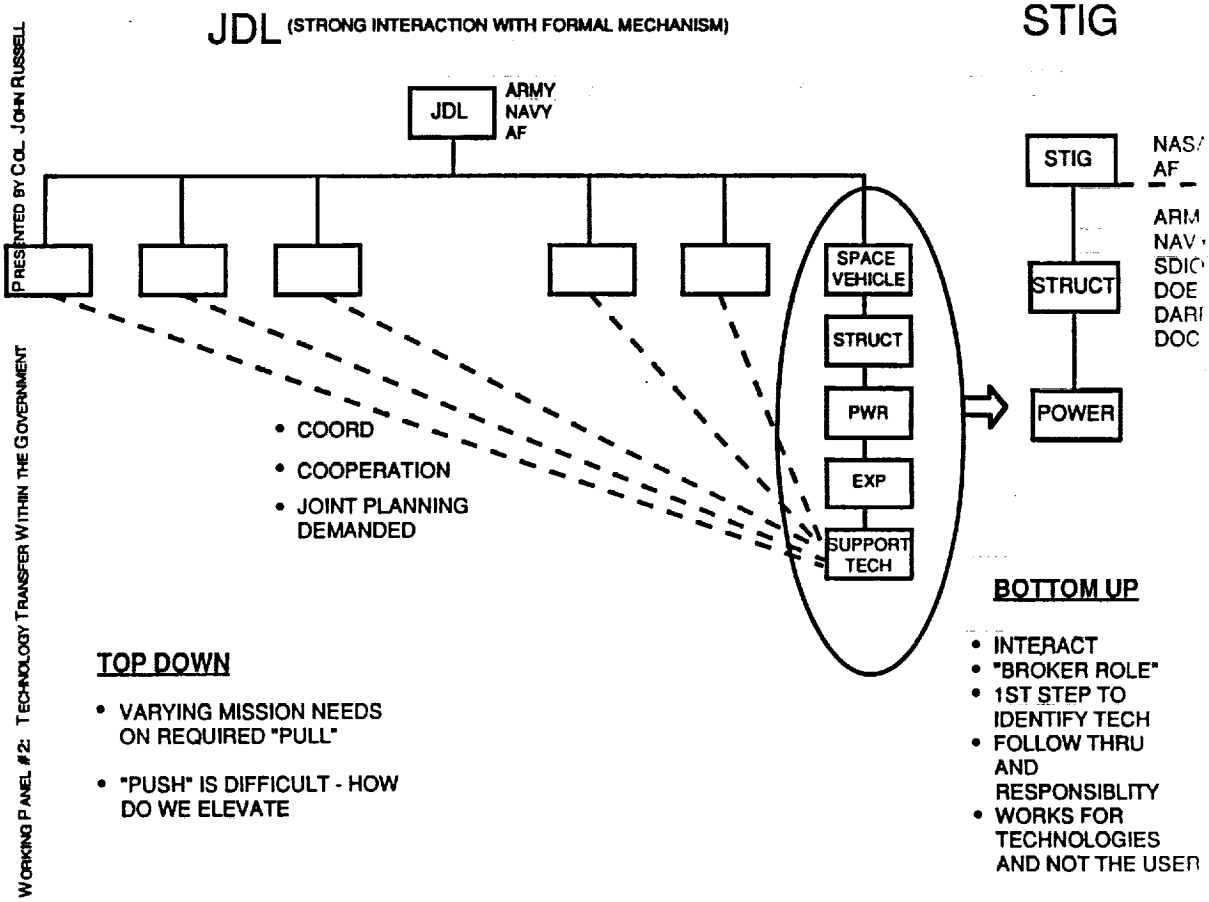
B TRANSFER FROM NASA TO OTHER US GOVERNMENT ~~CIVIL~~ SPACE MISSION PROGRAMS

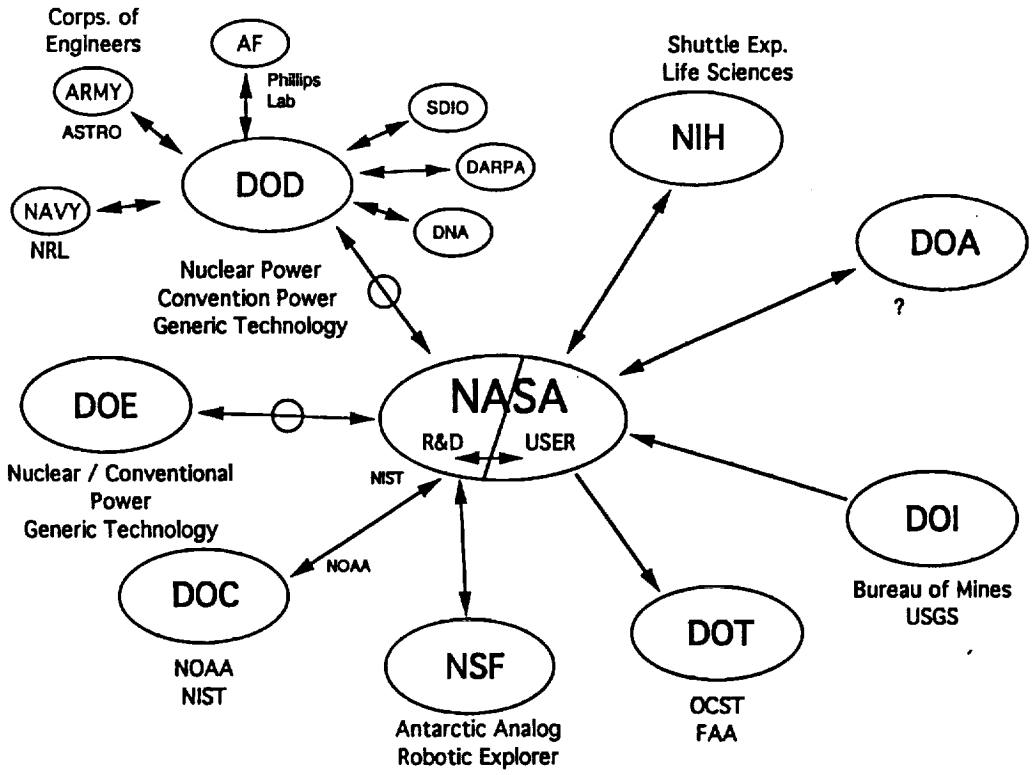
MAJOR SUBTOPIC ISSUES ARE ESSENTIALLY THE SAME.

Technology Maturation Milestones



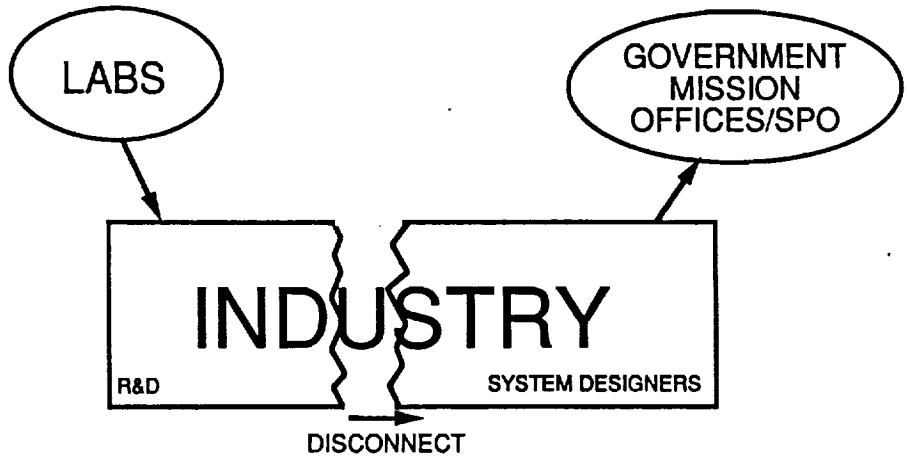
PRESENTED BY COL JOHN RUSSELL
WORKING PANEL #2: TECHNOLOGY TRANSFER WITHIN THE GOVERNMENT



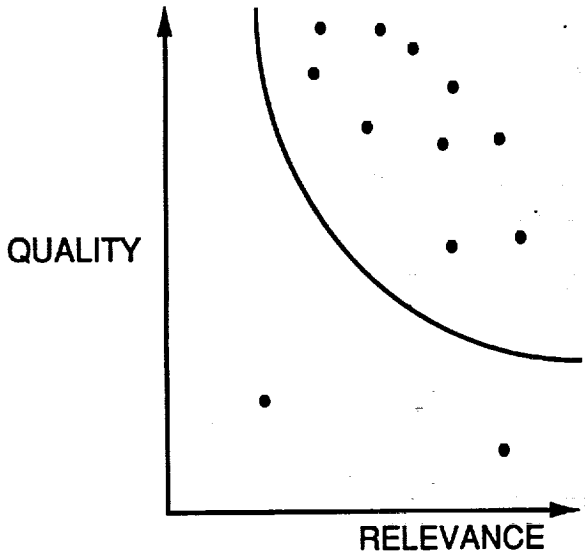


- Use planning process to look for areas of commonality (combine resources)
- Joint roadmaps
- Communications is key -- STIG
- Include Indusrtial partner

WORKING PANEL #2: TECHNOLOGY TRANSFER WITHIN THE GOVERNMENT PRESENTED BY COL JOHN RUSSELL



MEASURES OF MERIT



VARY WITH LEVEL/TYPE AT TECHNOLOGY

CONCLUSIONS

- USEFUL MECHANISMS ARE IN PLACE
- NEWER MECHANISMS NEED TO MATURE, THEN BE REVISITED
- CULTURE SHIFT MAY BE NECESSARY

Omit

T. Working Panel #3: Transfer between NASA and the Aerospace Community

Russell C. Cykoski
General Research Corporation

Robert G. Steen
Princeton Synergetics, Inc.

The following participants of the workshop were members of this panel:

Individual	Organization
Adelson, Dr. Harold	TRW
Bowles, Mr. Norman	Department of Transportation
Dunbar, Mr. Dennis	General Dynamics
Fuller, Mr. Joseph	Futron Corporation
Gernand, Mr. Joseph	Rockwell International
Holcomb, Mr. Lee	NASA Headquarters
Jennings, Mr. John	NASA Headquarters
Marinzel, Mr. Ronald	BDM International Inc.
Marzwell, Dr. Neville	Jet Propulsion Laboratory
McGovern, Dr. Dennis	McDonnell Douglas
Morris, Mr. Charles	NASA Headquarters
Olstad, Dr. Walter	Lockheed
Palmer, Dr. Larry	Hughes Network Systems
Sackheim, Mr. Robert	TRW
Thurman, Mr. Don	Marshall Space Flight Center
Weaver, Mr. Willard	Langley Research Center
Wells, Mr. Damon	Department of Transportation

The panel agreed to discuss the two suggested subtopics pertaining to technology transfer between the NASA and the aerospace community:

A. Technology transfer associated with a projected Government application.

B. Technology transfer associated with a commercial space sector application.

Mr. Sackheim served as chair of the panel on Wednesday, and was succeeded by Mr. Dunbar on Thursday. Dr. Olstad was Rapporteur for subtopic A. Dr. Marzwell was Rapporteur for subtopic B. Mr. Cykoski acted as Facilitator for the panel. No Issue To Be Considered (ITBC) forms were submitted.

There were four pilot presentations given during the session. The first, presented by Mr. Bowles, focused on commercial space activities as they relate to international competitiveness issues and the need for greater self-determination by private industry. Mr. Gernand followed with a discussion of two technology partnership models, one for government as a customer of technology and one for government as a facilitator for a commercial customer. Mr. Morris described the NASP program and its technology transfer activities. Mr. Holcomb discussed the High Performance Computing and Communications Program and its relation to international competitiveness, including the role of technology transfer in greater speed innovation.

The working panel divided into two subtopic discussion groups. The subtopic A working group discussed several issues, including concern about the degree of government control and the extent of industry dependence. The subpanel members agreed that funding priorities were incompatible with goals for national competitiveness and that greater financial support is needed for technology transfer. The nature of the transfer process was questioned regarding the amount of technology designated for commercial use, the necessary level of development needed for transfer, and the type of incentives needed for greater transfer. The subpanel also discussed the Japanese model of tech transfer for comparison, and the effectiveness of

the SBIR program for large aerospace firms.

The subtopic B working group had a briefer discussion, with the subpanel members submitting written comments to the rapporteur. These comments are reflected in the subtopic B presentation given at the plenary session held Thursday morning.

At the plenary session, Mr. Dunbar, Dr. Olstad, and Dr. Marzwell made presentations summarizing the panel's conclusions and recommendations regarding both subtopics. Those findings are listed below:

Subtopic A: Technology transfer associated with a projected Government application

Issues

- Management (in government and industry) lacks understanding of the tech transfer process and its importance.
- There has been an increase in the number of inhibiting laws and regulations.
- NASA and industry have lost their enthusiasm for tech transfer activities.
- The amount of personnel mobility is inadequate.
- R&T reacts in knee-jerk fashion to programmatic instabilities.

Conclusions and Recommendations

- Clarify the roles for parties involved in tech transfer.
- Develop common understanding of the tech transfer process.
- Recreate "passion" for tech transfer among involved parties, especially NASA.
- Institute a National Space Technology Facilities Policy.
- Increase the amount of personnel exchange.
- Improve the management of tech transfer activities, especially through the ITP.

Subtopic B: Technology transfer associated with a commercial space sector application

Issues

- Lack of long-term strategic goals for government agencies involved in tech transfer.
- Industry relies too heavily on government for space market needs and definition due to lack of adequate capital requirements.
- Commercial sectors incur undue risk due to the low readiness levels of the government's R&D base.
- No clear funding for engineering prototyping, qualification, or flight validation.
- Human competence, training, and education levels do not match higher and more complex technology levels.
- Multi-mode technology transfer organizations are highly disorganized.
- SBIR effectiveness has no impact on space systems development due to a shortage in capital borrowing capabilities.

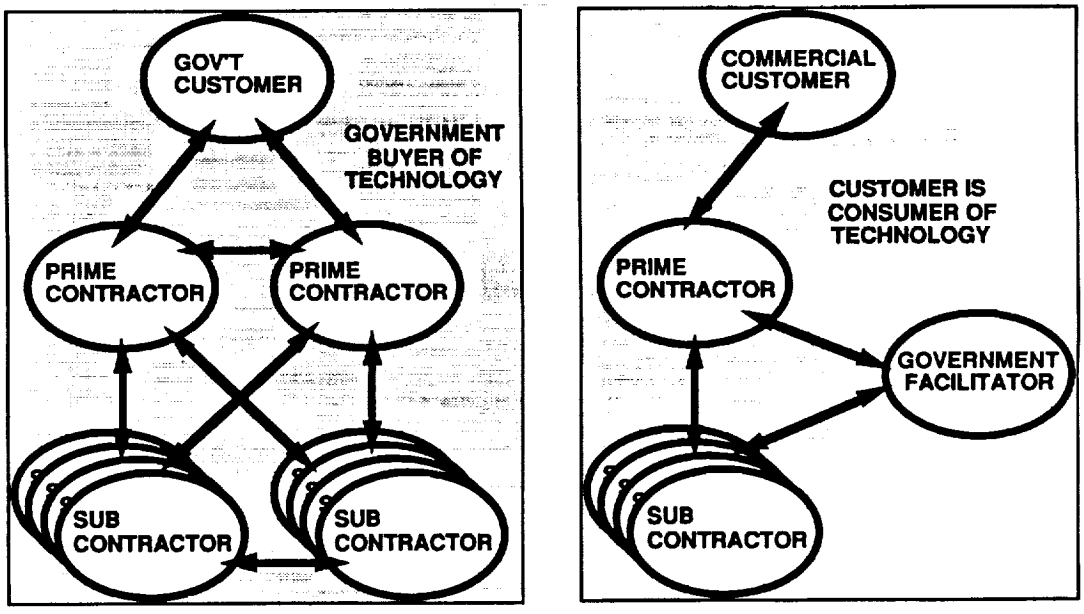
Conclusions and Recommendations

- A new methodology and approach to tech transfer is more important than more money.
- Cost effective, goal-oriented consortiums are a promising new endeavor.
- Joint technology fairs or shows are more effective than publications alone where a "hands-on" approach is encouraged.
- Define a quantifiable procedure with measurable objectives for technology transfer.
- Develop a culture for business between government and industry based on cost effectiveness and technology transfer.

CIVIL SPACE TECHNOLOGY TRANSFER WORKSHOP

Joseph Gernand

TWO TECHNOLOGY PARTNERSHIP MODELS FOR CONSIDERATION



SUCCESSFUL TEAMS SHARE INFORMATION

COMPETITIVE MARKET PLACE NECESSITATES SOME BARRIERS

ISSUES TO TECH TRANSFER	PROTECTIVE BARRIERS
INTELLECTUAL PROPERTY RIGHTS	PATENT LAWS
NATIONAL SECURITY	MUNITIONS CONTROL ACT
MARKET NICHE OR SHARE	PROPRIETARY INFORMATION AGREEMENTS

COOPERATION TOWARD COMMON GOAL REQUIRES CONTROL IN THE SHEARING OF PRIVATE INFORMATION

MANY BARRIERS ARE UNNECESSARY AND DETRIMENTAL

HUMAN
- "NO NEW TECHNOLOGY" PROGRAMS
- NIH
- IGNORANCE
- "IF IT ISN'T BROKE DON'T FIX IT"

INSTITUTIONAL
- POOR DISSEMINATION PRACTICES
- LIMITED INFORMATION DATA BASING AND CONSOLIDATION
- NO LINK BETWEEN TECHNOLOGY & STRATEGIC PLANNING
- LIMITED RESEARCH DURING EARLY PROGRAM PHASES

MANY PROGRAMS EXIST TO FACILITATE TECHNOLOGY TRANSFER AMONG GOV'T AND INDUSTRY USERS

MODELS

MANTECH

TECHNOLOGY UTILIZATION

WORKING GROUPS

PUBLICATIONS (TECH BRIEFS, SPIN-OFFS, TECHNICAL REPORTS, ETC.)

ARE THESE AND THE MANY OTHER SIMILAR PROGRAMS MEETING THE TECHNOLOGY TRANSFER REQUIREMENTS OF THE 2 PARTNERSHIP MODELS ?

ARE THERE ADEQUATE TECHNOLOGY TRANSFER MECHANISMS FOR THE TWO MODELS ?

WHAT ARE THE MODELS TECHNOLOGY TRANSFER REQUIREMENTS ?

HOW SHOULD THE SUCCESS OF APPROACHES BE MEASURED ?

WHAT SHOULD BE DONE (IF ANYTHING) TO IMPROVE / AUGMENT / SUPPLEMENT THE EXISTING APPROACHES ?

Office of
Aeronautics and
Space
Technology

NASP TECHNOLOGY TRANSFER

Presentation to

ITP Workshop

Charles Morris
Assistant Director
March 18, 1992

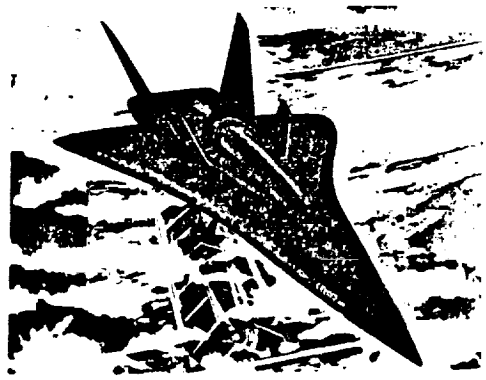
NATIONAL AERO-SPACE PLANE (NASP)

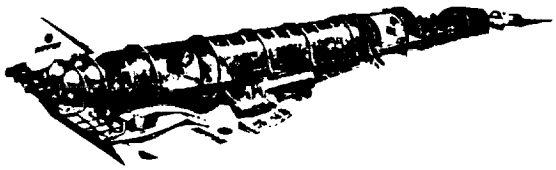
GOAL: To develop and then demonstrate the technologies for single-stage-to-orbit flight and hypersonic cruise with airbreathing primary propulsion and horizontal takeoff and landing

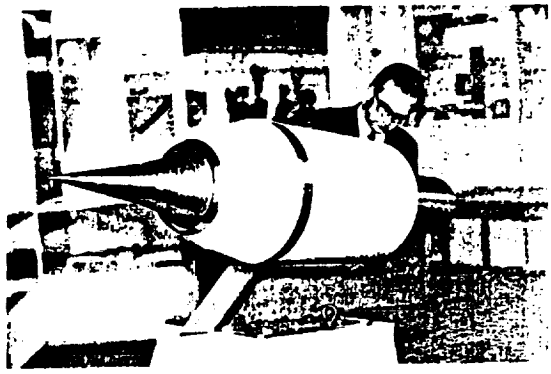
VALUE:
- technology for flexible, efficient access to space
- technology for hypersonic cruise
- advancement of U.S. aerospace-technology base

INTERNATIONAL AEROSPACE-PLANE TECHNOLOGY

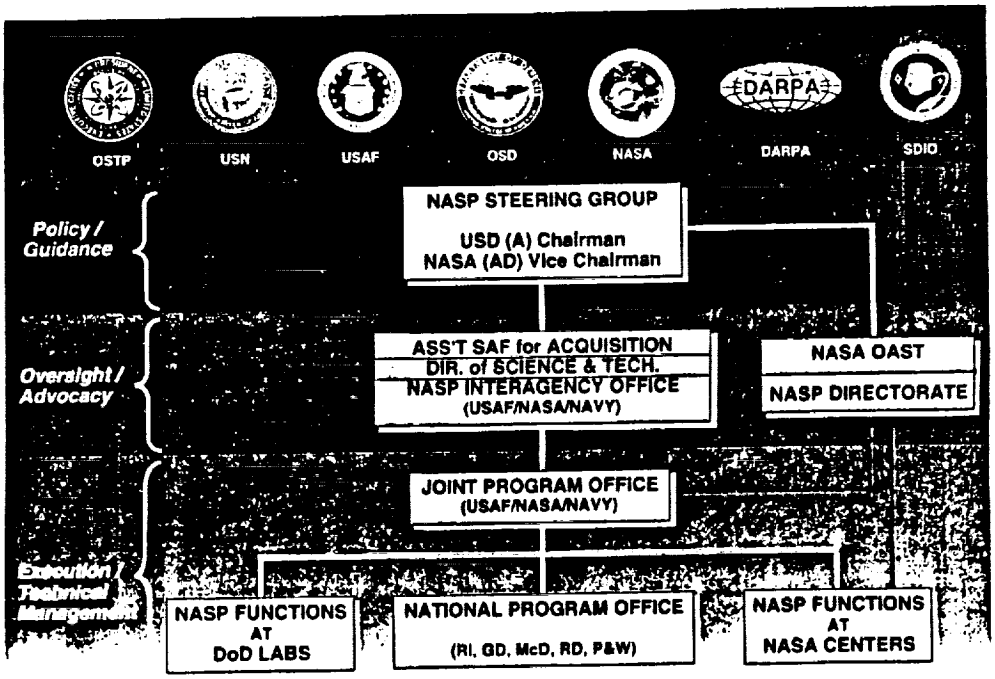
- Several countries are pursuing aerospace-plane technologies: the German vehicle concept is named Sanger (right); the Japanese are working toward concepts for single-stage-to-orbit (below); the Russian civil aerospace-plane project has flight-tested a subscale scramjet to Mach 5.5 (below right).
- International competitors have already used government / industry teams to gain large segments of the aerospace market (i.e., Airbus and ESA -Ariane).





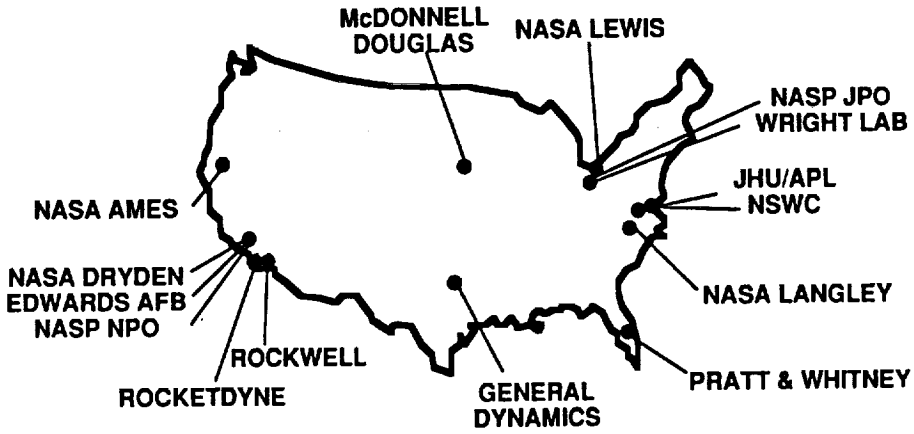


NASP PROGRAM MANAGEMENT ORGANIZATION

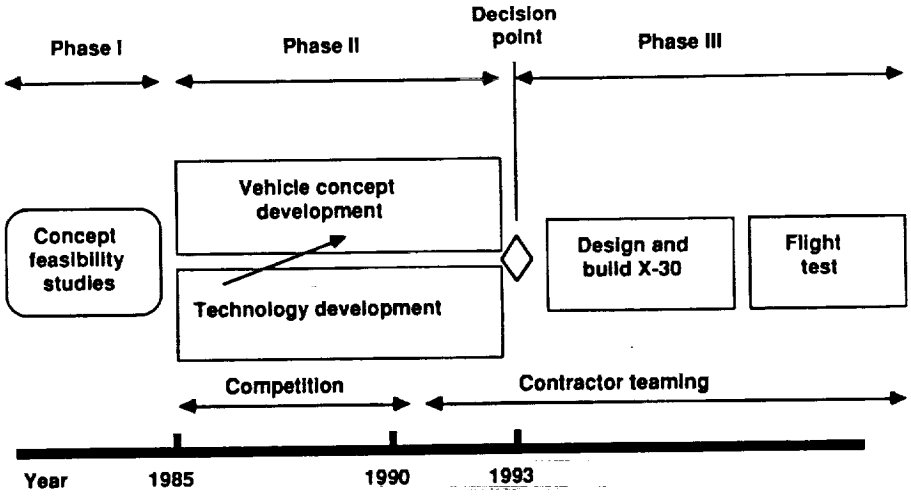


NASP NATIONAL TEAM

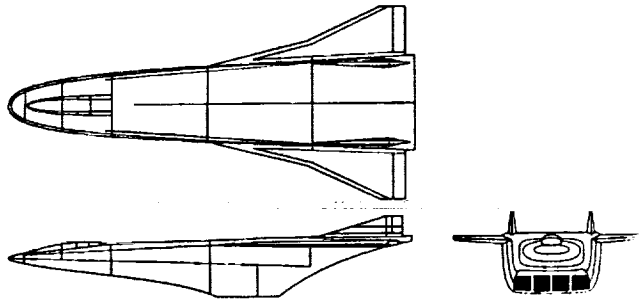
- The NASP prime contractors formed a single team for NASP in 1990. The airframe team members are General Dynamics, McDonnell Douglas, and North American Rockwell. The engine team members are Pratt & Whitney and Rocketdyne. Their joint site, the NASP National Program Office, is located in Palmdale, California. They have 460 subcontractors in 40 states.
- The government laboratories are key members of the industry/government national team. They have 114 subcontractors in 24 states. The key participants include the Air Force Wright Laboratory, NASA Research Centers (Ames, Langley, and Lewis), the Naval Surface Weapons Center, and Johns Hopkins University/Applied Physics Laboratory.



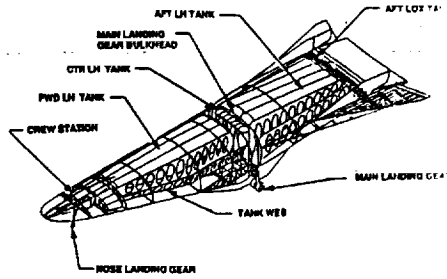
NASP SCHEDULE



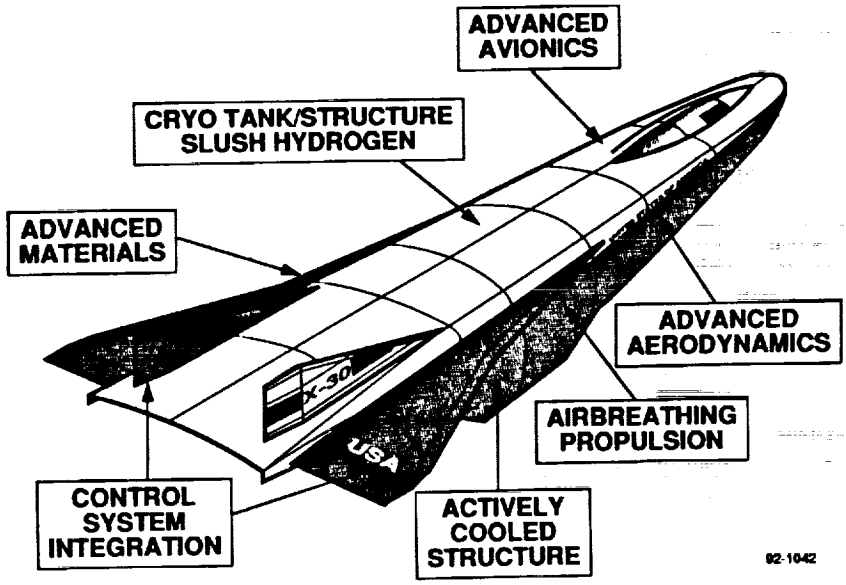
NASP VEHICLE CONCEPT
(X-30)



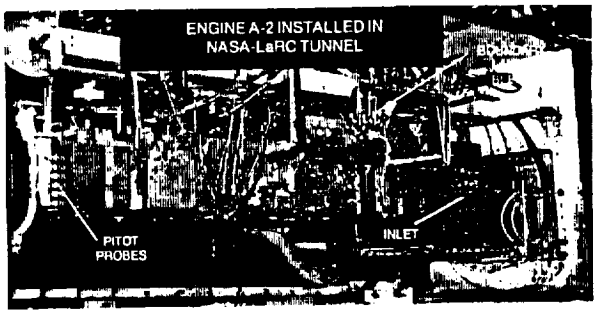
- Payload: instrumentation
- Lifting-body shape with delta wings
- Flattened nose: lower drag and smoother inflow to engine
- Propulsion: low-speed system / ramjet / scramjet / rocket
- Fuel: slush hydrogen
- Cryogenic fuel tank: graphite epoxy
- Fuselage shell: fiber-reinforced titanium
- Thermal protection: carbon-carbon panels, active cooling, and passive cooling (heat pipe)

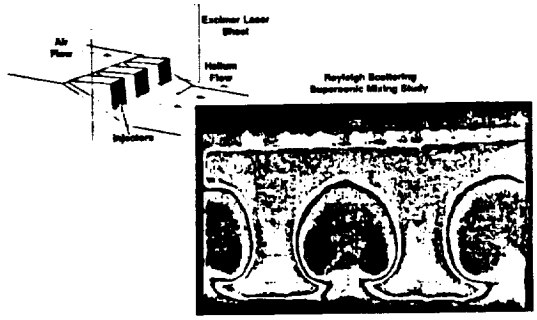


KEY AERO-SPACE PLANE TECHNOLOGIES



NASP PROPULSION TECHNOLOGY

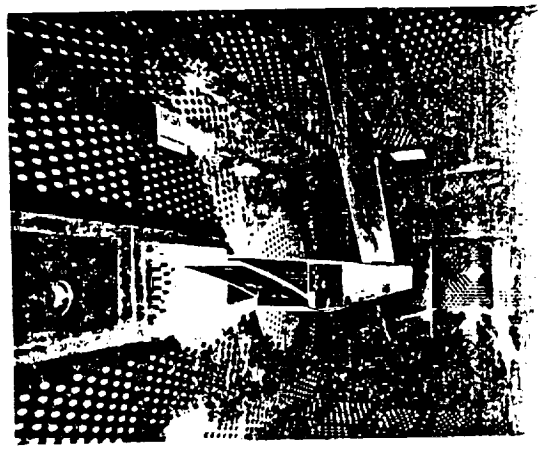


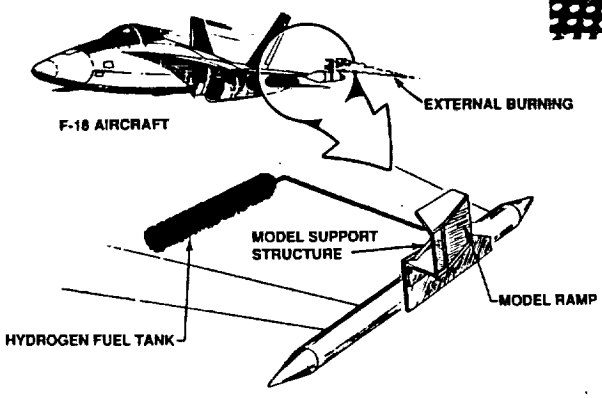


- The NASP propulsion systems must perform efficiently between Mach 0 and 25.
- 1/4 to 1/6-scale model scramjets (above left) have been tested in conditions simulating flight as fast as Mach 8.
- The NASP data base includes ground-test results on components, such as fuel injectors (above right), for flight conditions up to Mach 17.

NASP PROPULSION TECHNOLOGY - NOZZLES

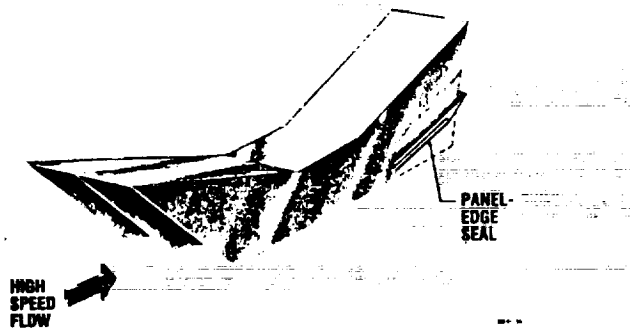
- The rear undersurface of the X-30 acts as a nozzle - the pressure of the exhaust provides thrust.
- Wind-tunnel tests (right) explored X-30 performance and allowed validation of computer codes.
- Flight tests with an F-18 aircraft (below) complemented wind-tunnel data on external burning - a way to reduce nozzle drag at transonic speeds.

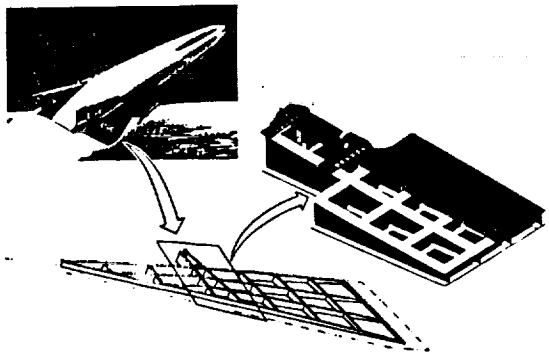


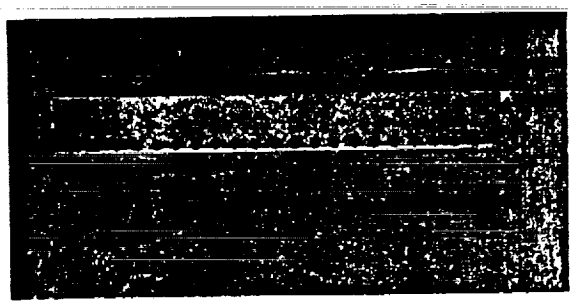


NASP STRUCTURES AND MATERIALS

- Movable panels in extremely hot regions of the engines require edge seals (right). Tests with red-hot fixtures verified sealing properties of "rope" and ceramic wafer seals (below right).
- Structural tests of a simulated wing segment (below) revealed a need to improve computer modeling of some titanium metal-matrix structures.

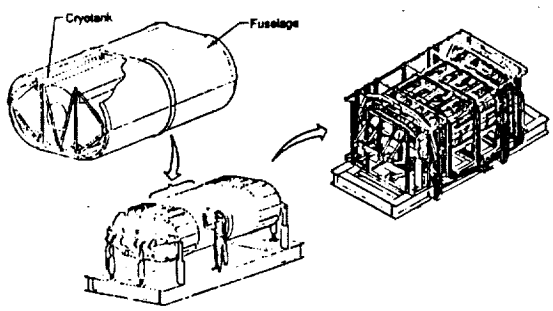


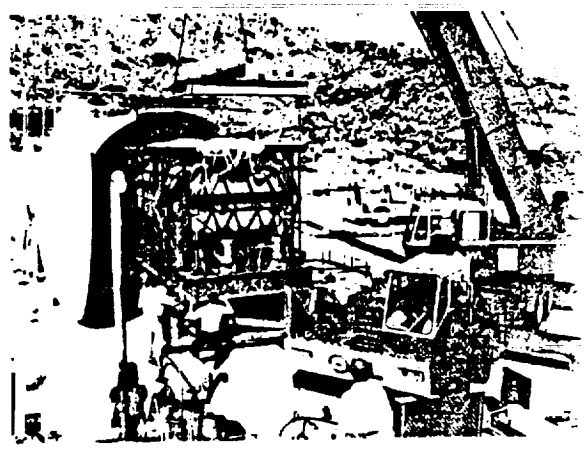




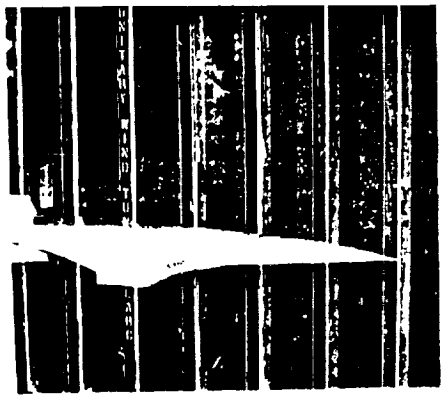
NASP STRUCTURES AND MATERIALS

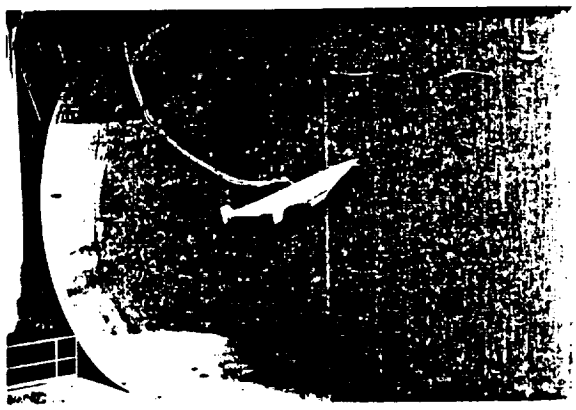
- A 900-gallon graphite-epoxy fuel tank installed in a simulated fuselage shell of titanium metal-matrix composite was tested at Wyle Labs in Norco, California.
- On February 7, 1992, it was filled with liquid hydrogen (at -423° F). The assembly then successfully endured bending and heating (1300° F) loads on the shell that simulated Mach 16, NASP conditions.



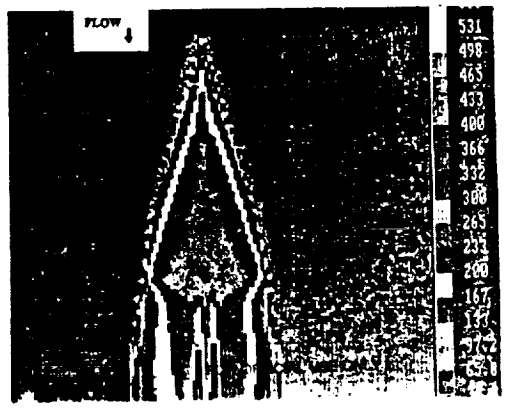


NASP AEROTHERMODYNAMICS

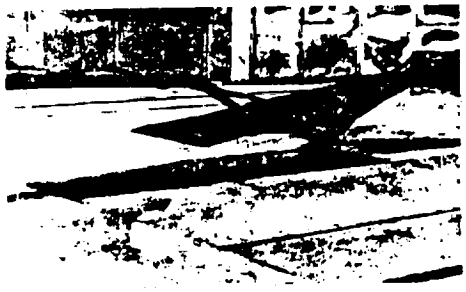


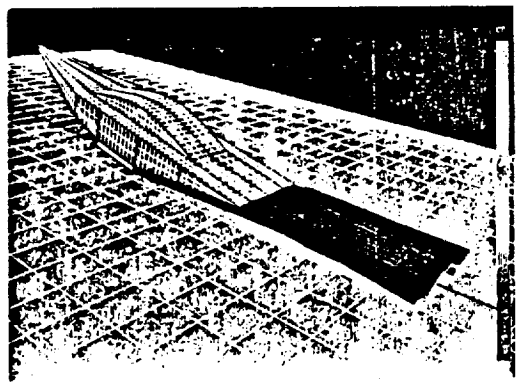


- Much initial aerothermal testing was done with the Test-Techniques Demonstrator (TTD) model, shown here.
- The pictures show models for supersonic tests (above) and subsonic, "free-flight" tests with thrusting engine simulators (above right).
- A digitized, "false-color" image of aerothermal heating on the TTD nose is shown for Mach 10 flow (right).



NASP AEROPROPULSION INTEGRATION

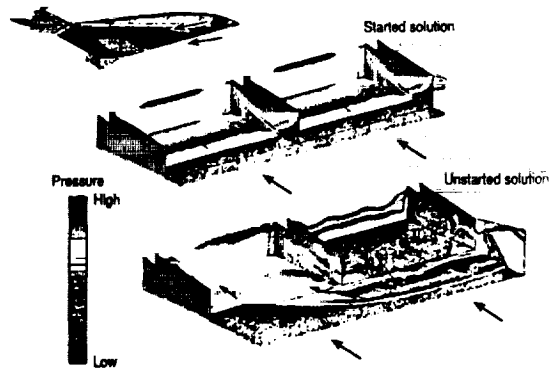


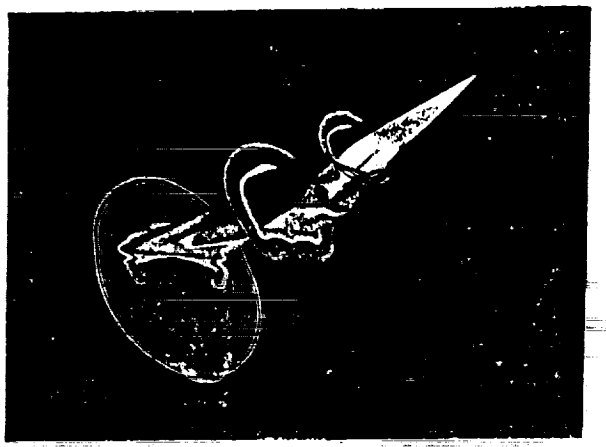


- The propulsion system and the aerodynamic systems interact in different ways in different parts of the flight profile.
- Results for a powered TTD-type model in wind-tunnel tests were verified by computer calculations. They show strong interactions between exterior aerodynamics and propulsion on takeoff.

NASP COMPUTATIONAL FLUID DYNAMICS (CFD)

- Powerful supercomputers allow the exploration of propulsion phenomena such as an engine unstart, something like a backfire, at Mach 10 (right).

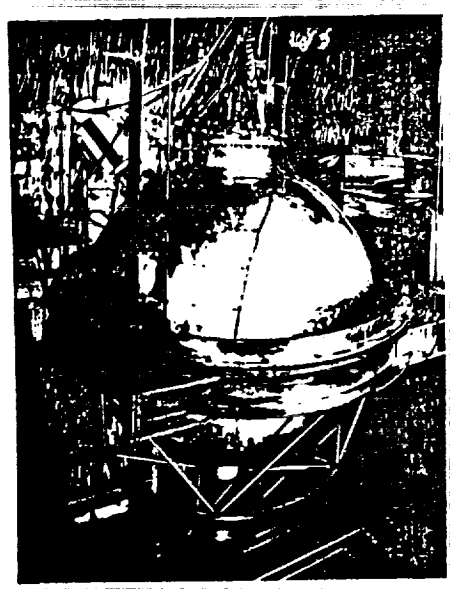


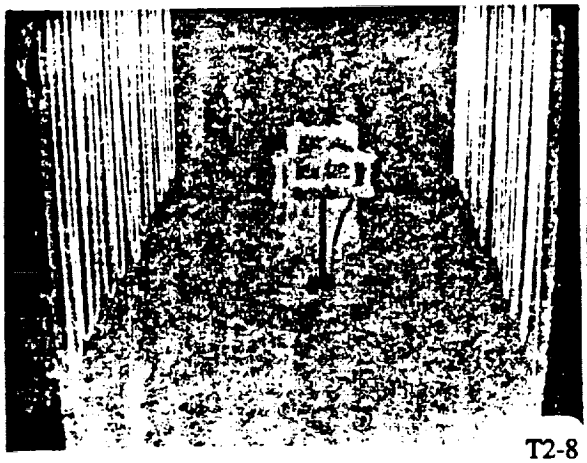


- CFD calculations for the TTD at Mach 10 predict nozzle performance and exhaust effects on tail control surfaces (left).

NASP SYSTEMS RESEARCH AND DEVELOPMENT

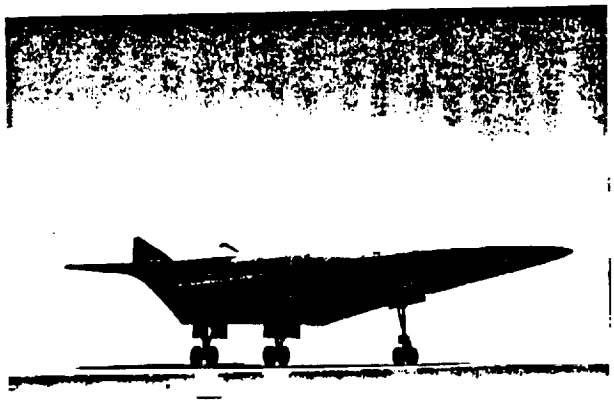
- Slush hydrogen, a mixture of frozen and liquid hydrogen, has greater density and heat-sink capability than liquid hydrogen. Scaled-up systems have demonstrated production of over 50,000 gallons of slush. A 5-foot diameter tank (right) provided crucial data on slush handling and transfer.
- NASP instrumentation must give good information at extreme conditions. The test, pictured below, shows strain-gages measuring loads at 1775 degrees Fahrenheit.





NATIONAL AERO-SPACE PLANE

- NASP is developing the technologies to satisfy important U.S. civil and military needs
- NASP is making significant technical progress
- NASP remains a technically challenging program
- NASP needs full FY93 funding to ensure continued progress



Only after flight validation can the technologies be applied to the next generation of aerospace vehicles with confidence and safety

NASP TECHNOLOGY TRANSFER MECHANISMS

- NASP JOINT PROGRAM OFFICE:
  - JPO CONTRACTOR SUPPORT (SAIC)
  - USAF RESERVISTS TEAM
  - SDIO TECHNOLOGY APPLICATIONS INFORMATION SYSTEM
- NASA - STANDARD T.U. CONTACTS - "TECH BRIEFS," ETS.
- JOINT ACTIVITIES: FOCUSED WORKSHOPS

  (EX: MATERIALS AND INSTRUMENTATION TECHNOLOGY WORKSHOP AT LANGLEY ON MARCH 24 AND 25, 1992)
- NASP CONTRACTORS AND SUBCONTRACTORS

NASP TECHNOLOGY TRANSFER CONTACTS

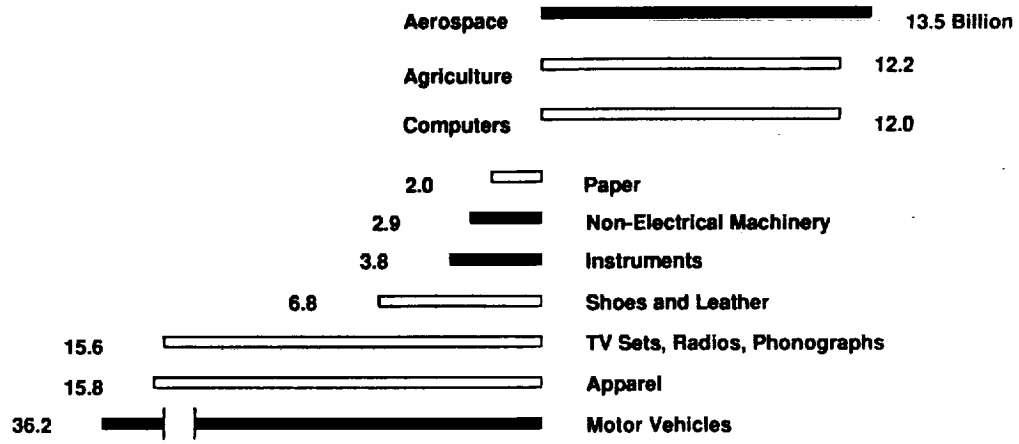
- NASP JOINT PROGRAM OFFICE:
  - APPLICATIONS DIRECTORATE (COL. MATTHEWS, BILL POWELL,.....)
  - SPECIAL ASSISTANT FOR TECH. TRANS. (DICK CULPEPPER)
- NASA, CODE C- TECHNOLOGY UTILIZATION OFFICE (RAY GILBERT)
- NASA, CODE RN - NASP DIRECTORATE (CHARLES MORRIS)

NASP TECHNOLOGY TRANSFER CHALLENGES

- IDENTIFICATION OF TECHNOLOGY APPLICATIONS (RE.: "CONNECTIONS" BY BURKE)
- PROGRAM PROTECTION - SOME OF NASP PROGRAM IS CLASSIFIED AND SOME IS PROTECTED BY ITAR
- CONTRACTOR RETICENCE TO IDENTIFY APPLICATION BEFORE "CONTROL" OF MARKET
- TRANSFER TO U.S. VERSUS OTHERS: PATENTS, SDIO SYSTEM, ETC.
- PRESSURE ON TECHNICAL COMMUNITY MEMBERS TO "PUBLISH OR PERISH" .-> UNCONTROLLED DISSEMINATION
- FOREIGN COUNTRIES HAVE ORGANIZATIONS TO ENHANCE TECHNOLOGY TRANSFER FROM U.S.

NASP

1991 U.S. Balance of Trade Estimates*



- **Potential Impact of NASP Technology is Significant (▬)**

* Source: Univ. of Md INFORUM Model

NASP

Computational Fluid Dynamics (CFD)

NASP Impact on CFD

- New Algorithms for Faster Computations
- Better Modeling of Physics
  - Turbulence
  - Combustion
- Validation of Codes Via Comparison with Experiments

Technology Description

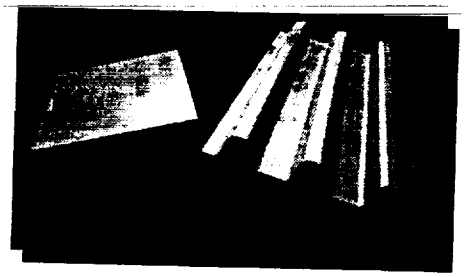
- High Speed Computing Tool
  - Predicts Aerodynamics of Aircraft, Missiles, Auto
  - Models Internal Flows of Aircraft, Auto Engines

Applications of NASP CFD Technology

- More than 50 Users Include:
  - MD-11 CFD Analysis by Douglas Aircraft (Long Beach, CA)
  - High Speed Civil Transport CFD Analysis by Boeing (Seattle, WA)
  - Standard Design Tool for Inlet/Exhaust Systems at GE Aircraft Engines (Evendale, OH)

NASP

Metal Matrix Composites



Technology Description

- Advanced Metal Matrices
- High Strength Fibers
- Lay-up Providing Tailored Strength Properties

NASP Impact

- Compatible Fibers and Matrices
- XD™ Process
  - Clean, Well Bonded Interfaces
  - Tensile Strength Increase of 50%
- Fabricability Demonstrated

Applications of NASP Technology

- Texas Instruments (MA)
  - Copper Nioblum Rings
  - Circuit Board Componets
- Howmet Corp. (Greenwich, CT)
  - XD-Process Ti Al Missile Fins
- Martin Marietta Corp (Bethesda, MD)
  - XD-Ti Impeller

NASP

Advanced Titanium Alloys

Technology Description

- High Strength, Light Weight Materials
- High Temperature Capability

Primary Materials for NASP Hot Structure Air Frame

NASP Impact

- Alloys with 100x Improvement in Corrosion Resistance
- Higher Temperature Capable Alloys [1500°F to 1800°F]
- Fabricability Comparable to Current Alloys

Applications of NASP Technology

- Timet (Henderson, NV)
  - Matrix Material for Fiber Reinforced Composites
  - Sour Gas Well Piping
  - Orthopedic Implants
- Boeing (Seattle,WA)
  - 777 Tail Cone

NASP

Beryllium Alloys

Technology Description

- Lightweight Material with High Elastic Modulus
- Material with Good Thermal Conductivity

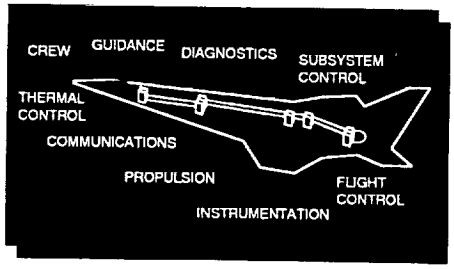
NASP Impact

- Fabrication Methods that Raise Temperature Capability
- Rapid Solification Rotary Atomization Powder Process

- Manufacturing Sciences Corp (Oak Ridge, TN)
  - Product Line in Place:
    - -- Mirror for Space-Based Solar Power
    - -- Tubing for High-Energy Physics
    - -- Foil for X-Ray Windows

NASP

Neural Network for Fault Monitoring/Diagnosis



Technology Description

- "Neuron-like" Computer Chips
- Interconnections of Chips Analogous to Operation of Human Brain
- Trainable Computer System

NASP Impact

- Novel Design and Hardware Implementation
- Use of Neural Network for Fault Monitoring Function
  - NASP Thermal Management System

Application of NASP Technology

- NASP Neural Network Concept Adapted for System Diagnosis of Cray Supercomputer (Minneapolis, MN)
- NASP Small Business Phase II Award
  - Accurate Automation Corp (Chattanooga, TN)

NASP TECHNOLOGY TRANSFER SUMMARY

- NASP IS PROACTIVE DESPITE CLASSIFICATION AND ITAR RESTRICTIONS ON SOME INFORMATION
- BOTH NASA AND DOD ARE INVOLVED
- THE EFFORT IS NEW AND STILL EVOLVING

ROBOTIC TECHNOLOGY EVOLUTION AND TRANSFER

PRESENTATION TO THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS - SOCIETY OF AEROSPACE TECHNOLOGY TECHNICAL COMMITTEE

JPL

Neville I. Marzwell

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
U.S.A.

14 February 1990
Los Angeles Hilton, California

JPL Robotic Technology Evolution and Transfer

CONTENTS

WHY TECHNOLOGY TRANSFER

PUBLIC LAW 96-480/STEVEN-WYDLER TECHNOLOGY INNOVATION ACT OF 1980

(1) TECHNOLOGY AND INDUSTRIAL INNOVATION ARE CENTRAL TO THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL WELL-BEING OF CITIZENS OF THE UNITED STATES

(2) TECHNOLOGY AND INDUSTRIAL INNOVATION OFFER AN IMPROVED STANDARD OF LIVING, INCREASED PUBLIC AND PRIVATE SECTOR PRODUCTIVITY, CREATION OF NEW INDUSTRIES AND EMPLOYMENT OPPORTUNITIES, IMPROVED PUBLIC SERVICES AND ENHANCED COMPETITIVENESS OF UNITED STATES PRODUCTS IN WORLD MARKETS

(3) MANY NEW DISCOVERIES AND ADVANCES IN SCIENCE OCCUR IN UNIVERSITIES AND FEDERAL LABORATORIES, WHILE THE APPLICATION OF THIS NEW KNOWLEDGE TO COMMERCIAL AND USEFUL PUBLIC PURPOSES DEPENDS LARGELY UPON ACTIONS BY BUSINESS AND LABOR. COOPERATION AMONG ACADEMIA, FEDERAL LABORATORIES, LABOR, AND INDUSTRY, IN SUCH FORMS AS TECHNOLOGY TRANSFER, PERSONNEL EXCHANGE, JOINT RESEARCH PROJECTS, AND OTHERS, SHOULD BE RENEWED, EXPANDED, AND STRENGTHENED (U.S. CONGRESS, 1980:SEC. 2)

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CONCEPTS AND DEFINITIONS

THE CONCEPT OF TECHNOLOGY TRANSFER IS NOT A SIMPLE ONE:

- TO EXPLORE THE CONCEPT OF TECH-TRANSFER, A NECESSARY STEP IS TO CONSIDER THE IDEA OF TECHNOLOGY (Gee, 1974)
- MACHINES AND PHYSICAL TOOLS ARE COMMON REFERENTS FOR TECHNOLOGY (Doctors, 1963 Tornatzky et al 1983)
- ...ANY TOOL OR TECHNIQUE, ANY PRODUCT OR PROCESS, ANY PHYSICAL EQUIPMENT OR METHOD OF DOING OR MAKING BY WHICH HUMAN CAPABILITY IS EXTENDED (Schon, 1969)
- TECHNOLOGY IS THE MEANS OR CAPACITY TO PERFORM A PARTICULAR ACTIVITY (Gruber and Marquis, 1968)
- TECHNOLOGY HAS BEEN DEFINED SIMPLY AS THE APPLICATION OF SCIENCE (Gee, 1974)
- WHEREAS SCIENCE IS CONCERNED WITH THE INCREASE OF KNOWLEDGE AND UNDERSTANDING, TECHNOLOGY IS DIRECTED TOWARD USE...THE OUTPUT OF TECHNOLOGICAL ACTIVITY IS A PRODUCT, PROCESS, TECHNIQUE, OR MATERIAL DEVELOPED FOR SOME SPECIFIC USE. TECHNOLOGY...CAN INCORPORATE INVENTIONS...PATENTS ARE MORE COMMONLY THE OUTGROWTH OF TECHNOLOGY RATHER THAN OF SCIENCE (Gee)

CONCEPTS AND DEFINITIONS

VERTICAL TECH-TRANSFER

- ...A GENERAL PRINCIPLE IS APPLIED TO PRODUCE A NEW PRODUCT, DEVICE, OR PROCESS WITHIN A GIVEN SCIENTIFIC OR TECHNICAL DISCIPLINE, AND, GENERALLY WITHIN AN ORGANIZATIONAL ENTITY SUCH AS A SINGLE CORPORATION OR GOVERNMENT AGENCY (Doctors, 1969).
- ...THE VERTICAL FLOW OF TECHNOLOGY IS FROM A LABORATORY TO A GIVEN APPLICATION, IN A GIVEN DISCIPLINE (Essoglou 1975).

HORIZONTAL TECH-TRANSFER

- ...SECONDARY APPLICATIONS, WHEREIN TECHNOLOGY WHICH ORIGINATES IN ONE SECTOR (SUCH AS AEROSPACE) IS USED IN ANOTHER SECTOR (SUCH AS URBAN TRANSPORTATION OR HEALTH...) (Linhares, 1976).
- ...ONE TECHNOLOGY IS ADAPTED TO A DIFFERENT AREA OF APPLICATION, GENERALLY ACROSS INSTITUTIONAL LINES. AN EXAMPLE MIGHT BE SEEN IN ... THE USE OF A NEW METAL ALLOY DEVELOPED FOR A ROCKET ENGINE IN A BOILER FOR A STEEL MILL (Doctors, 1969).

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CONCEPTS AND DEFINITIONS
TECHNOLOGY TRANSFER

1) MOVEMENT OF TECHNOLOGY AFTER SOME TYPE OF ADAPTATION:

- "... THE PROCESS WHEREBY TECHNICAL INFORMATION ORIGINATING IN ONE INSTITUTIONAL SETTING IS ADAPTED FOR USE IN ANOTHER INSTITUTIONAL SETTING... MORE THAN THE MERE DISSEMINATION OF TECHNICAL INFORMATION, IT IMPLIES THE ADAPTATION OF NEW TECHNOLOGY THROUGH A CREATIVE TRANSFORMATION AND APPLICATION TO A DIFFERENT END USE" (Doctors, 1969).
- "... THE PROCESS OF EMPLOYING A TECHNOLOGY FOR A PURPOSE OTHER THAN THAT FOR WHICH IT WAS DEVELOPED... TECH TRANSFER FOCUSES ON THE UTILIZATION OF PREVIOUS RESEARCH" (Foster, 1971).

2) MOVEMENT OF TECHNOLOGY BOTH WITH AND WITHOUT ADAPTATION:

- WHEN SCIENTIFIC OR TECHNICAL INFORMATION GENERATED AND/OR USED IN ONE CONTEXT IS REEVALUATED AND/OR IMPLEMENTED IN A DIFFERENT CONTEXT, THE PROCESS IS CALLED TECHNOLOGY TRANSFER (Bar-Zakay, 1970).
- ... AN EFFORT TO BRING THE RESULTS OF RESEARCH AND DEVELOPMENT TO NEW USERS... TECHNOLOGY TRANSFER CALLS FOR THE TRANSFORMATION OF RESEARCH AND TECHNOLOGY INTO PRODUCTS, PROCESSES, OR SERVICES; OR TO THE APPLICATION OF RESEARCH DEVELOPED FOR ONE PURPOSE TO A SECONDARY PURPOSE (Myran, 1978).

FACTORS INFLUENCING TECH-TRANSFER

TECHNO-ECONOMIC FACTORS

- THE DEGREE OF GENERAL CONNECTION OF THE TECHNOLOGY TO THE FIRM'S EXISTING OPERATIONS WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE SPECIFICITY OF THE RELATIONSHIP BETWEEN THE TECHNOLOGY AND SOME EXISTING AND RECOGNIZED PROBLEM WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE DEGREE OF URGENCY OF THE PROBLEM TO WHICH THE TECHNOLOGY WAS RELATED WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE QUALITY OF INFORMATION RECEIVED FROM THE SOURCE ABOUT THE INNOVATION WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- MATURITY OF THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- AVAILABILITY OF PERSONNEL TO IMPLEMENT THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- AVAILABILITY OF FINANCIAL RESOURCES TO IMPLEMENT THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION

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FACTORS INFLUENCING TECH-TRANSFER

ORGANIZATIONAL FACTORS

THE DEGREE OF TOP MANAGEMENT INTEREST IN THE PIECE OF TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION

- THE DEGREE OF SUCCESS OF ADOPTION WILL BE INFLUENCED BY THE DIMENSIONS OF ORGANIZATIONAL CLIMATE OF THE ADOPTING ORGANIZATION
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF CONFRONTATION IN JOINT-DECISION MAKING IS HIGHER
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF SMOOTHING IN JOINT-DECISION MAKING IS LOWER
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF FORCING IN JOINT-DECISION MAKING IS LOWER

FACTORS INFLUENCING TECH-TRANSFER

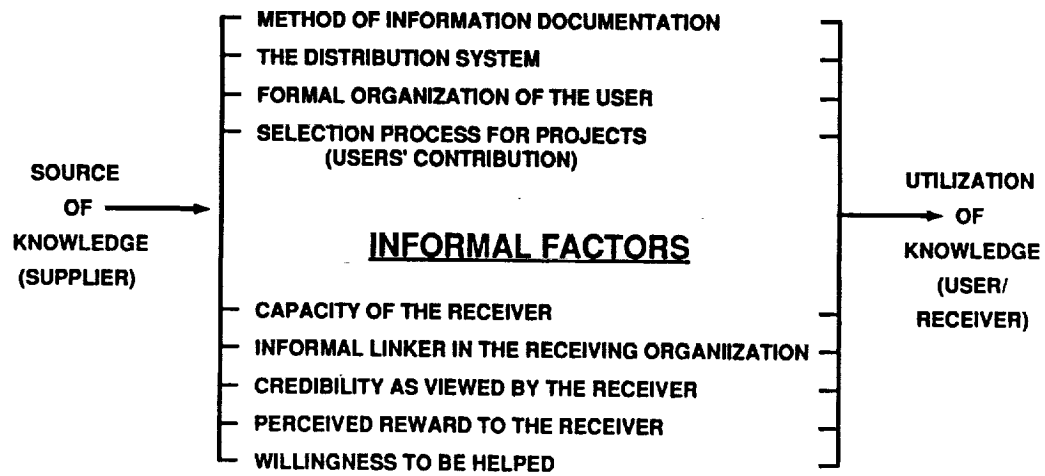
COMMUNICATION FACTORS

- THE LEVEL OF COMMUNICATION NEEDS IS DEPENDENT ON TECHNOLOGY MATURITY AND THE "GAP" BETWEEN BASIC RESEARCH AND READINESS FOR APPLIED RESEARCH OF THE TECHNOLOGY (COMMERCIALIZATION)

TECHNOLOGY MATURITY

- INCREASED MATURITY IMPLIES LESS RISK AND UNCERTAINTY FOR THE COMMERCIAL ADOPTER, AND, THEREFORE, GREATER PROBABILITY OF SUCCESSFUL TECHNOLOGY TRANSFER. THE MORE MATURE THE TECHNOLOGY, THE MORE LIKELY IS THE FIRM TO ATTEMPT TO TRANSFER AND COMMERCIALIZE IT

FACTORS AFFECTING TECH-TRANSFER



BARRIERS IN TECH-TRANSFER

- DIFFERENCE IN "ATTITUDES" CAN CONSTITUTE A "TRANSFER GAP"
  - THE GAP BETWEEN IDEA AND PROTOTYPE
  - THE COMMUNICATIONS GAP BETWEEN ORGANIZATIONS
  - THE DISPARITY BETWEEN THE BUYER'S CONCEPT OF WORTH OF NEW TECHNOLOGY AND THE SELLER'S OPINION OF ITS VALUE
  - THE REFUSAL OF BUYERS TO RECOGNIZE THAT OUTSIDE TECHNOLOGY CAN BE VALUABLE TO THEM
  - A BIASED INTERPRETATION OF THE RISK VERSUS RETURN AXIOM
  - A TENDENCY ON THE PART OF MANY ORGANIZATIONS TO DISCOURAGE THE SALE OF A TECHNOLOGY EVEN WHEN IT WOULD BE TO THEIR BENEFIT TO DO SO (Evans, 1976:29-30).
- TECH-TRANSFER ORGANIZATION RELATIONSHIP WITHIN THE COMPANY
  - TECH-TRANSFER FUNCTIONS SHOULD BE UNCOUPLED FROM THE MARKETING, PRODUCTION AND R&D DEPARTMENTS
    - IDEALLY, A COMPANY SHOULD BUILD A TECH-TRANSFER TEAM THAT OPERATES IN THE NEW BUSINESS DEPARTMENT, ALTHOUGH, OF COURSE, THE TEAM WILL INTERFACE WITH THE R&D, MARKETING, AND MANUFACTURING FUNCTIONS (Foster, 1971:111).
  - ORGANIZATION FOR TECHNOLOGY TRANSFER SHOULD BE BASED ON PAIRING PROBLEMS AND CUSTOMERS

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TYPES OF BARRIERS IN TECH-TRANSFER

- ENVIRONMENT BETWEEN THE R&D GENERAL SYSTEM (FEDERAL LAB, UNIV OR PRIVATE LAB) AND THE COMPANY GENERAL SYSTEM (USER TO WHOM THE TECHNOLOGY IS TO BE TRANSFERRED)
- ENVIRONMENT BETWEEN THE DEPARTMENTS AND DIVISIONS WITHIN THE LABORATORY OR COMPANY WHICH REPRESENT THE SUBSYSTEMS OF BOTH GENERAL SYSTEMS
  - BETWEEN THE GENERAL SYSTEMS
    1. NO FORMAL TRANSFER POLICIES
    2. COST BARRIERS
    3. TIME HORIZON CONFLICT
    4. INFRINGEMENT PROBLEMS
  - BETWEEN SUBSYSTEMS
    1. INERTIA BARRIER
    2. LACK OF AN INCENTIVE STRUCTURE
    3. COST BARRIER
    4. COMMUNICATION
    5. TIME BARRIER
    6. GEOGRAPHIC DISTANCE
    7. NON-EXISTENT TRANSFER MANAGEMENT STRUCTURE
    8. TECHNOLOGY BARRIER
  - BETWEEN ELEMENT
    1. LACK OF AN INCENTIVE STRUCTURE
    2. HIGH RISK OF BEING BLAMED FOR FAILURE
    3. INSECURITY OF RETAINING JOB IF NOT SUCCESSFUL
    4. MUTUAL DISRESPECT
    5. UNIQUE REQUIREMENTS OF EACH SUBSYSTEM
    6. UPDATING OF TECHNOLOGY NEEDS
    7. TIME BARRIER
    8. LACK OF TRANSFER ORGANIZATION MANAGERS

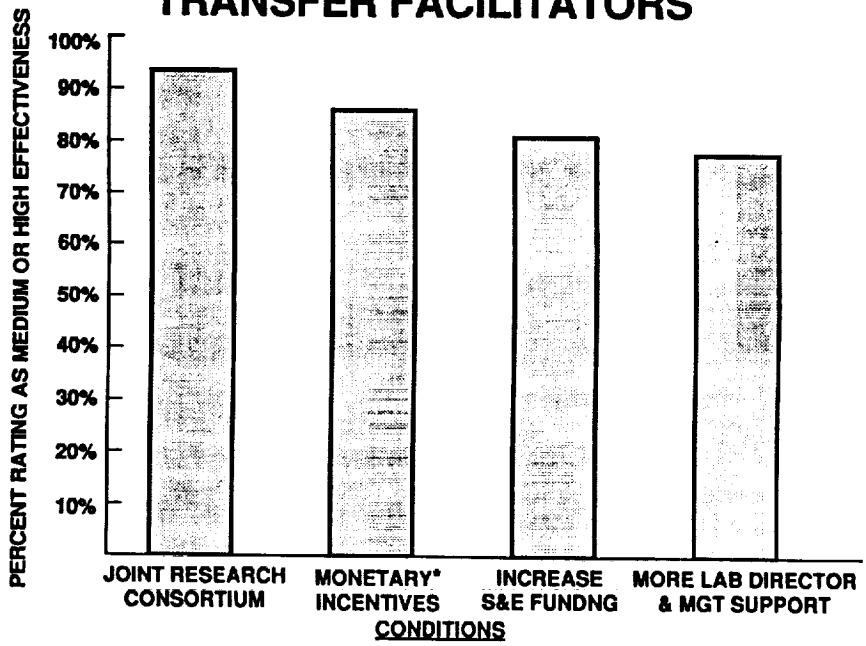
ENHANCING FACTORS TO TECH-TRANSFER

INTERPERSONAL RELATIONSHIP

... THE MECHANISM OF TECHNOLOGICAL TRANSFER IS ONE OF AGENTS, NOT AGENCIES; OF THE MOVEMENT OF PEOPLE AMONG ESTABLISHMENTS, RATHER THAN OF THE ROUTING OF INFORMATION THROUGH COMMUNICATION SYSTEMS (Burns, 1969:12).

THE NATIONAL REFERRAL CENTER, A SERVICE OPERATED UNDER THE LIBRARY OF CONGRESS, HEARTILY SUBSCRIBES TO THE CONVICTION THAT SCIENTIFIC AND TECHNICAL INFORMATION IS MOST EFFECTIVELY TRANSFERRED FROM PERSON TO PERSON, NOT FROM MEDIA TO PEOPLE (Timmons, 1978: 34).

KEY TECHNOLOGY TRANSFER FACILITATORS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST FACILITATORS OF TECHNOLOGY TRANSFER

* LACK OF INCENTIVES WAS A KEY BARRIER

ENHANCING ROLES IN TECH-TRANSFER

- TECHNOLOGICAL GATEKEEPER "EXPERT SCIENTIST TO THE WORLD OF SCIENCE"
  - IS ONE WHO CONTROLS A STRATEGIC PORTION OF THE TECHNICAL LEVEL OF THE COMMUNICATION CHANNEL (Brown, 1979) AND THE DIFFUSION OF INFORMATION WHICH IS A MULTI-STEP PATTERN
  - TECHNOLOGICAL GATEKEEPERS CREATE AWARENESS OF NEW PRODUCTS AND PROCESSES BY THEIR ABILITY TO ABSORB INFORMATION AND TRANSLATE IT INTO MORE UNDERSTANDABLE FORM NOT ONLY FOR THEIR COLLEAGUES BUT ALSO FOR TOP MANAGEMENT (Tornatzky et al 1983)
- TECHNOLOGICAL LINKERS "R&D MANAGERS"
  - OPERATES WITHIN THE ORGANIZATION WHICH RECEIVES THE KNOWLEDGE (Creighton, 1972)

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MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER

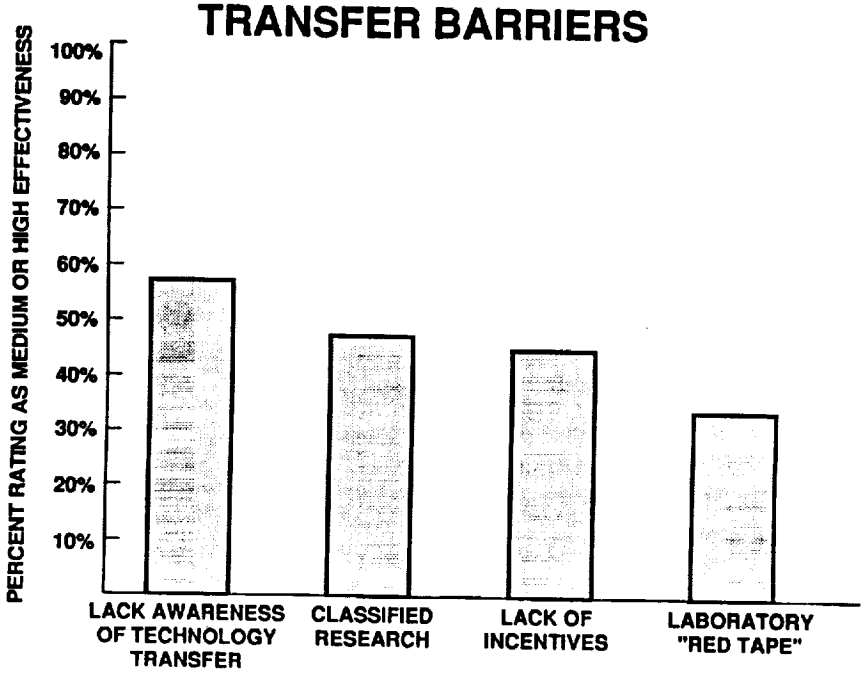
1. A TENDENCY TO ASSUME WITHOUT PROOF THAT THERE IS A RECEIVER FOR THE TECHNOLOGY, THAT IS, THAT SOMEBODY ACTUALLY WANTS IT AND WILL ACCEPT IT
2. LACK OF INTEREST AND SUPPORT BY TOP MANAGEMENT, THAT IS, THOSE WHO MAKE POLICY AND CONTROL THE NECESSARY RESOURCES
3. LACK OF INTEREST OR EFFORT BY MANAGERS AT THE LEVEL WHERE TECHNOLOGY TRANSFER WILL ACTUALLY BE IMPLEMENTED
4. FAILURE TO FIX RESPONSIBILITY AND ACCOUNTABILITY FOR GETTING THE JOB DONE
5. LACK OF AWARENESS OF THE VALUE OF TECHNOLOGY TRANSFER
6. LACK OF FUNDING FOR THE TRANSFER EFFORT
7. LACK OF PERSONNEL ASSIGNED TO THE TASK OR LACK OF SUFFICIENT TIME AVAILABLE TO THOSE WHO ARE ASSIGNED TO THE TASK
8. LACK OF NECESSARY KNOWLEDGE AND TRAINING FOR THOSE ASSIGNED THE TASK
9. RESTRICTIONS ON MOBILITY OF PERSONNEL
10. INDIFFERENCE TO TECHNOLOGY TRANSFER

MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER (Cont'd)

11. POWER GAMES INTENDED TO MAINTAIN OR PROMOTE PERSONAL AMBITIONS, SUCH AS JOB PROTECTION, COMMERCIAL INTEREST, POLITICAL AMBITIONS, STATUS, OR CONTROL OF THE WORK SITUATION. USUALLY TAKES THE FORM OF SECRECY. (Hawthorne 1978)
12. POOR INTERPERSONAL RELATIONS – THE PARTIES REACT NEGATIVELY TO EACH OTHER
13. EXPECTATIONS OF ONE PARTY ARE NOT SHARED BY THE OTHER PARTIES
14. LACK OF CONTINUED ORGANIZATIONAL COMMITMENT TO THE EFFORT
15. PROMISING MORE THAN CAN BE DELIVERED
16. SOMEONE TAKING OFFENSE, WHERE NONE WAS INTENDED, AT A SUGGESTION THAT SOME ACTIVITY THEY ARE RESPONSIBLE FOR COULD BE IMPROVED
17. CULTURAL DIFFERENCES: ETHNIC, REGIONAL, NATIONAL, OR ORGANIZATIONAL
18. EMPLOYMENT SENIORITY SYSTEMS OR FEATHERBEDDING
19. DOCUMENTS TOO TECHNICAL FOR THE POTENTIAL USER TO UNDERSTAND
20. EXCESSIVE GOVERNMENT REQUIREMENTS FOR PRODUCT TESTING AND APPROVAL

JPL Robotic Technology Evolution and Transfer

KEY TECHNOLOGY TRANSFER BARRIERS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST BARRIERS TO TECHNOLOGY TRANSFER

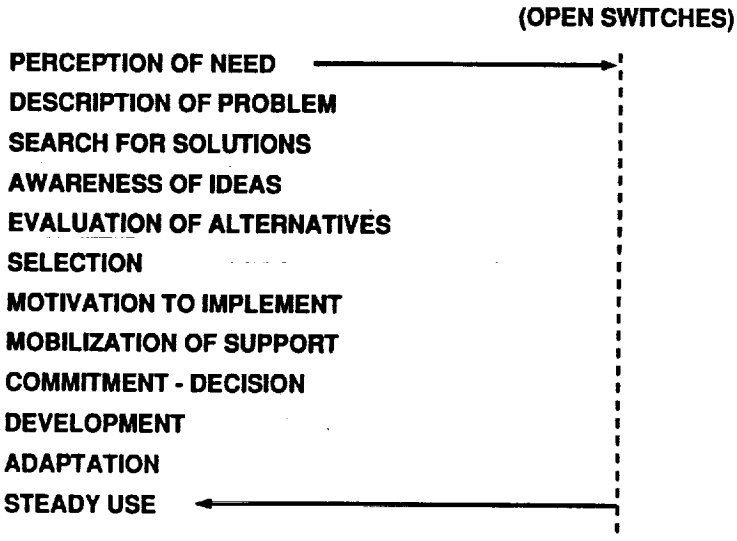
BAR-ZAKAY TECH TRANSFER EVOLUTION MODEL (1970) (Cont'd)

STAGE	DONOR	BOTH	RECIPIENT
(ADAPTATION)			
		DECISION: GO/NO GO	
IMPLEMENTATION	CONSIDER CAPITAL AND HARDWARE	RECRUIT RESOURCES	CONSIDER PEOPLE AND EMOTIONS
	OVERCOME PREJUDICE		BUILD COHESIVE ORGANIZATION
	PROVIDE TRAINING		PROVIDE SUPPORTING ELEMENTS
	OVERCOME RESISTANCE TO CHANGE		ENSURE BUREAUCRATIC SUPPORT
		RUN PILOT OPERATION	
		DECISION: GO/NO GO	
MAINTENANCE	DELEGATE AUTHORITY	RUN FULL-SCALE OPERATION	ENSURE COMPATIBILITY WITH SUPPORTING ELEMENTS
	ASSIST IN TROUBLE-SHOOTING		EVALUATE SIDE EFFECTS
	IDENTIFY DIVERSIFICATION POSSIBILITIES		PERFORM CONCURRENT R&D
	EVALUATE NET BENEFITS		EVALUATE NET BENEFITS
		EVALUATE SUCCESS	
		DECISION: GO/NO GO	

JPL Robotic Technology Evolution and Transfer

BARRIERS THAT RESULTS IN PROJECT ATTRITION OR NO TRANSFER

GAUNTLET OPEN SWITCH MODEL



TECHNOLOGY DEVELOPMENT STAGES

TECHNOLOGY PROGRAM

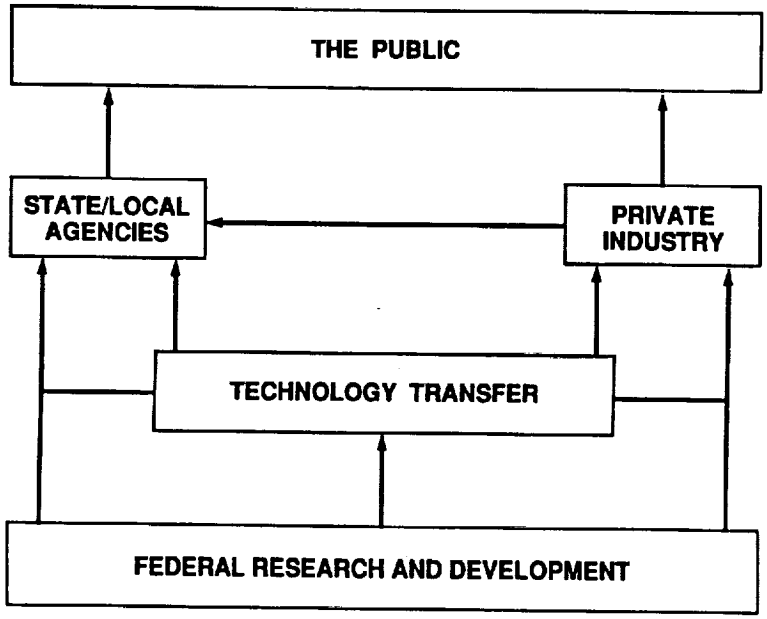
1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. CONCEPTUAL DESIGN FORMULATED
3. CONCEPTUAL DESIGN TESTED ANALYTICALLY OR EXPERIMENTALLY

USER

4. CRITICAL FUNCTION/CHARACTERISTIC DEMONSTRATED
5. COMPONENT/BRASSBOARD TESTED IN RELEVANT ENVIRONMENT
6. PROTOTYPE/ENGINEERING MODEL TESTED IN RELEVANT ENVIRONMENT
7. ENGINEERING MODEL SPACE QUALIFIED

JPL Robotic Technology Evolution and Transfer

TECHNOLOGY TRANSFER SYTEM



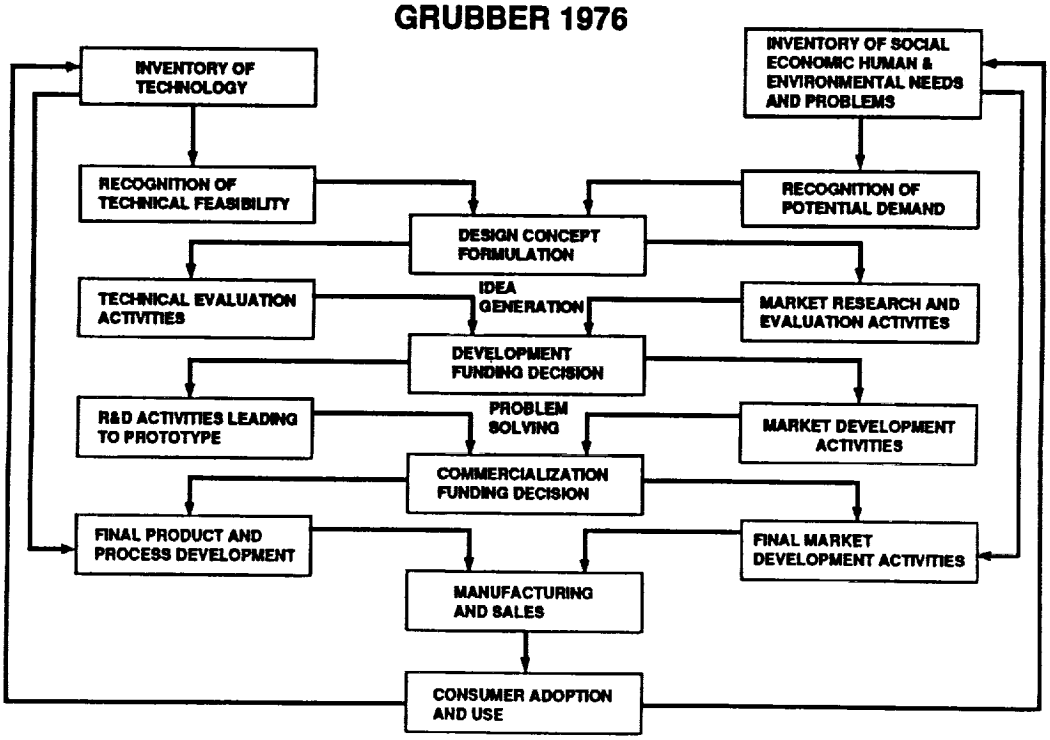
STRATEGIES FOR PROMOTING TECH-TRANSFER TO PRIVATE SECTOR

TECHNOLOGY TRANSFER STRATEGY	PURPOSE	TRANSFER MECHANISMS
PASSIVE	TO MAKE INFORMATION ACCESSIBLE TO THOSE INDIVIDUALS AND ORGANIZATIONS SEARCHING FOR SOLUTIONS TO CUSTOMER/SOCIETY PROBLEMS	TECHNICAL DATABASES NTIS PROFESSIONAL JOURNALS TRADE PUBLICATIONS CONFERENCES WORKSHOPS
ROLE-DIRECTED	TO ACTIVELY PROMOTE AWARENESS OF NEW TECHNOLOGY TO INDIVIDUALS OCCUPYING BOUNDARY-SPANNING ROLES IN ORGANIZATIONS	PROFESSIONAL JOURNALS AND SEMINAR PRESENTATIONS TARGETED TO CERTAIN DISCIPLINES TRADE PUBLICATIONS AND SEMINAR PRESENTATIONS TARGETED TO INDUSTRY GROUPS OR NATIONAL ASSOCIATIONS TECHNOLOGY FAIRS INDUSTRY TEAMS
ORGANIZATION DIRECTED	TO ACTIVELY PROMOTE THE ADOPTION OF NEW PRODUCT OR PROCESS CONCEPTS TO INNOVATOR FIRMS IN AN INDUSTRY	TRANSFER OF R&D PERSONNEL DEMONSTRATION PROJECTS PERSONAL CONTACTS ONSITE VISITS JOINT VENTURES TAX INCENTIVES

JPL Robotic Technology Evolution and Transfer

EVOLUTION PROCESS TO TECH-TRANSFER

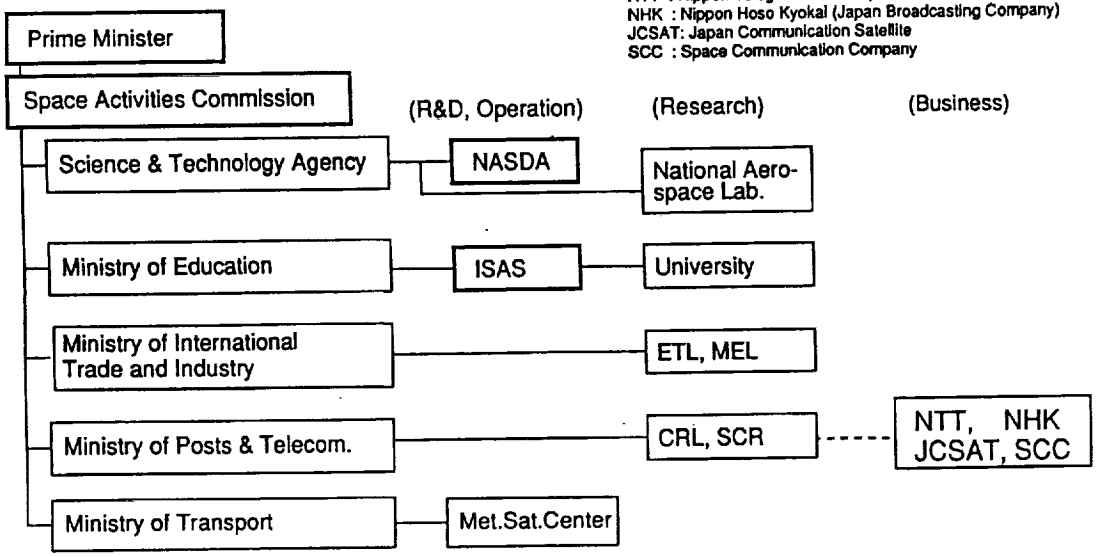
GRUBBER 1976



Japanese Space Related Organizations

NASDA
宇宙開発事業団

NASDA: National Space Development Agency of Japan
ISAS : Institute of Space and Astronautical Science
ETL : Electro-Tecnical Laboratory
MEL : Mechanical Engineering Laboratory
JSUP : Japan Space Utilization Promotion Center
USEF : Institute of Unmanned Space Experiment Flyer
CRL : Communication Research Laboratory
SCR : Space Communication Research Institute
NTT : Nippon Telegram and Telephone
NHK : Nippon Hoso Kyokai (Japan Broadcasting Company)
JCSAT: Japan Communication Satellite
SCC : Space Communication Company



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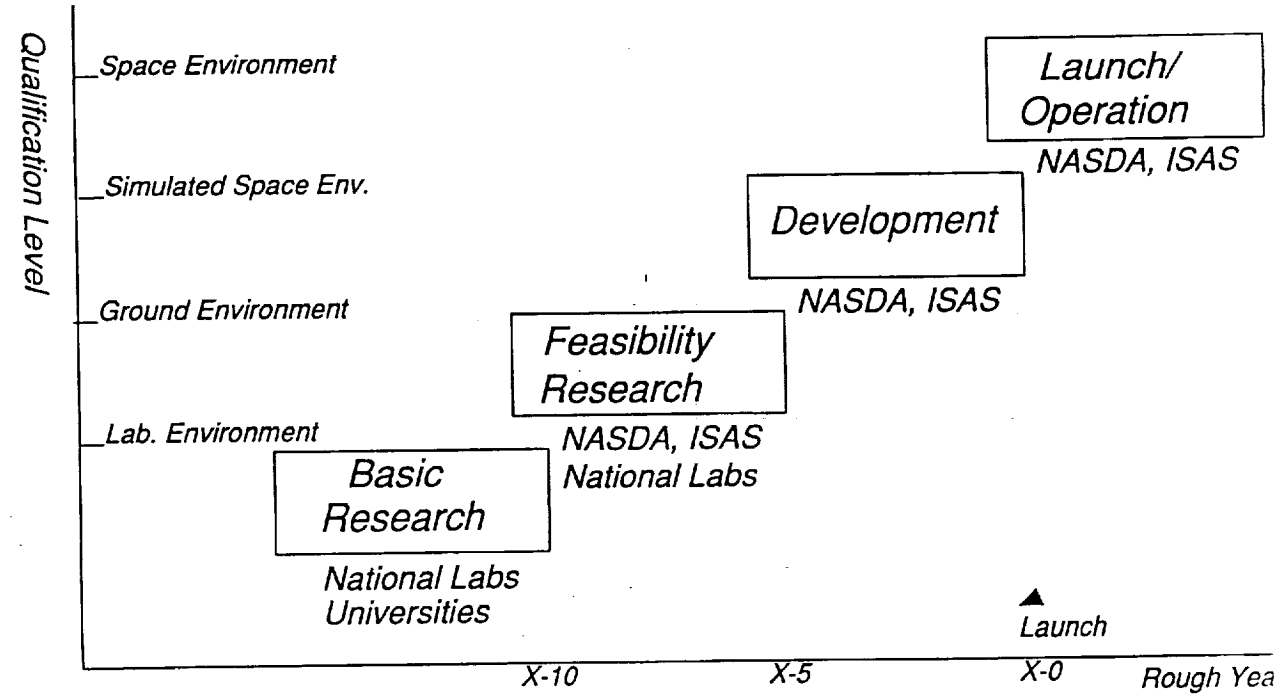
R & D of Space Technologis

NASDA
宇宙開発事業団



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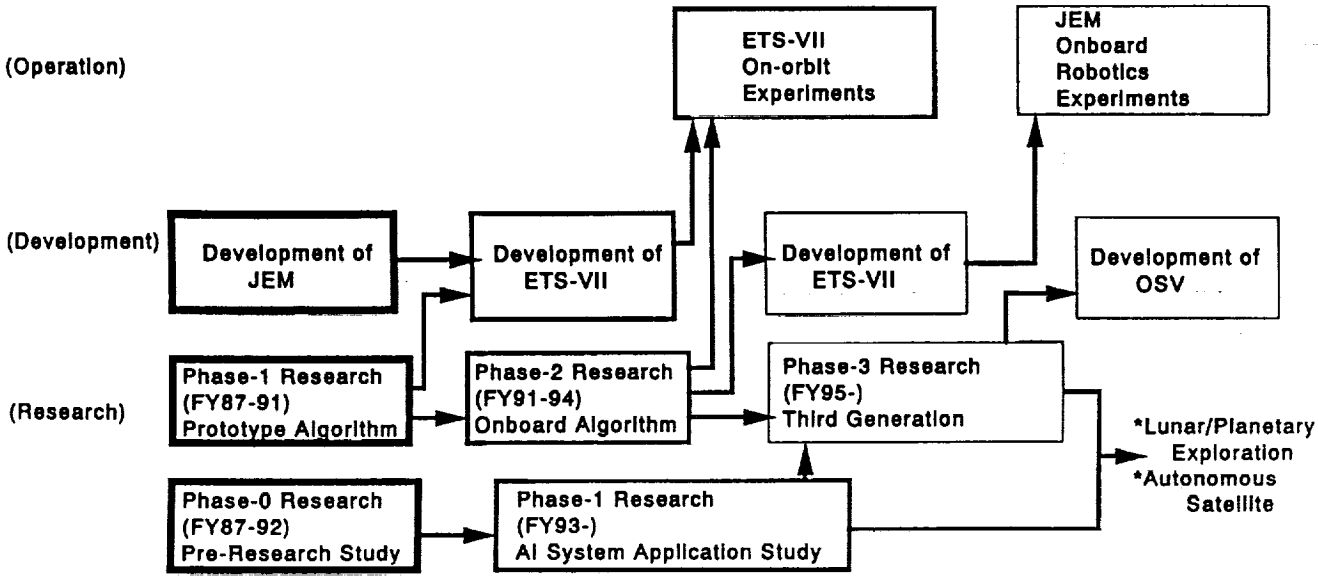
NASDA's Space Robotics and AI

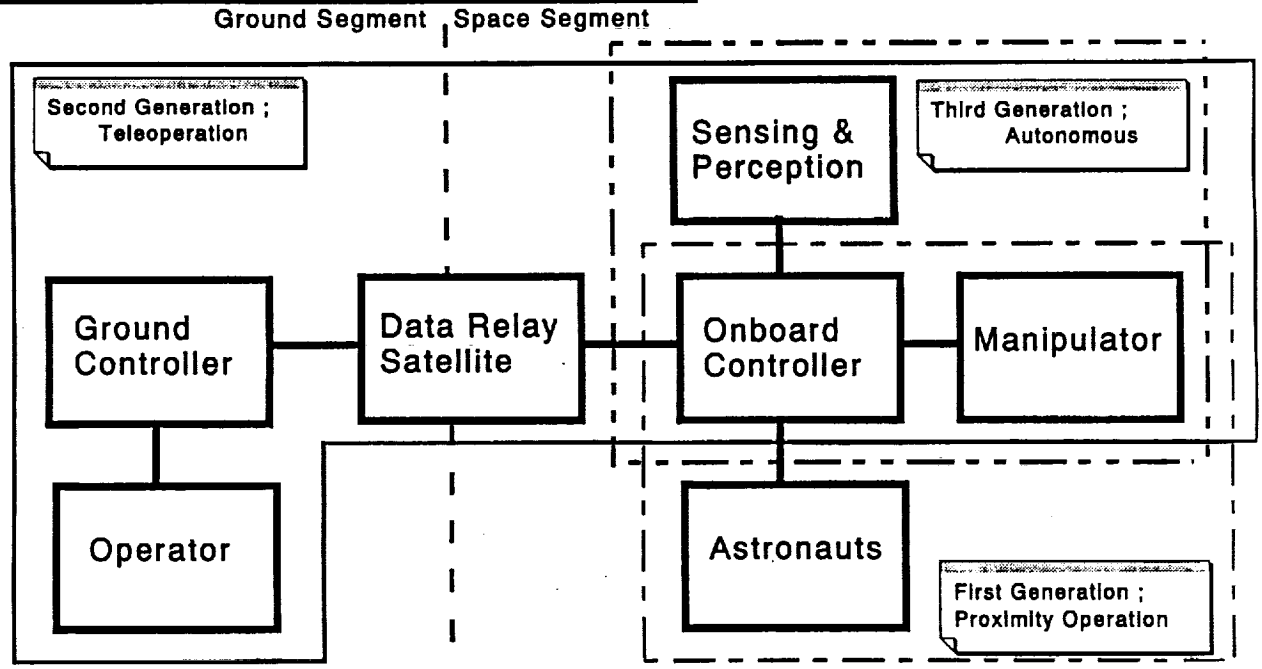
NASDA
National Space Development Agency of Japan

■ R&D Plan

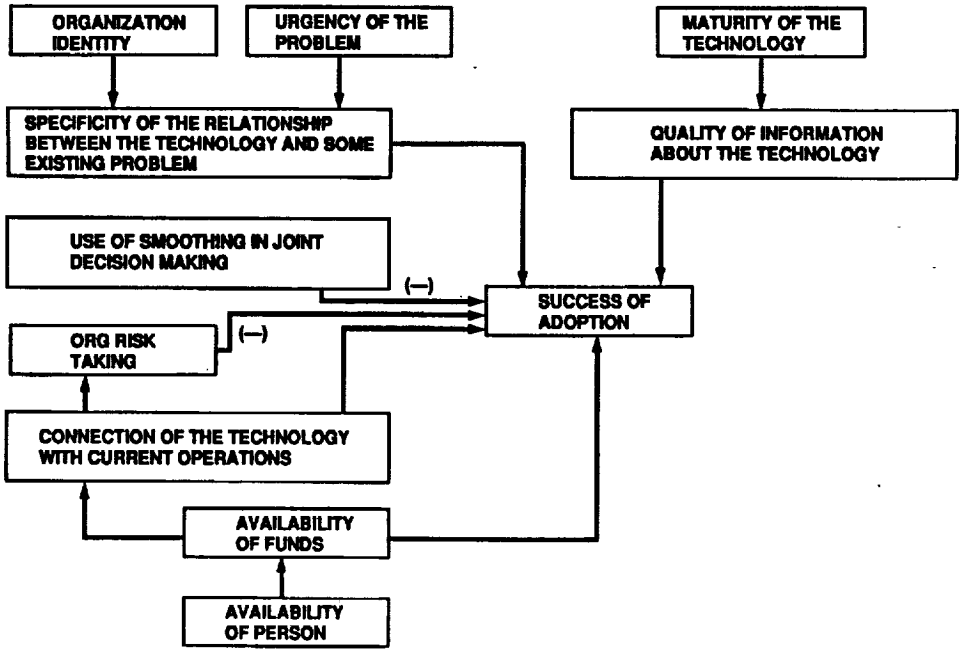


Generation of Space Robots

NASDA
National Space Development Agency of Japan



ENVIRONMENTAL CONDITIONING FOR TECH-TRANSFER



NASA

HIGH PERFORMANCE COMPUTING and COMMUNICATIONS PROGRAM

Lee Holcomb

OAST

FEDERAL PROGRAM GOAL AND OBJECTIVES

OAST HPCC

- EXTEND U.S. LEADERSHIP IN HIGH PERFORMANCE COMPUTING AND COMPUTER COMMUNICATIONS
- DISSEMINATE THE TECHNOLOGIES TO SPEED INNOVATION AND TO SERVE NATIONAL GOALS
- SPUR GAINS IN INDUSTRIAL COMPETITIVENESS BY MAKING HIGH PERFORMANCE COMPUTING INTEGRAL TO DESIGN AND PRODUCTION

PRESIDENTIAL COMMITMENT

OAST HPCC

❒ 1991 CALTECH COMMENCEMENT SPEECH

"...we must invest now in a brighter future. That's why our administration fully supports high-performance computing, and math and science education."

❒ HIGH PERFORMANCE COMPUTING ACT OF 1991 (P.L. 102-194)

"The development if high performance computing and communications technology offers the potential to transform radically the way in which all Americans will work, learn and communicate in the future. It holds the promise of changing society as much as the other great inventions of the 20th century, including the telephone, air travel and radio and TV."

FEDERAL HPCC PROGRAM RESPONSIBILITIES*

OAST HPCC

ACTIVITY / AGENCY	HIGH PERFORMANCE COMPUTING SYSTEMS	ADVANCED SOFTWARE TECHNOLOGY AND ALGORITHMS	NATIONAL RESEARCH AND EDUCATION NETWORK	BASIC RESEARCH AND HUMAN RESOURCES
DARPA	• Technology development and coordination for teraops systems	• Technology development for parallel algorithms and software tools	• Technology development and coordination for gigabits networks	• University programs
DOE	• Technology development • Systems evaluation	• Energy applications research centers • Energy grand challenge and computation research • Software tools	• Gigabits applications research • Access to energy research facilities and databases	• Basic research and education programs
NASA	• Aeronautics and space application testbeds	• Software coordination • Computational research in: • Aereosciences • Earth and space sciences	• Access to aeronautic and spaceflight research centers	• Research institutes and university block grants
NSF	• Basic architecture research • Prototyping experimental systems	• Research in: • Software tools, databases • Grand Challenges • Computer access	• Facilities coordination and deployment • Gigabits research	
DOC/NIST	• Research in systems instrumentation and performance measurement • Research in interfaces and standards	• Research in: • software indexing and exchange • scalable parallel algorithms	• Coordinate performance assessment and standards • Programs in protocols and security	• Programs in: • Basic research • Education/training/curricula • Infrastructure
DOC/NOAA		• Ocean and atmospheric computation research • Software tools • Computational techniques	• Ocean and atmospheric mission facilities • Access to environmental data bases	
EPA		• Research in environmental computations, databases, and application testbeds	• Environmental mission assimilation by the states	• Technology transfer to States • University programs
NIH/NLM		• Medical application testbeds for medical computation research	• Development of intelligent gateways • Access for academic medical centers	• Basic Research • Interships for parallel algorithm development • Training and career development

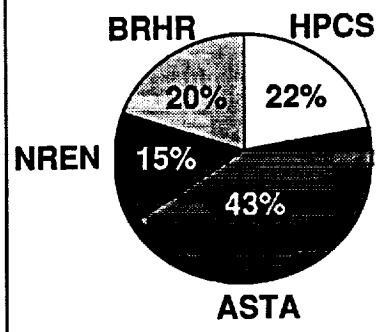
* Department of Education participation expected in FY 1993

FEDERAL HPCC PROGRAM FUNDING FY 92-93

OAST — HPCC

(Dollars in millions)

AGENCY	FY 1992	FY 1993
DARPA	232.2	275.0
NSF	200.9	261.9
DOE	92.3	109.1
NASA	71.2	89.1
HHS/NIH	41.3	44.9
DOC/NOAA	9.8	10.8
EPA	5.0	8.0
DOC/NIST	2.1	4.1
Total	654.8	802.9



APPROACH

OAST — HPCC

- ESTABLISH HIGH PERFORMANCE COMPUTING TESTBEDS
- CONSTITUTE APPLICATION SOFTWARE TEAMS COMPOSED OF DISCIPLINE AND COMPUTATIONAL SCIENTISTS TO UTILIZE AND EVALUATE TESTBEDS
- PROMOTE COLLABORATION, EXCHANGE OF IDEAS AND SHARING OF SOFTWARE AMONG HPCC SOFTWARE DEVELOPERS
- PROMOTE TECHNOLOGY TRANSFER

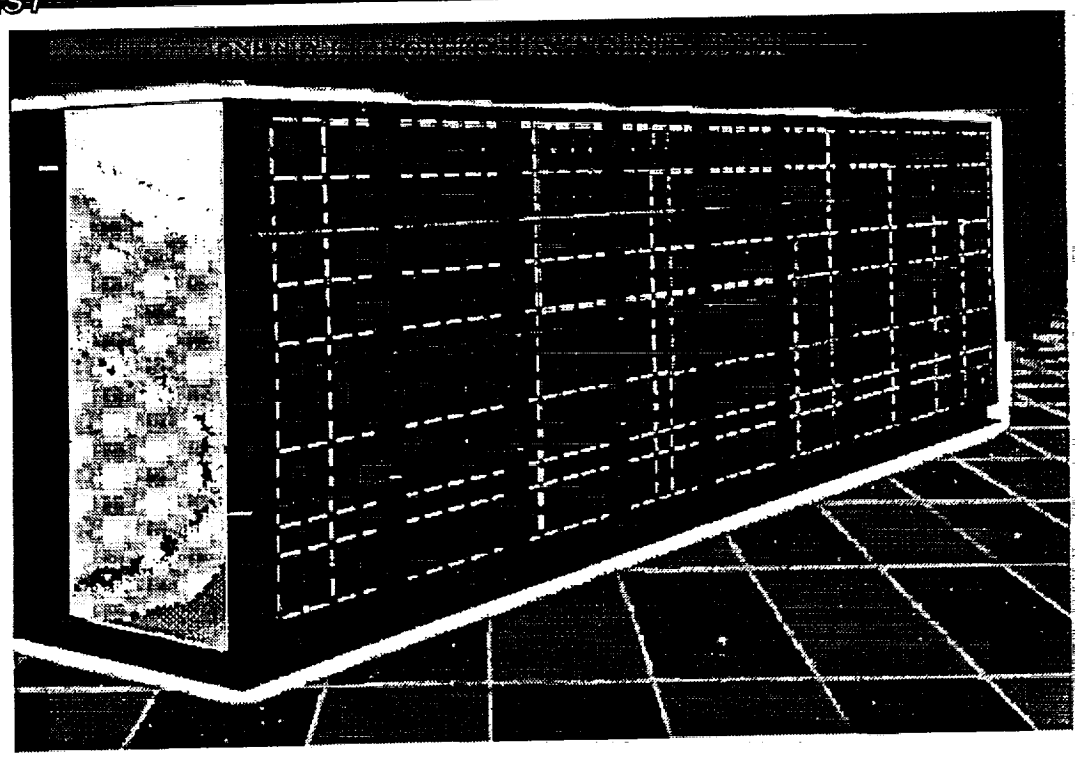
CONCURRENT SUPERCOMPUTER CONSORTIUM

OAST HPCC

PURPOSE ACQUIRE AND UTILIZE THE INTEL TOUCHSTONE DELTA SUPERCOMPUTER

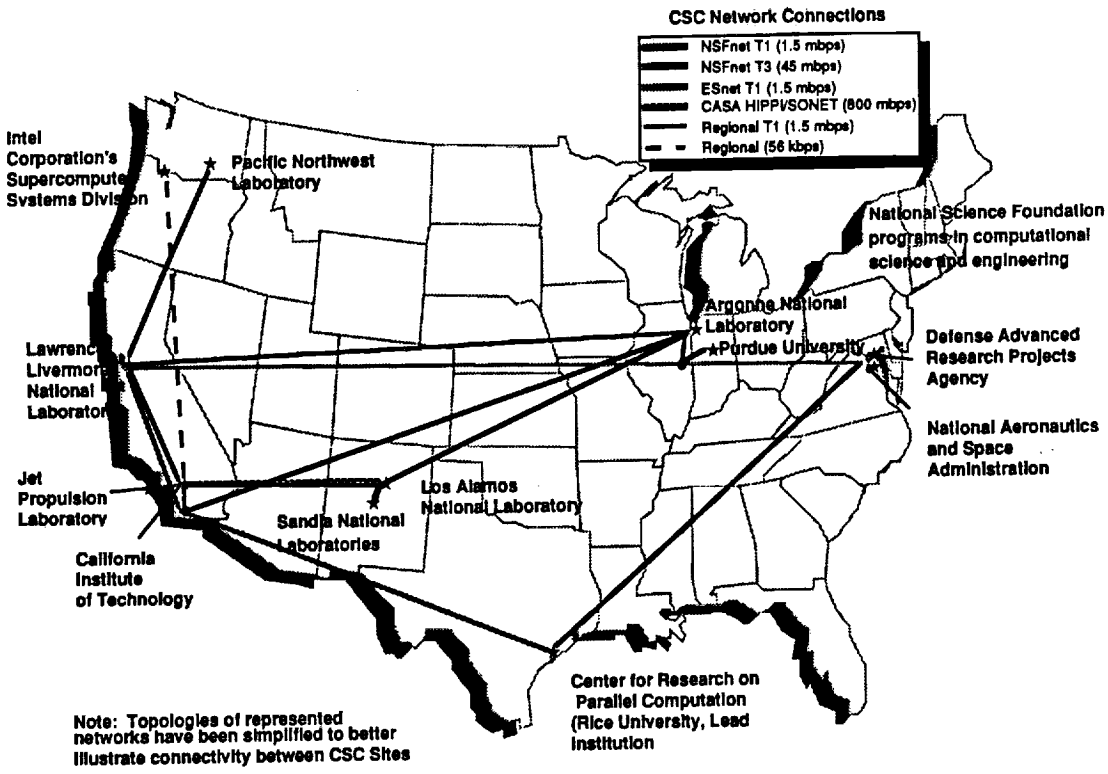
- DELTA IS WORLD'S FASTEST INSTALLED SUPERCOMPUTER
  - — PEAK SPEED OF 32 GFLOPS USING THE 528 NUMERIC PROCESSORS
  - — 13 GFLOPS SPEED OBTAINED ON A LINPAC BENCHMARK CODE OF ORDER 25,000 BY 25,000
- LOCATED AT CALTECH: ACCEPTANCE TESTING COMPLETED
- PEAK SPEED EXPECTED TO BE 32 GIGAFLOPS,
- INTEL TOUCHSTONE DELTA IS ONE OF SERIES OF DARPA DEVELOPED MASSIVELY PARALLEL COMPUTERS
- PARTNERS INCLUDE OVER 14 GOVERNMENT, INDUSTRY AND ACADEMIA ORGANIZATIONS

OAST HPCC



DELTA CONSORTIUM PARTNERS

OAST HPCC



COMPUTATIONAL AEROSCIENCES CONSORTIUM

OAST HPCC

- DEVELOP A MECHANISM TO ALLOW AEROSPACE INDUSTRY TO INFLUENCE THE REQUIREMENTS, STANDARDS, AND DIRECTION OF NASA'S COMPUTATIONAL AEROSCIENCES (CAS) PROJECT
- PROVIDE A MECHANISM TO ALLOW INDUSTRY TO INTELLECTUALLY PARTICIPATE IN THE DEVELOPMENT OF SELECTED "GENERIC" CAS APPLICATIONS SOFTWARE AND SYSTEMS SOFTWARE BASE
- FACILITATE THE TRANSFER OF CAS TECHNOLOGY TO AEROSPACE USERS
- PROVIDE INDUSTRY ACCESS TO HIGH PERFORMANCE COMPUTING RESOURCES
- PROVIDE A MECHANISM TO ALLOW INDUSTRY TO COMMERCIALIZE APPROPRIATE PRODUCTS

PRIVATE SECTOR PARTICIPANTS

OAST HPCC

- INDUSTRY

  BOEING, GENERAL ELECTRIC, GRUMMAN, MCDONNELL DOUGLAS, NORTHRUP, LOCKEHHED, UNITED TECHNOLOGIES, TRW, ROCKWELL, GENERAL MOTORS, GENERAL DYNAMICS, MOTOROLA

- ACADEMIA

  SYRACUSE, MISSISSIPPI STATE, USRA, UNIVERSITY OF CALIFORNIA-DAVIS

RATIONALE

OAST HPCC

- GENERIC, PRE-COMPETITIVE TECHNOLOGY
  - — RISK AND COST
  - — ULTIMATE COMMERCIAL PRODUCTS ARE DIVERSE AND UNDETERMINED
- INFLUENCE STANDARDS THROUGH DIVERSITY OF APPLICATIONS
- INTELLECTUAL PROPERTY RIGHTS CAN BE VESTED IN CONSORTIUM MEMBERS FOR COMMERCIALIZATION
- PROVIDES MECHANISM FOR COMBINING DIVERSE INTELLECTUAL POINTS-OF-VIEW
- TECHNOLOGY TRANSFER IS THROUGH DIRECT PARTICIPATION

WORKING PANEL #3

TECH TRANSFER BETWEEN NASA AND THE AEROSPACE COMMUNITY

ROBERT SACKHEIM & DENNIS DUNBAR

TECHNOLOGY TRANSFER BETWEEN THE
GOVERNMENT AND THE AEROSPACE INDUSTRY

OVERVIEW

THE OBJECT OF THIS WORKING GROUP PANEL IS TO REVIEW QUESTIONS AND ISSUES PERTAINING TO TECHNOLOGY TRANSFER BETWEEN THE GOVERNMENT AND THE AEROSPACE INDUSTRY FOR USE ON BOTH GOVERNMENT AND COMMERCIAL SPACE CUSTOMER APPLICATIONS.

TEAM LEADER - ROBERT SACKHEIM - TRW
PRESENTER - DENNIS DUNBAR - GD CLS

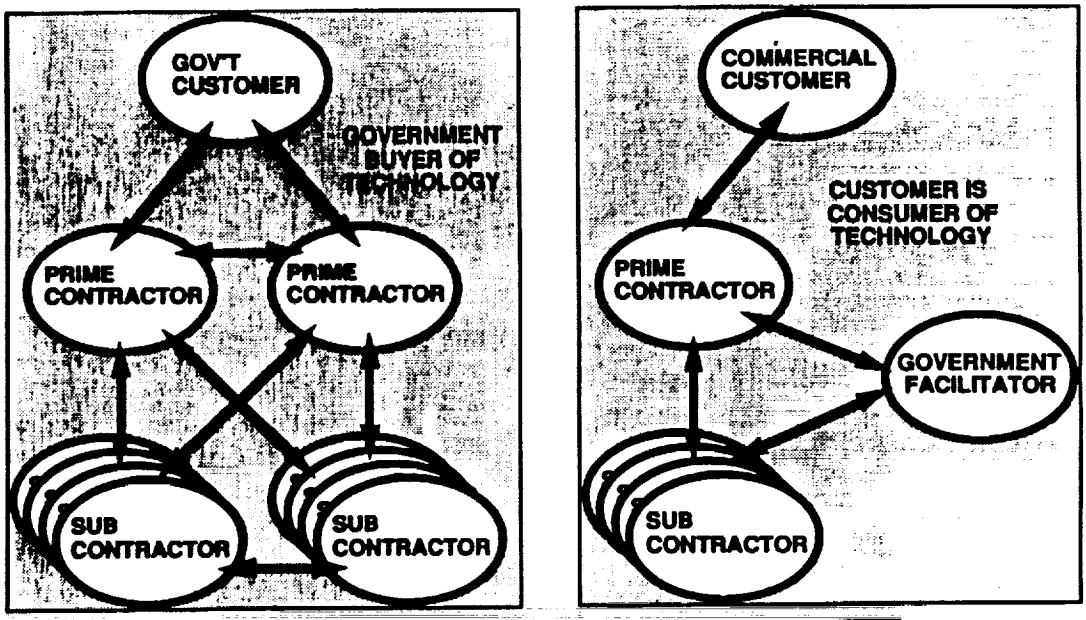
SUBTOPIC A - GOVERNMENT CUSTOMER
RAPPORTEUR - WALT OSTAD - LOCKHEED

SUBTOPIC B - COMMERCIAL CUSTOMER
RAPPORTEUR - NEVILLE MARZWELL - JPL

MEMBERS

HAROLD ADELSON - TRW
JOE GERNAND - RI
JOHN JENNINGS - NASA C
NORM BOWLES - DOT OCST
JOE FULLER - FUTRON
LEE HOLCOMB - NASA R
RON MARINZEL - BDM
DENNIS MCGOVERN - MD SSC
WILLARD WEAVER - NASA LANGLEY
LARRY PALMER - HUGHES HNS
DON THURMAN - NASA MSFC
DAMON WELLS - DOT OCST

TWO TECHNOLOGY PARTNERSHIP MODELS FOR CONSIDERATION



SUCCESSFUL TEAMS SHARE INFORMATION

GOVERNMENT TO AEROSPACE INDUSTRY

KEY ISSUES AND QUESTIONS

1. DOES THE GOVERNMENT EXERT TOO MUCH CONTROL?
2. DOES NASA HAVE A CHARTER AND/OR AN INTENT TO SUPPORT / ENHANCE U.S. INDUSTRY COMMERCIAL COMPETITIVENESS?
3. TO WHAT EXTENT SHOULD INDUSTRY DEPEND ON THE GOVERNMENT?
4. ARE FUNDING PRIORITIES COMPATIBLE WITH NATIONAL PRIORITIES FOR COMMERCIAL COMPETITIVENESS?
5. HOW FAR SHOULD THE GOVERNMENT TAKE TECHNOLOGY FOR COMMERCIAL USE?
   a) R&T BASE AND FOCUSED (LEVEL 5 & 6)
   b) BRIDGE TECHNOLOGY (LEVEL 7, 8 & 9)
   c) HOW TO FUND BRIDGE TECHNOLOGY
      - DIRECT GOVERNMENT FUNDING (CRAD)
      - INVESTMENT TAX CREDITS (BASED ON SALES)
      - CRADA / CRDA
      - MANDATED POLICY & INCENTIVES
      - GOVERNMENT FUNDED DEMO'S AND FLIGHT TESTS
      - "ANCHOR TENANT" OR "BLOCK BUY" PQMTS

GOVERNMENT TO AEROSPACE INDUSTRY (CONTINUED)

KEY ISSUES AND QUESTIONS

6. CAN THE GOVERNMENT PROVIDE OTHER BROAD INCENTIVES FOR TECHNOLOGY TRANSFER?
7. TO WHAT LEVEL SHOULD THE GOVERNMENT TRANSFER TECHNOLOGY?
   - AS A FUNCTION OF DEVELOPMENT RISK (ACTS)
   - AS A FUNCTION OF GOVERNMENT BENEFITS AND PAYBACK (ELV'S)
8. SHOULD THE U.S. MULTI-NODE TECH TRANSFER ORGANIZATION BE MODIFIED IN THE JAPANESE MITI STYLE?
9. ARE SBIR'S COST EFFECTIVE FOR LARGE AEROSPACE FIRMS? CAN THERE BE MORE EFFECTIVE UTILIZATION?

OBSERVATIONS & SUGGESTIONS

1. NASA, OMB, NS,C ETC. NEED TO AGREE ON A CHARTER FOR SUPPORTING U.S. COMMERCIAL COMPETITIVENESS.

2. NASA AND INDUSTRY NEED A PLAN FOR "BRIDGE" TECHNOLOGY FUNDING.

3. COMMERCIAL COMPETITIVENESS NATIONAL PRIORITY VS. FUNDING PRIORITY IS OUT OF BALANCE: MORE FUNDS NEEDED.

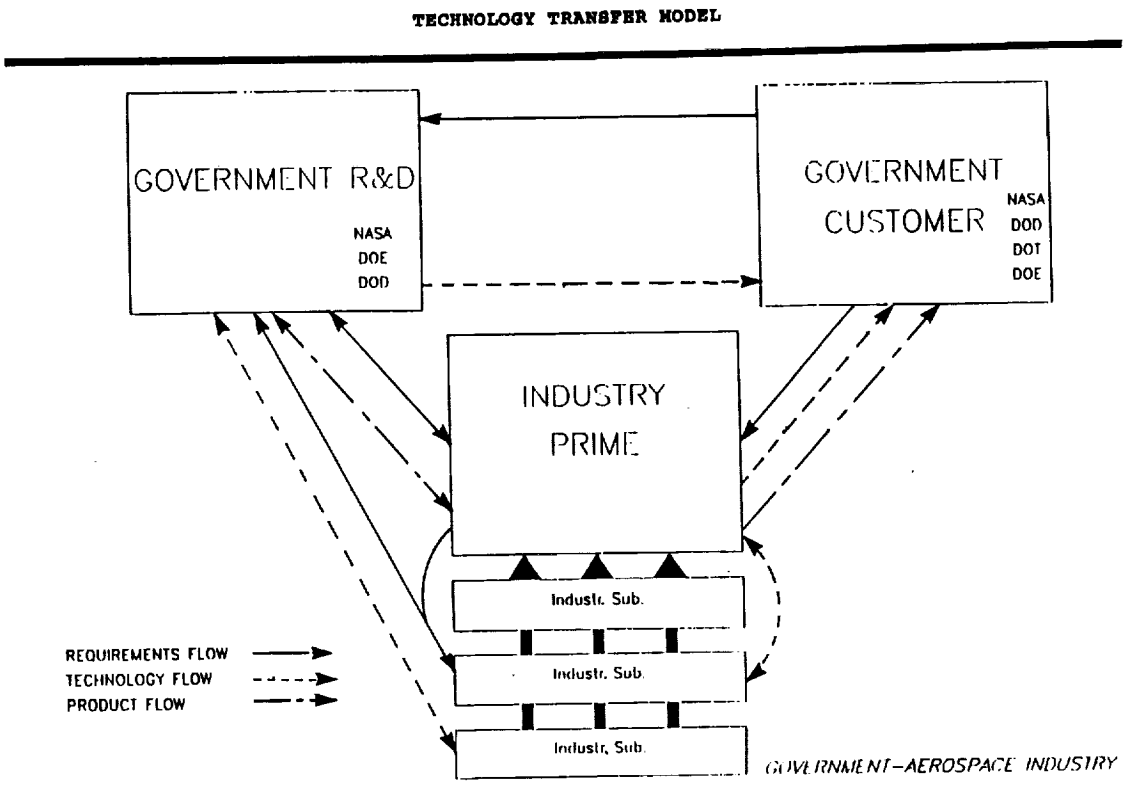
4. NEED TO REVISIT "OVER-INSTITUTIONALIZATION" OF THE TECH TRANSFER PROCESS BY TOO MANY FEDERAL AGENCIES. THIS IS BOUND TO RESULT IN NON-VALUE ADDED COST BURDENS TO THE TECHNOLOGY IMPLEMENTATION PROCESS - ESPECIALLY FOR THE AEROSPACE INDUSTRY.

5. NEED MORE FINANCIAL INCENTIVES FOR INDUSTRY TO TAKE THE RISKS NECESSARY FOR EFFECTIVE TECHNOLOGY TRANSFER TO LARGE SPACE SYSTEMS. (EG: THE NACA - AIRCRAFT INDUSTRY MODEL)

Subtopic A

Technology Transfer Associated With A Projected Government Application

Dr. Walter Olstad



WITH APOLOGIES TO JOHN PRESTON

EFFICIENCY OF TECHNOLOGY TRANSFER

$$\eta_{TT} = (Pa_U - P_{TD}) \frac{(T_{DI}/T_{TPD})}{N_P \cdot N_O (1 + N_{TTI})}$$

WHERE

Pa_U, Pa_{TD} = PASSION OF "HANDS-ON" USER, TECH. DEVELOPER
T_{DI} = DIRECT INTERACTION TIME BETWEEN DEVELOPER & USER
T_{TPD} = TOTAL PRODUCT DEVELOPMENT TIME
N_P = NUMBER OF VALUE-ADDING PLAYERS IN PROCESS
N_O = NUMBER OF DISTINCT ORGANISATIONS INVOLVED
N_{TTI} = NUMBER OF TECH. TRANSFER INTERMEDIARIES

LESSONS LEARNED / INSIGHTS

APOLLO

- NASA - INDUSTRY TEAMWORK
- CLARITY OF NASA AND INDUSTRY ROLES
- RESOURCES AND PASSION OVERCAME OBSTACLES
- TRADITIONAL TRANSFER MECHANISMS PROACTIVELY USED
- STRONG ROLE FOR NASA FACILITIES AND FLIGHT EXPERIMENTS

SSF

- NASA AND INDUSTRY LESS OF A TEAM
- MORE CONFUSION THAN CLARITY ABOUT TECHNOLOGY ROLES
- UNSTABLE REQUIREMENTS DISRUPT TECHNOLOGY DEVELOPMENT
- TRADITIONAL TRANSFER MECHANISMS FORGOTTEN
- UNCERTAIN RESOURCES AND WAVERING PASSION

GOVERNMENT - AEROSPACE INDUSTRY

KEY ISSUES / BARRIERS

- MANAGEMENT LACKS UNDERSTANDING OF TECHNOLOGY TRANSFER IMPORTANCE / PROCESS
- INDUSTRY ISN'T ANY BETTER
- INADEQUATE PERSONNEL MOBILITY
- GROWTH OF INHIBITING LAWS / REGULATIONS
- KNEE-JERK REACTIONS OF R&T TO PROGRAMMATIC INSTABILITIES
- LOSS OF PASSION IN NASA AND INDUSTRY

GOVERNMENT - AEROSPACE INDUSTRY

TRANSFER MECHANISMS THAT WORK BETWEEN.....

NASA R&T - INDUSTRY

- PROFESSIONAL/TECHNICAL INTERCHANGE
- PUBLISHED TECHNICAL MATERIALS
- IRAD REVIEWS
- PERSONNEL EXCHANGES
- SHARING OF FACILITIES
- CONTRACT R&D
- CONTRACT CONCEPT/SYSTEMS STUDIES
- SBIR

INDUSTRY - NASA CUSTOMER

- TECHNICAL MARKETING/WHITE PAPERS
- SOLICITATIONS/PROPOSALS
- CONTRACT CONCEPT/SYSTEMS STUDIES
- PERSONNEL CO-LOCATIONS/LIAISONS
- USE OF GOVERNMENT FACILITIES
- DATA DELIVERABLES
- PRODUCT DELIVERABLES (TEST ARTICLES/PROTOTYPES/FINAL)

GOVERNMENT - AEROSPACE INDUSTRY

ENHANCEMENT OPPORTUNITIES

- CLARIFY NASA VS. INDUSTRY ROLE IN TECHNOLOGY DEVELOPMENT/TRANSFER
  - WHAT TECHNOLOGY READINESS LEVEL AND WHY?
  - WHO'S THE CUSTOMER?
- INSTILL PASSION IN NASA FOR TECHNOLOGY TRANSFER
  - CLARIFY OAST/RESEARCH CENTER CHARTERS FOR TECHNOLOGY TRANSFER
  - PROVIDE POSITIVE INCENTIVES
- INCREASE "WIN-WIN" PERSONNEL EXCHANGE
  - DEVELOP ASSIGNMENTS
  - MANAGEMENT COMMITMENT AND FOLLOW THROUGH
  - CAREER CHANGES
- INSTITUTE NATIONAL SPACE TECHNOLOGY FACILITIES POLICY
  - GROUND-BASED SIMULATION (LARGE SCALE, HIGH COST)
  - SPACE-BASED FACILITIES (QUICK ACCESS, AFFORDABLE)
- MANAGE TECHNOLOGY TRANSFER
  - RECOGNIZE INDUSTRY'S ROLE IN THE ITP
  - BUILD CONNECTIVITY AMONG ALL TECHNOLOGY PLANS
- STREAMLINE PROCUREMENT PROCESS FOR CRAD

GOVERNMENT - AEROSPACE INDUSTRY

WHO SHOULD DO WHAT

- OAST / RESEARCH CENTER MANAGEMENT / INDUSTRY MANAGEMENT...
  - CLARIFY UNDERSTANDING OF TRANSFER PROCESS
  - CLARIFY ROLES FOR OPTIMUM TRANSFER
- OAST - GAIN LONG-TERM COMMITMENT FOR TECHNOLOGY PLAN
- OAST - INCLUDE TRANSFER (AND RECOGNIZE INDUSTRY'S ROLE) IN THE ITP
- OAST / RESEARCH CENTERS / INDUSTRY - INCREASE INTERACTION AND BECOME A TEAM
- EVERYONE - FIND WAYS TO RECREATE THE PASSION

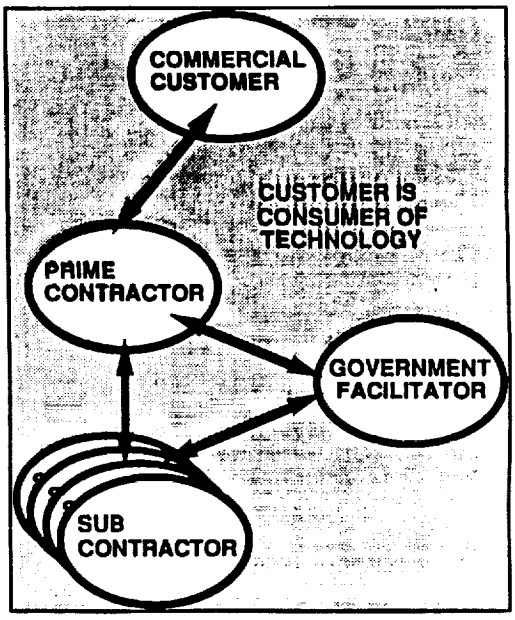
GOVERNMENT - AEROSPACE INDUSTRY

Subtopic B

Technology Transfer Associated With A Commercial Space Sector Application

Dr. Neville Marzwell

TWO TECHNOLOGY PARTNERSHIP MODELS FOR CONSIDERATION



SUCCESSFUL TEAMS SHARE INFORMATION

FACTORS INFLUENCING TECH-TRANSFER

- TECHNO-ECONOMIC FACTORS

  QUALITY OF INFORMATION, MATURITY OF THE TECH. AVAILABILITY OF QUALIFIED / MOTIVATED PERSONNEL, AVAILABILITY OF RESOURCES

- ORGANIZATIONAL FACTORS

  CLIMATE, SMOOTHING IN JOINT-DECISION MAKING DONE AT LOWER LEVEL

- COMMUNICATION FACTORS

  LEVEL OF COMMUNICATION DEPENDENT ON THE "GAP" BETWEEN BASIC RESEARCH AND READINESS FOR ENGINEERING PROTOTYPING

- TECHNOLOGY MATURITY

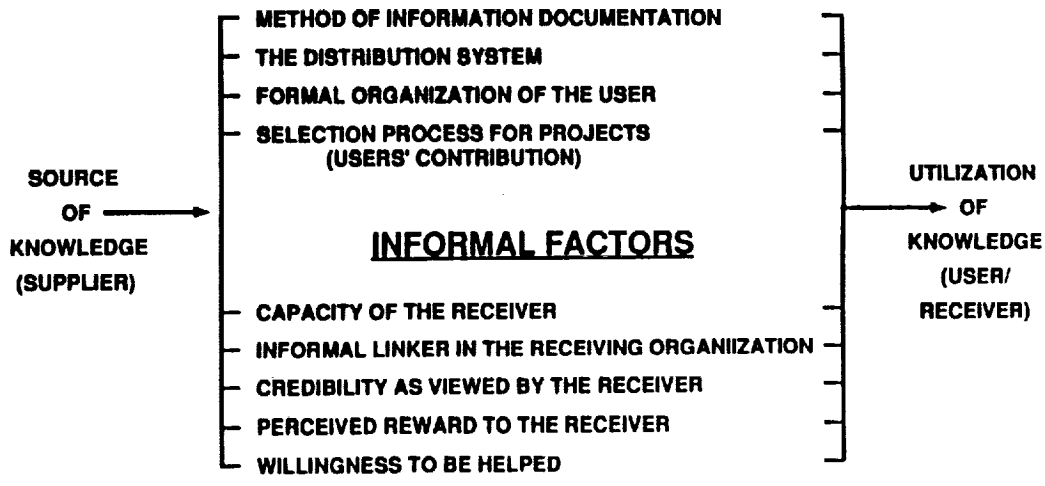
  INCREASED MATURITY IMPLIES LESS RISK AND THEREFORE GREATER PROBABILITY OF SUCCESS

- CULTURAL DIFFERENTIAL

  BUSINESS AND PROFESSIONAL PRACTICE

JPL *Robotic Technology Evolution and Transfer*

FACTORS AFFECTING TECH-TRANSFER



TYPES OF BARRIERS IN TECH-TRANSFER

- ENVIRONMENT BETWEEN THE R&D GENERAL SYSTEM (FEDERAL LAB, UNIV OR PRIVATE LAB) AND THE COMPANY GENERAL SYSTEM (USER TO WHOM THE TECHNOLOGY IS TO BE TRANSFERRED)

- ENVIRONMENT BETWEEN THE DEPARTMENTS AND DIVISIONS WITHIN THE LABORATORY OR COMPANY WHICH REPRESENT THE SUBSYSTEMS OF BOTH GENERAL SYSTEMS

  - BETWEEN THE GENERAL SYSTEMS
    1. NO FORMAL TRANSFER POLICIES
    2. COST BARRIERS
    3. TIME HORIZON CONFLICT
    4. INFRINGEMENT PROBLEMS

  - BETWEEN SUBSYSTEMS
    1. INERTIA BARRIER
    2. LACK OF AN INCENTIVE STRUCTURE
    3. COST BARRIER
    4. COMMUNICATION
    5. TIME BARRIER
    6. GEOGRAPHIC DISTANCE
    7. NON-EXISTENT TRANSFER MANAGEMENT STRUCTURE
    8. TECHNOLOGY BARRIER

  - BETWEEN ELEMENT
    1. LACK OF AN INCENTIVE STRUCTURE
    2. HIGH RISK OF BEING BLAMED FOR FAILURE
    3. INSECURITY OF RETAINING JOB IF NOT SUCCESSFUL
    4. MUTUAL DISRESPECT
    5. UNIQUE REQUIREMENTS OF EACH SUBSYSTEM
    6. UPDATING OF TECHNOLOGY NEEDS
    7. TIME BARRIER
    8. LACK OF TRANSFER ORGANIZATION MANAGERS

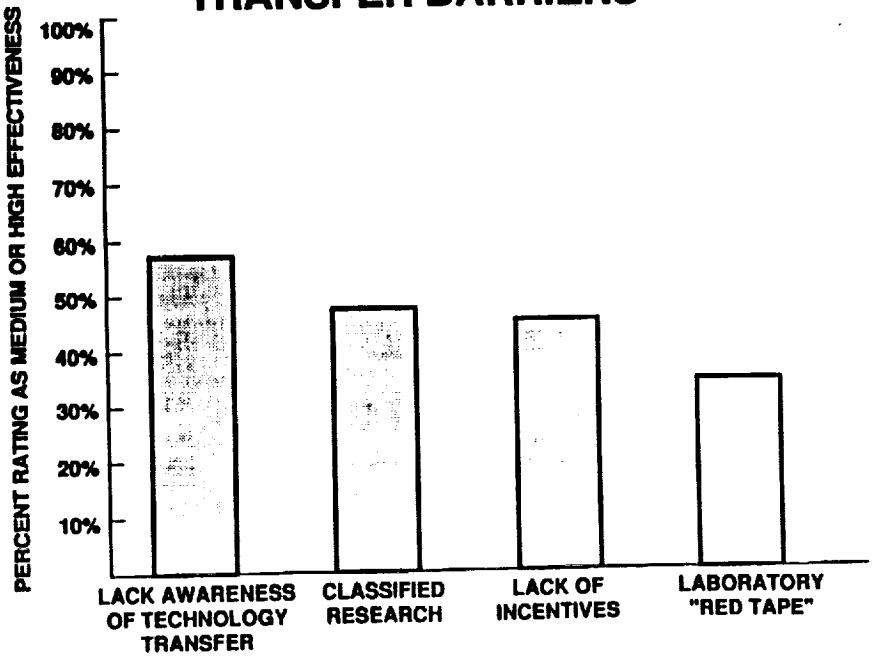
MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER

1. A TENDENCY TO ASSUME WITHOUT PROOF THAT THERE IS A RECEIVER FOR THE TECHNOLOGY, THAT IS, THAT SOMEBODY ACTUALLY WANTS IT AND WILL ACCEPT IT
2. LACK OF INTEREST AND SUPPORT BY TOP MANAGEMENT, THAT IS, THOSE WHO MAKE POLICY AND CONTROL THE NECESSARY RESOURCES
3. LACK OF INTEREST OR EFFORT BY MANAGERS AT THE LEVEL WHERE TECHNOLOGY TRANSFER WILL ACTUALLY BE IMPLEMENTED
4. FAILURE TO FIX RESPONSIBILITY AND ACCOUNTABILITY FOR GETTING THE JOB DONE
5. LACK OF AWARENESS OF THE VALUE OF TECHNOLOGY TRANSFER
6. LACK OF FUNDING FOR THE TRANSFER EFFORT
7. LACK OF PERSONNEL ASSIGNED TO THE TASK OR LACK OF SUFFICIENT TIME AVAILABLE TO THOSE WHO ARE ASSIGNED TO THE TASK
8. LACK OF NECESSARY KNOWLEDGE AND TRAINING FOR THOSE ASSIGNED THE TASK
9. RESTRICTIONS ON MOBILITY OF PERSONNEL
10. INDIFFERENCE TO TECHNOLOGY TRANSFER

MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER (Cont'd)

11. POWER GAMES INTENDED TO MAINTAIN OR PROMOTE PERSONAL AMBITIONS, SUCH AS JOB PROTECTION, COMMERCIAL INTEREST, POLITICAL AMBITIONS, STATUS, OR CONTROL OF THE WORK SITUATION. USUALLY TAKES THE FORM OF SECRECY. (Hawthorne 1978)
12. POOR INTERPERSONAL RELATIONS – THE PARTIES REACT NEGATIVELY TO EACH OTHER
13. EXPECTATIONS OF ONE PARTY ARE NOT SHARED BY THE OTHER PARTIES
14. LACK OF CONTINUED ORGANIZATIONAL COMMITMENT TO THE EFFORT
15. PROMISING MORE THAN CAN BE DELIVERED
16. SOMEONE TAKING OFFENSE, WHERE NONE WAS INTENDED, AT A SUGGESTION THAT SOME ACTIVITY THEY ARE RESPONSIBLE FOR COULD BE IMPROVED
17. CULTURAL DIFFERENCES: ETHNIC, REGIONAL, NATIONAL, OR ORGANIZATIONAL
18. EMPLOYMENT SENIORITY SYSTEMS OR FEATHERBEDDING
19. DOCUMENTS TOO TECHNICAL FOR THE POTENTIAL USER TO UNDERSTAND
20. EXCESSIVE GOVERNMENT REQUIREMENTS FOR PRODUCT TESTING AND APPROVAL

KEY TECHNOLOGY TRANSFER BARRIERS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST BARRIERS TO TECHNOLOGY TRANSFER

SPECIFIC BARRIERS TO COMMERCIALIZATION

- GOVERNMENT PROCEDURES, REGULATIONS, DOCUMENTATION AND CONTROLS.
- LACK OF DIRECTION, DEFINITION, ROLES, RESPONSIBILITY AND ACCOUNTABILITY OF GOVERNMENT AGENCIES IN TECHNOLOGY TRANSFER.
- LACK OF LONG-TERM STRATEGIC GOALS FOR GOVERNMENT AGENCIES WHICH RESULTS IN UNCERTAINTIES, TURBULENCES, FLUCTUATIONS AND PRIORITIES FOR SPACE SYSTEMS.
- GOVERNMENT DOES NOT TAKE R&D BASE TO HIGH ENOUGH LEVEL OF READINESS TO REDUCE RISK TO INDUSTRIAL/COMMERCIAL SECTORS.
  - SIMULATION MODEL IS FAR FROM BEING AN ENGINEERING PROTOTYPE OR A FLIGHT TESTED SUBSYSTEM
  - INFRASTRUCTURE TO SUPPORT BRIDGING
  - ECONOMICAL INCENTIVES
  - LACK OF POLICY AND STRATEGY
- LACK AND MAGNITUDE OF CAPITAL REQUIREMENTS RENDERED INDUSTRY DEPENDENT ON GOVERNMENT FOR SPACE MARKET NEEDS AND DEFINITION.
- GOVERNMENTAL AGENCIES FUNDING STRUCTURE OF BASE R&D FOCUSED TECHNOLOGY BUT NO CLEAR FUNDING FOR ENGINEERING PROTOTYPING, QUALIFICATION AND FLIGHT VALIDATION.
- HIGHER AND MORE COMPLEX TECHNOLOGY LEVEL BEING DEVELOPED WHICH HAS NOT BEEN MATCHED BY INCREASED HUMAN COMPETENCE, TRAINING AND EDUCATION.
- MULTI-MODI TECH. TRANSFER ORGANIZATIONS HIGHLY DISORGANIZED, INEFFICIENT WHEN COMPARED TO JAPAN'S CONSORTIUM OF GOVERNMENT AGENCIES, BANKS, INDUSTRY AND UNIVERSITIES.
- SBIR EFFECTIVENESS RECOGNIZED FOR SMALL SUBSYSTEMS BUT HAS NO IMPACT ON SPACE SYSTEMS DEVELOPMENT DUE TO SHORTAGE IN CAPITAL BORROWING CAPABILITIES.

Development of EVOLUTION MODEL (Cont'd) Tech. Transf. Infrast.

STAGE	DONOR	BOTH	RECIPIENT
(ADAPTATION)			
		DECISION: GO/NO GO	
IMPLEMENTATION	CONSIDER CAPITAL AND HARDWARE	RECRUIT RESOURCES	CONSIDER PEOPLE AND EMOTIONS
	OVERCOME PREJUDICE		BUILD COHESIVE ORGANIZATION
	PROVIDE TRAINING		PROVIDE SUPPORTING ELEMENTS
	OVERCOME RESISTANCE TO CHANGE		ENSURE BUREAUCRATIC SUPPORT
		RUN PILOT OPERATION	
		DECISION: GO/NO GO	
MAINTENANCE	DELEGATE AUTHORITY	RUN FULL-SCALE OPERATION	ENSURE COMPATIBILITY WITH SUPPORTING ELEMENTS
	ASSIST IN TROUBLE-SHOOTING		EVALUATE SIDE EFFECTS
	IDENTIFY DIVERSIFICATION POSSIBILITIES		PERFORM CONCURRENT R&D
	EVALUATE NET BENEFITS		EVALUATE NET BENEFITS
		EVALUATE SUCCESS	
		DECISION: GO/NO GO	

Development of Tech EVOLUTION MODEL Transfer Infrastruc

STAGE	DONOR	BOTH	RECIPIENT
SEARCH		UNRECOGNIZED TT OPPORTUNITY	
	IDENTIFY CAPABILITIES		IDENTIFY NEEDS
	ESTABLISH POLICIES AND PRIORITIES		ESTABLISH POLICIES AND PRIORITIES
	DEVELOP INCENTIVES TO SEARCH FOR NEEDS		DEVELOP INCENTIVES TO SEARCH FOR CAPABILITIES
	PROVIDES CHANNELS FOR CONTACT		PROVIDE CHANNELS FOR CONTACT
		ESTABLISH VIABLE CONTACT	
		DECISION: GO/NO GO	
ADAPTATION		FORMULATE TT PROJECT	
	LEARN ENVIRONMENT OF RECIPIENT		EVALUATE SOCIO-ECONOMIC IMPLICATIONS
	EVALUATE ADAPTATION REQUIREMENTS		EVALUATE EFFECTIVENESS
	EVALUATE COST		EVALUATE OTHER ALTERNATIVES
	EVALUATE FEASIBILITY		EVALUATE DESIRABILITY
		ANALYZE COST EFFECTIVENESS	
		DECISION: GO/NO GO	
(IMPLEMENTATION)			

ENHANCING FACTORS TO TECH-TRANSFER

INTERPERSONAL RELATIONSHIP

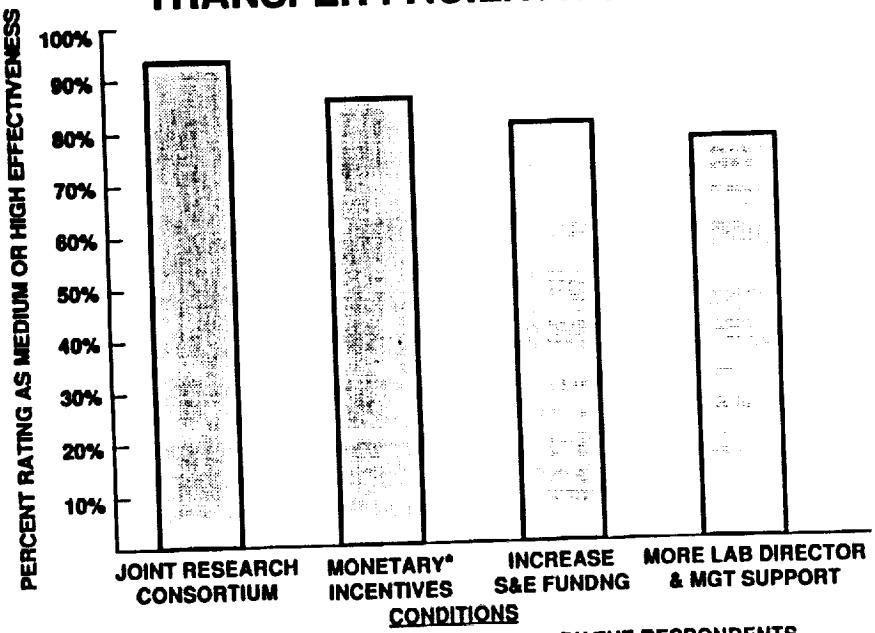
... THE MECHANISM OF TECHNOLOGICAL TRANSFER IS ONE OF AGENTS, NOT AGENCIES; OF THE MOVEMENT OF PEOPLE AMONG ESTABLISHMENTS, RATHER THAN OF THE ROUTING OF INFORMATION THROUGH COMMUNICATION SYSTEMS (Burns, 1969:12).

THE NATIONAL REFERRAL CENTER, A SERVICE OPERATED UNDER THE LIBRARY OF CONGRESS, HEARTILY SUBSCRIBES TO THE CONVICTION THAT SCIENTIFIC AND TECHNICAL INFORMATION IS MOST EFFECTIVELY TRANSFERRED FROM PERSON TO PERSON, NOT FROM MEDIA TO PEOPLE (Timmons, 1978: 34).

STRATEGIES FOR PROMOTING TECH-TRANSFER TO PRIVATE SECTOR

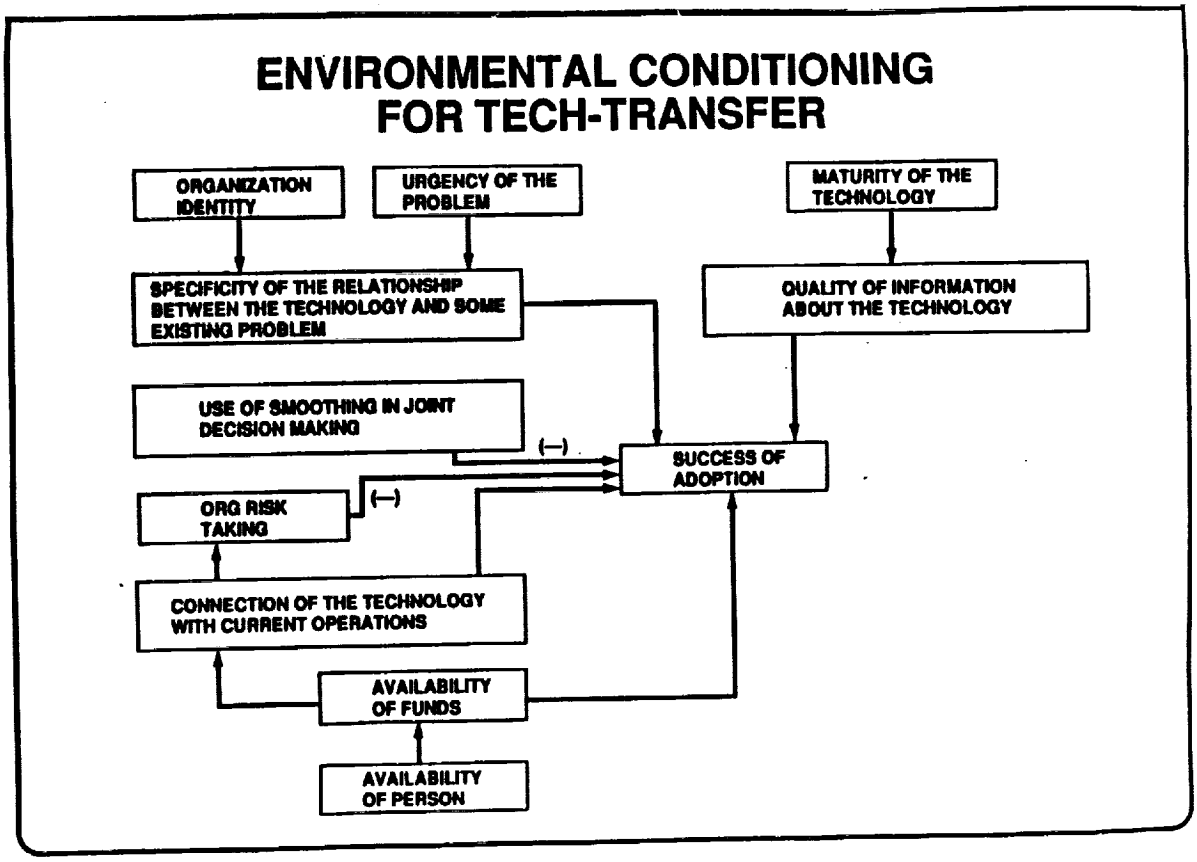
TECHNOLOGY TRANSFER STRATEGY	PURPOSE	TRANSFER MECHANISMS
PASSIVE	TO MAKE INFORMATION ACCESSIBLE TO THOSE INDIVIDUALS AND ORGANIZATIONS SEARCHING FOR SOLUTIONS TO CUSTOMER/SOCIETY PROBLEMS	TECHNICAL DATABASES NTIS PROFESSIONAL JOURNALS TRADE PUBLICATIONS CONFERENCES WORKSHOPS
ROLE-DIRECTED	TO ACTIVELY PROMOTE AWARENESS OF NEW TECHNOLOGY TO INDIVIDUALS OCCUPYING BOUNDARY-SPANNING ROLES IN ORGANIZATIONS	PROFESSIONAL JOURNALS AND SEMINAR PRESENTATIONS TARGETED TO CERTAIN DISCIPLINES TRADE PUBLICATIONS AND SEMINAR PRESENTATIONS TARGETED TO INDUSTRY GROUPS OR NATIONAL ASSOCIATIONS TECHNOLOGY FAIRS INDUSTRY TEAMS
ORGANIZATION DIRECTED	TO ACTIVELY PROMOTE THE ADOPTION OF NEW PRODUCT OR PROCESS CONCEPTS TO INNOVATOR FIRMS IN AN INDUSTRY	TRANSFER OF R&D PERSONNEL DEMONSTRATION PROJECTS PERSONAL CONTACTS ONSITE VISITS JOINT VENTURES TAX INCENTIVES

KEY TECHNOLOGY TRANSFER FACILITATORS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST FACILITATORS OF TECHNOLOGY TRANSFER

* LACK OF INCENTIVES WAS A KEY BARRIER



RECOMMENDATIONS

- DEFINE A QUANTIFIABLE PROCEDURE WITH MEASURABLE OBJECTIVES FOR GOVERNMENT / INDUSTRY TECHNOLOGY TRANSFER.
- DEVELOP A CULTURE FOR DOING BUSINESS BASED ON COST EFFECTIVENESS AND TECH TRANSFER IN BOTH GOVERNMENT AND COMMERCIAL SECTORS... "USE OF NASA FACILITIES... NASA PERSONNEL."
- MORE MONEY IS NOT THE MAIN ISSUE BUT A METHODOLOGY, AN APPROACH AND A NEW WAY OF LIFE IS NEEDED... "A FORUM... A FACILITATION IS NEEDED."
- PERSONNEL EXCHANGE, COST EFFECTIVE / GOAL ORIENTED CONSORTIUMS ARE THE MOST PROMISING ENDEAVORS. (TAX DEFERMENT/INITIATIVES FOR MONEY EARNED FROM TECH TRANSFER FOR 2 TO 3 YEARS)
- JOINT TECHNOLOGY FAIRS/SHOWS ARE MORE EFFECTIVE THAN PUBLICATIONS ALONE WHERE "HANDS-ON" IS ENCOURAGED.

U. Working Panel #4: Tech Transfer to the Broader Economy

Robert G. Steen
Princeton Synergetics, Inc.

The following participants of the workshop were members of this panel:

Individual	Organization
Alario, Mr. Joseph	Grumman
Anyos, Dr. Thomas	Electric Power Research Institute
Bartine, Mr. David	Oak Ridge National Laboratory
Carlson, Dr. Curt	David Sarnoff Research Center
Clark, Mr. Robert	National Media Laboratory
Culpepper, Dr. Ronald	Office of Naval Technology
Dyer, Mr. Gordon	Martin Marietta
Hodge, Mr. Ronald	General Electric
Kravitz, Dr. Larry	Allied Signal
Montanarelli, Mr. Nick	Department of Defense
Morrison, Mr. James	BDM International, Inc.
Ray, Dr. Joseph	Great Lakes Technology Transfer Center
Root, Mr. Jonathan	NASA Headquarters
Rivers, Mr. Lee	National Technology Transfer Center
Rydalch, Ms. Ann	Idaho National Engineering Laboratory
Steen, Mr. Robert	Princeton Synergetics, Inc.
Sutey, Dr. Anthony	Boeing
Vander Velde, Dr. George	Chemical Waste Management, Inc.

The panel agreed to discuss the three suggested subtopics pertaining to technology transfer between the civil space program and the broader economy:

A. Harvesting Commercially Developed Technologies for the Civil Space Mission,

B. Commercial Application of NASA/Govt. Developed Civil Space Technology, and

C. Commercial Applications of Government Funded Civil Space Technology.

Mr. Dyer served as chair of the panel on Wednesday, and was succeeded by Mr. Clark on Thursday. Mr. Morrison was Rapporteur for subtopic A. Ms. Rydalch was Rapporteur for subtopic B on Wednesday and was succeeded by Dr. Sutey on Thursday. Mr. Clark served as Rapporteur for subtopic C. Mr. Steen acted as Facilitator for the panel. Mr. Root submitted one Issue To Be Considered (ITBC) concerning the effect of procurement policy on the two-way transfer of technology.

Mr. Clark and Dr. Carlson made a joint presentation concerning the collaborative efforts of their organizations regarding technology transfer from the commercial sector to government. Both the Sarnoff Center and NML assemble consortia of high tech firms that, along with a government client, produce a good or service that not only meets a government need but also has a commercial application.

Several common themes were mentioned throughout the discussion. Traditional mechanisms for tech transfer were not considered by the panel to be adequately effective. For example, RFPs were characterized as primitive, often ignored by those firms most capable of providing the desired good or service. This lack of interaction between government and industry was considered to be indicative of the incompatibility of their respective agendas. There was consensus regarding the lack of awareness and communication between government and industry. In the cases where a transfer did occur, difficulty in measuring success was often cited. Also, many panel members felt NASA did not have the capacity to handle any greater level of transfer success due to the relatively low amount of resources devoted to tech transfer activities. In sum, greater cooperation was called for between government and industry in order to better understand each other's needs and priorities. This in turn was thought to lead to greater feedback, both as a measure for success

and as a means for improving the tech transfer process.

At the plenary session held Thursday morning, Mr. Morrison, Dr. Sutey, and Mr. Clark each made presentations summarizing the panel's conclusions and recommendations regarding each subtopic. Those findings are listed below:

Subtopic A: Harvesting Commercially Developed Technologies for the Civil Space Mission

Issues

- Government is not attuned to the workings of commercial industry.
- Many companies do not want to do business with the government.

Conclusions and Recommendations

- Government has a process and political orientation while industry has a product and ROI orientation.
- NASA does not have the resources to cope with success.
- New paradigms are needed for the relationship between government and industry.
- Government needs to be more flexible and responsive to industry.
- Commercial industry should be involved earlier in the development cycle.
- The commercial sector needs to be better educated on how to enter the system.
  (i.e. How do you get firms of the calibre of Sun Systems to read RFPs?)

Subtopic B: Commercial Application of NASA/Govt. Developed Civil Space Technology

Issues

- Industry is not aware of technology interchange opportunities.
- Measurement of success is difficult with complex criteria.

Conclusions and Recommendations

- Application of for-profit motivators to non-profits or labs may not succeed.
- Success cannot be entirely based on flowback.
- NASA should be more pro-active in supporting the national tech transfer network.
- Measurement of success should be built into a program or process.

Subtopic C: Commercial Applications of Government Funded Civil Space Technology

Issues

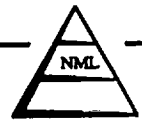
- Lack of awareness of tech transfer opportunities is a continual theme.
- Interaction with government is not "user friendly".

Conclusions and Recommendations

- No transfer occurs without interest from a commercial organization.
- Supported industry consortia are enjoying current success, such as the National Media Lab at 3M and the National Information Display Lab at the David Sarnoff Research Center.
- A commitment of financial support by government is needed for technology transfer.
- Government needs to identify certain industries most likely for tech transfer opportunities.
- Balanced support is needed for large *and* small commercialization efforts.

National Media Laboratory

ROBERT CLARK



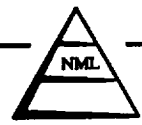
National Media Laboratory

... a Center of Excellence for storage technologies ...

Robert Clark
Deputy Director, NML

What is the National Media Lab?

- *A Jointly-Funded Government / Industry Lab*
- *A "Distributed" Industrial / University Laboratory*
  -a partnership of domestic industrial and university resources.
- *Focused upon government user support.*
- *A focus for technology and knowledge transfer between government, domestic industry and universities.*



*"**Storage technology** is a limiting factor in the application of other information technologies. Development of high-performance computing applications is dependent upon vast storage capacities...*

*....**Archiving and management of data** collected from satellites are already overwhelming existing storage facilities. Multi-media workstations, which are currently being developed, will store and process text, images, and voice and will require significantly larger secondary storage subsystems."*

Report of the National Critical Technologies Panel
March 1991

Motivation for a National *Media* Laboratory

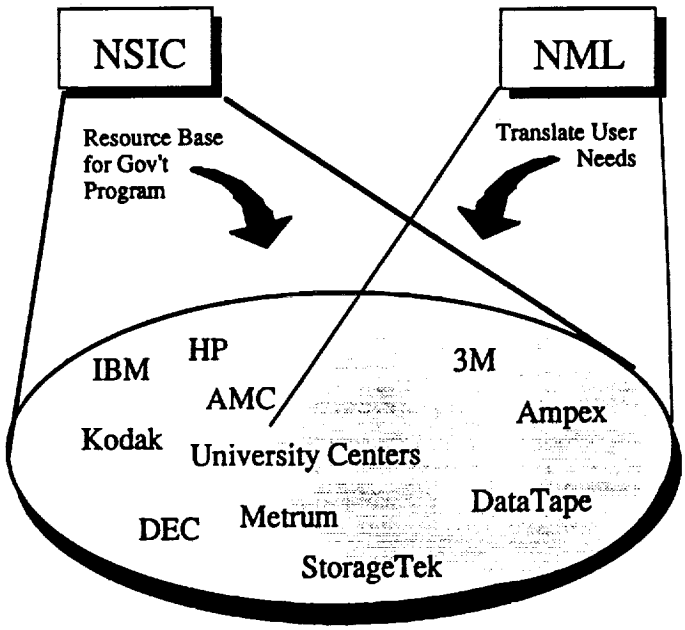
- **Recording systems are *THE* major government image and data exploitation bottleneck.**
- **Government data recording performance and storage requirements lead commercial practice by 3-5 years.**
- **The supporting commercial recorder industry is large but principally focused on video not data formats.**
- **Lack of standards.**
- **Lack of transfer of commercial knowledge base to program offices and operational sites.**

NSIC

MAJOR FOCUS:

Industry Needs

- Global Competition
- Advanced R&D
- Standards

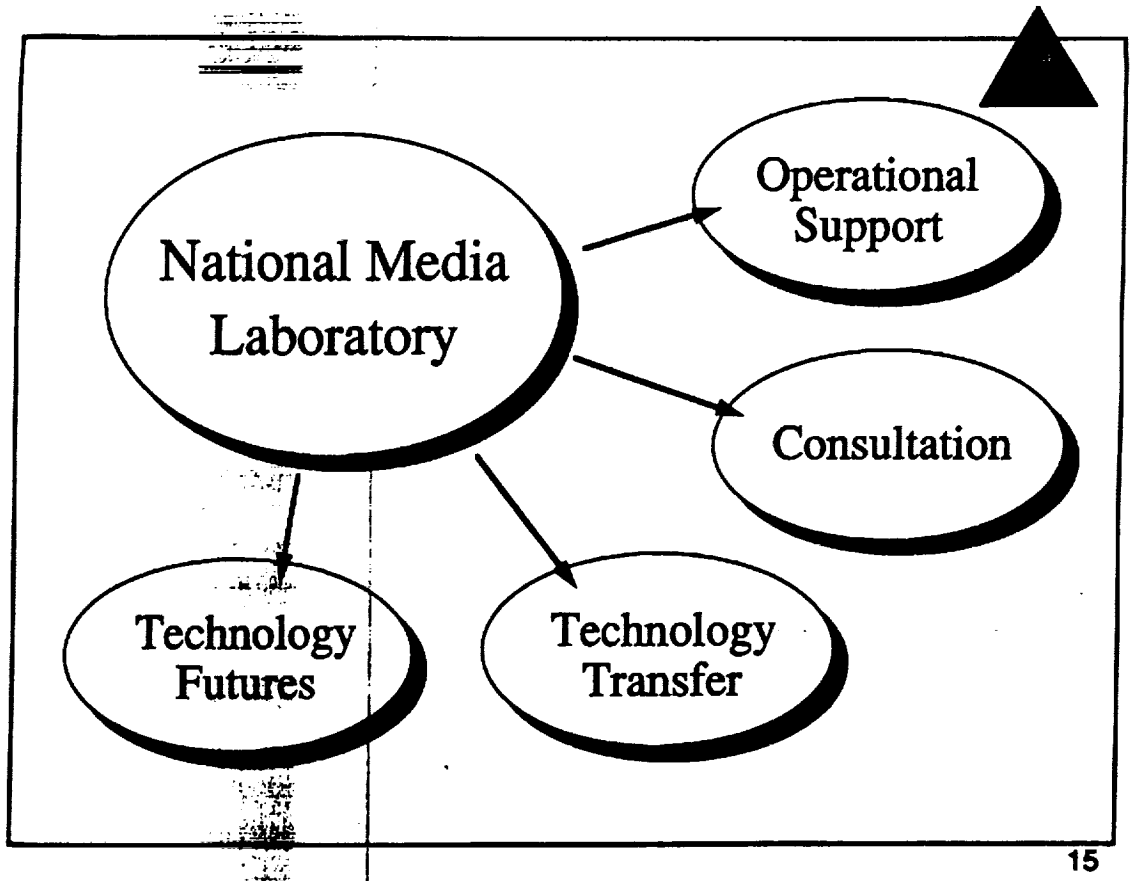


US Storage Community

MAJOR FOCUS:

Government User Needs

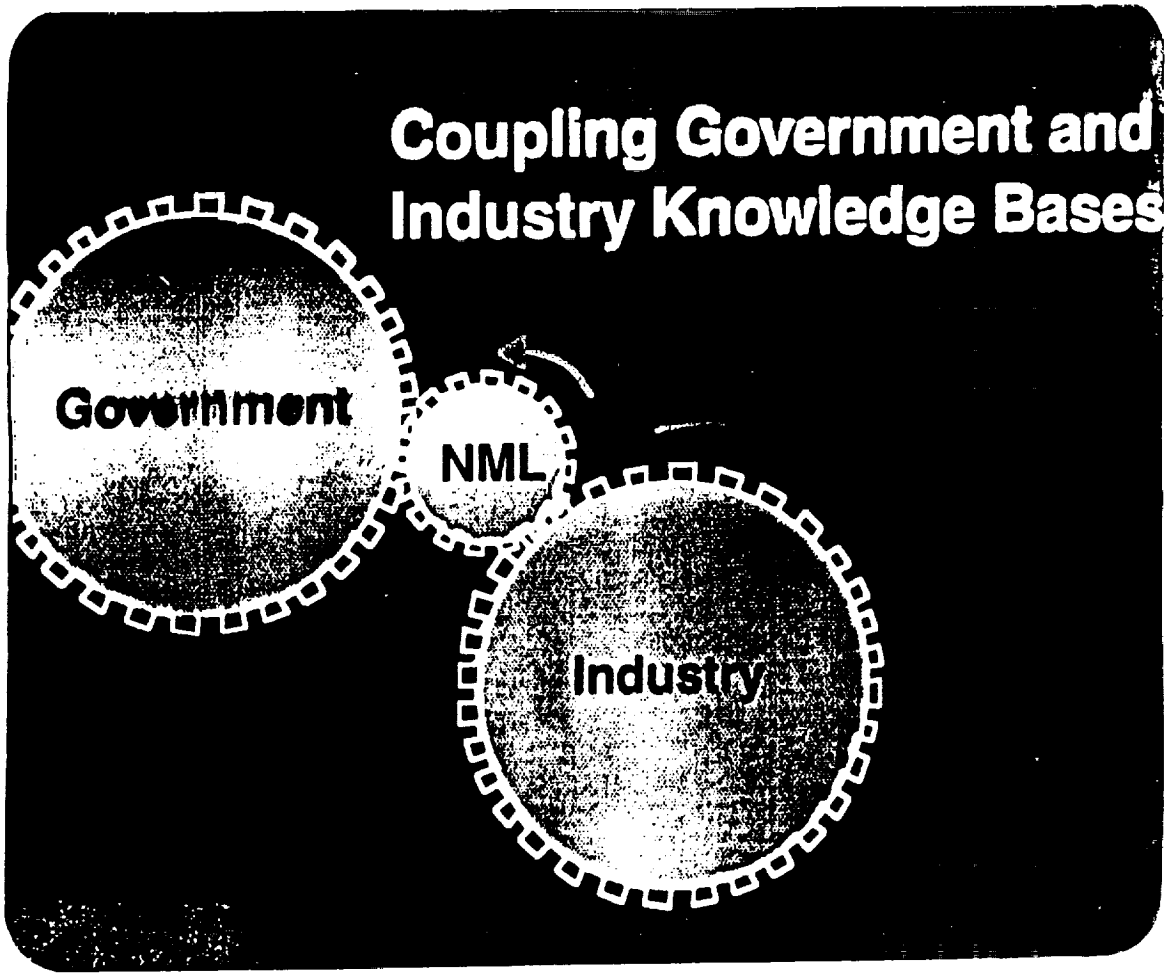
- O&M Support
- COTS
- Standards
- Advanced Products
- Domestic Source



NML

NML Mission

Support current government user data storage needs and assist them in getting the most efficient "commercial" solutions in the future.


Coupling Government and
Industry Knowledge Bases
Government
NML
Industry

IN Special

KAS → Primary

INTRODUCTION

to the

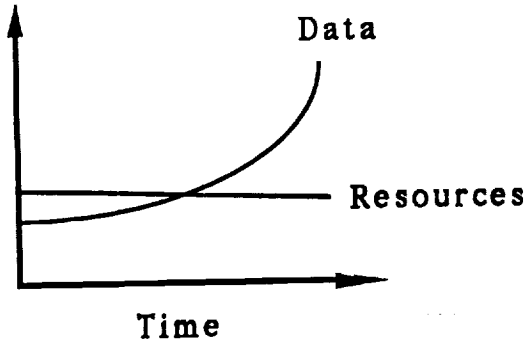
National Information Display Laboratory

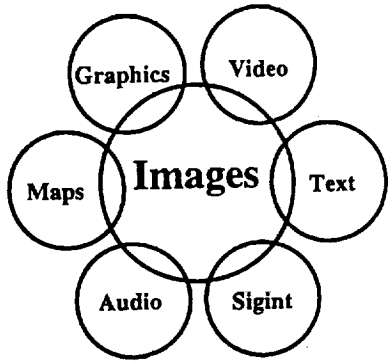
Dr. Curtis R. Carlson
Director, NIDL

E10

Government Information Needs

... rapidly exploiting and disseminating all critical information ...



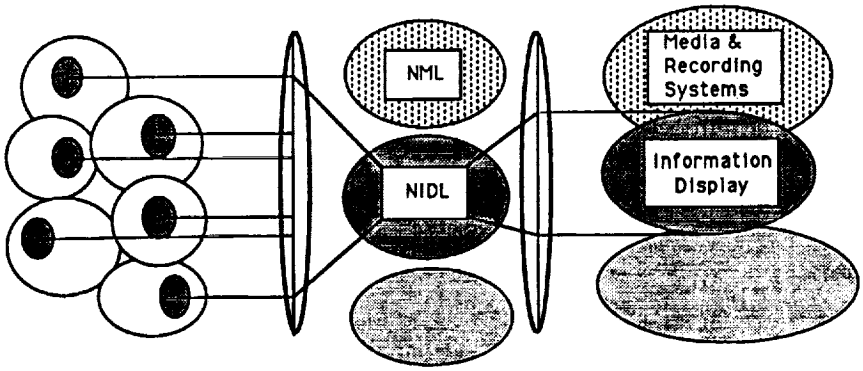


- Rapidly changing roles and responsibilities
- Increasingly diverse users
- Increasing data types

E13

The Center of Excellence Concept

... focusing the resources of Industry onto User's needs ...



Government Users

- Users & Developers of Technology
  - Program Offices
  - R&D Groups
- Core technologies, essential to success of program

Centers of Excellence

- Focus
- Leverage
- Standards
- Continuity
- User Support

Industry

- Commercial Manufacturers
- R&D Centers
- System Developers
- Universities

H3

National Lab Business Strategy

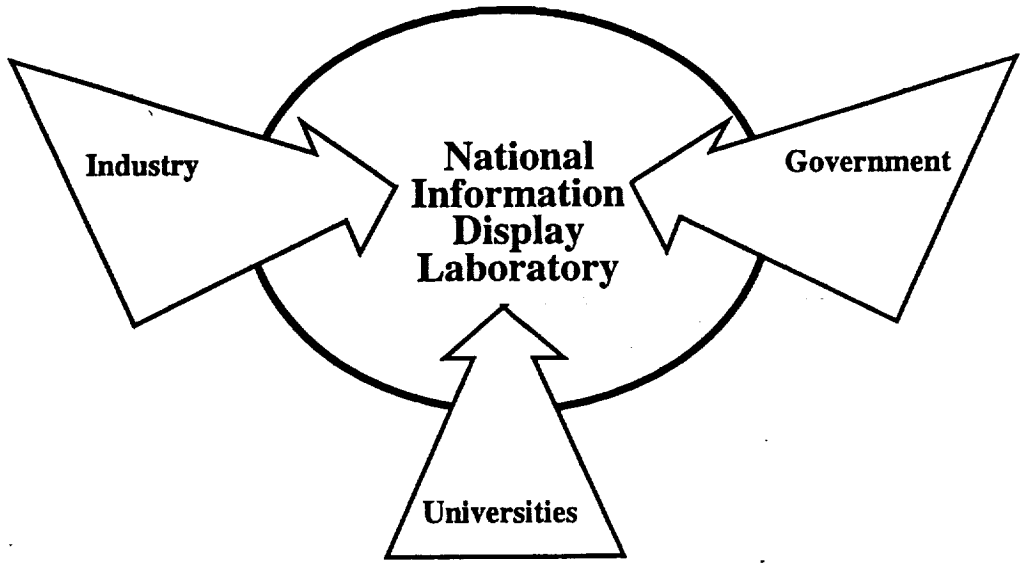
... developing programs with overwhelming value ...

- **Work with users to determine needs**
- **Begin "seed" program**
- **Seek partners with world leading capabilities**
  - **Government, Industry and Universities**
- **Develop programs that provide:**
  - **User satisfaction**
  - **Revolutionary Improvements**
  - **Path to commercialization**

H4

NIDL "Distributed" Laboratory

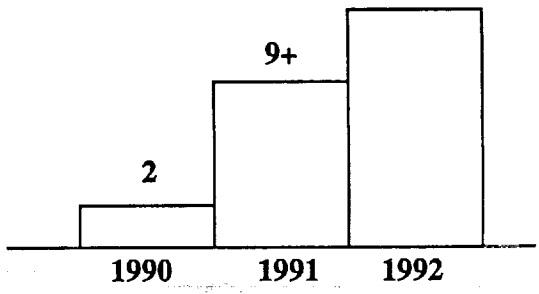
... combining resources of Government, Industry, and Academia ...

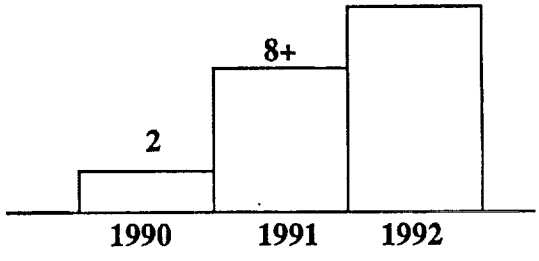


E15

Partners and Users

- Government Partners and Users
  - Air Force
  - Navy OP 94
  - USGS
  - JNIDS
  - OSTP
  - NEL
- Industry & Academia Partners
  - Princeton University
  - MIT
  - Texas Tech
  - Planar
  - RCA/TCE
  - DTI -AVP/MegaScan

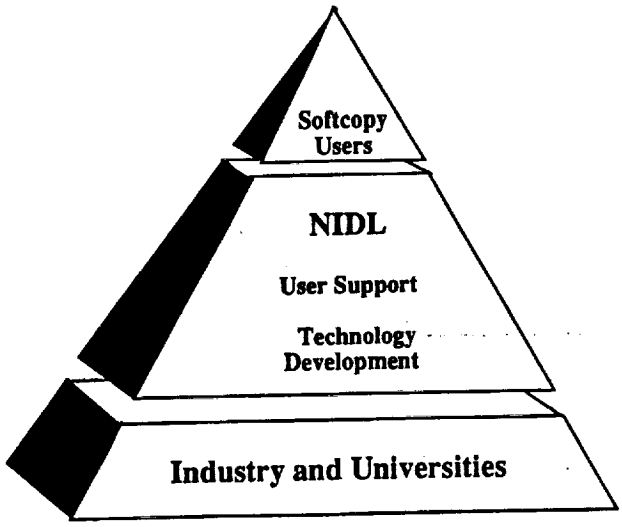




E16

National Information Display Laboratory

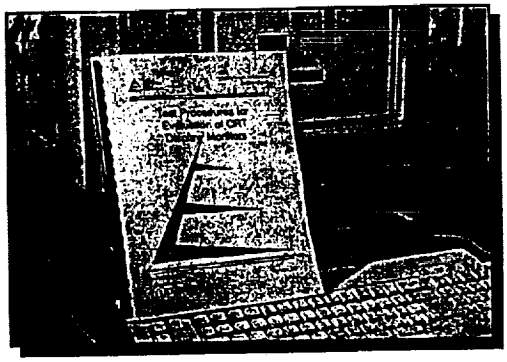
... a Center of Excellence for Softcopy technology ...



E17

Standards

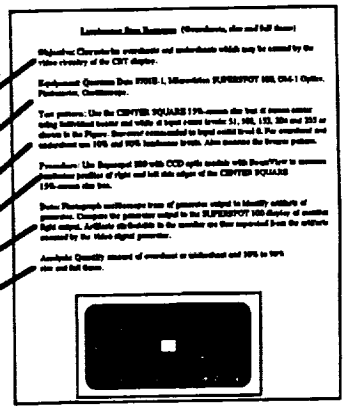
... establishing industry display and imaging standards that represent the government's viewpoint ...



Measurement Procedures

Luminance Step Response

- Objective
- Equipment
- Test pattern
- Procedure
- Data
- Analysis



E39

NIDL Organization

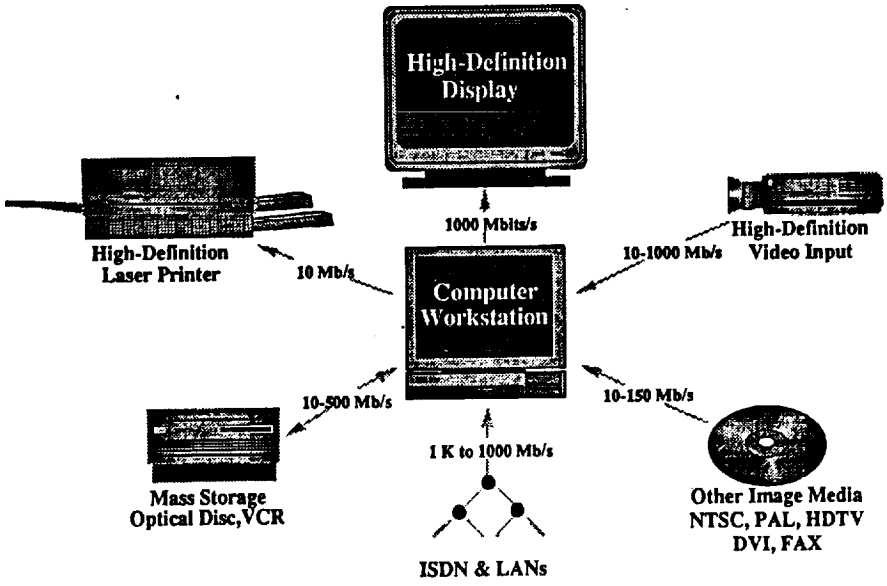
NIDL
Dr. Curtis R. Carlson
Executive Director

Display Technology	Softcopy Tools & Technology	Partners and Associates Program
Dr. Arthur H. Firester, Director	Dr. Norman D. Winarsky, Director	
• Advanced Displays	• Image & Signal Processing	• Government Organizations
• Display Modeling	• Man-Machine Interface	• Commercial Organizations
• User Support	• User Support	• Universities
		• Research Institutions

E18

Office Environment of the Late 1990's

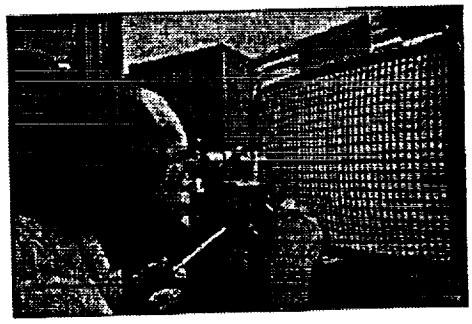
... the office will heavily exploit HDTV technology ...

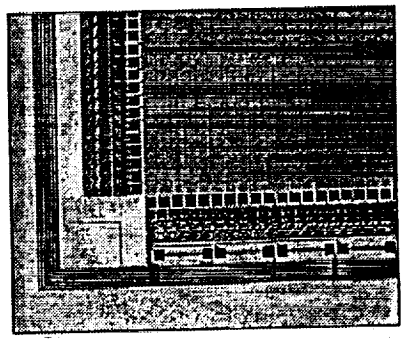


E22

Display Technologies

... large, uniform, high-resolution, bright displays ...

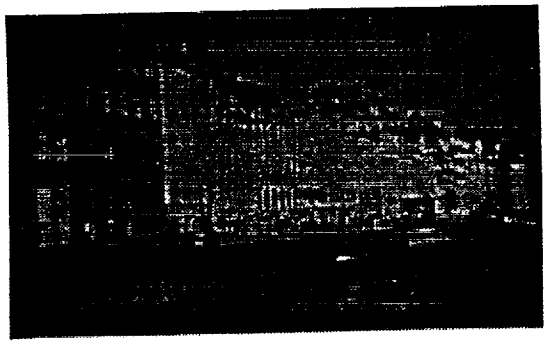




E23

HDTV

... the key is extremely high-performance image compression ...



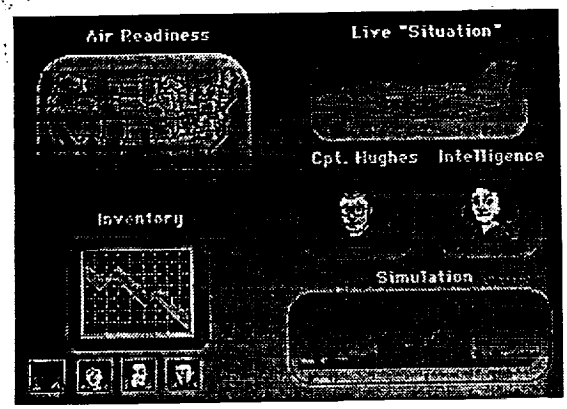
HDTV

NTSC

E24

High-Resolution Video Workstations

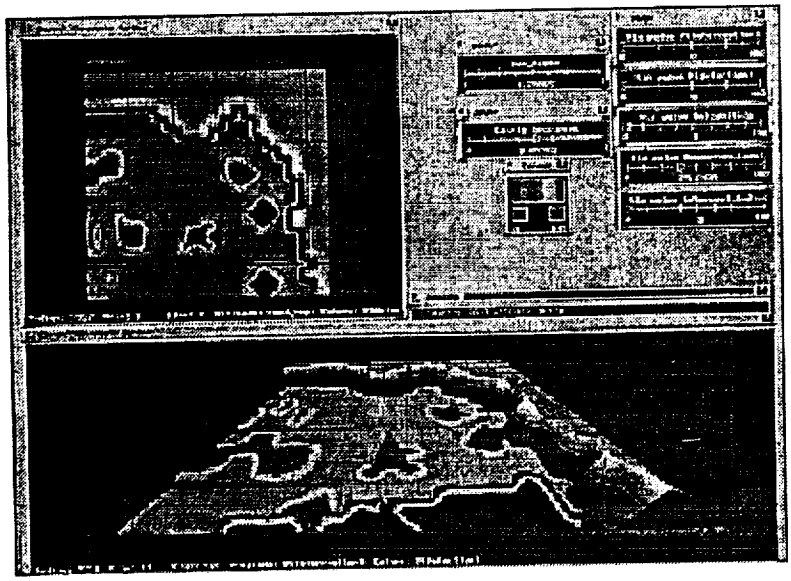
... will have multiple video and graphics windows ...



E25

Data Visualization

... presenting data to users in their visual language ...

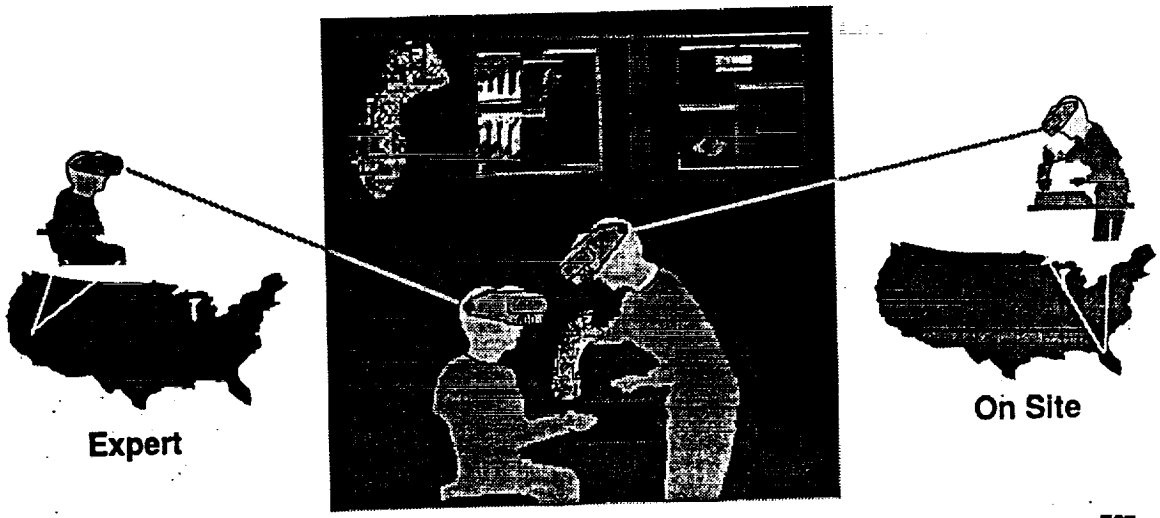


E26

Virtual Reality

... creating real-time, high-resolution, 3D synthetic environments ...

Collaborative Workplace

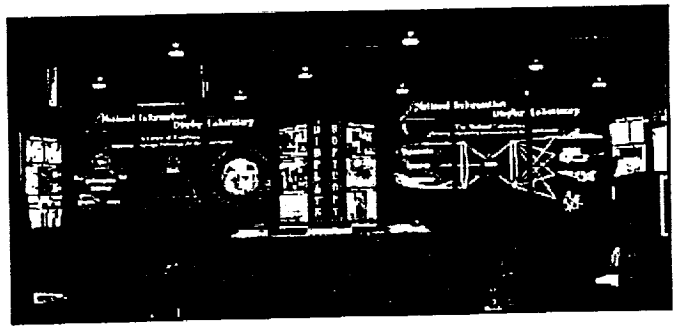


E27

Communications

... reaching out to both the Government and Industry ...

- Government
  - IPWG
  - NASA
  - JNIDS
  - NEL
  - DNI
  - DARPA
  - ORD
  - OSTP
  - FAA
  - IRDC
  - DCA staff
  - Navy Op 94
- Industry
  - Int'l. Display Conference Keynote
  - SID Plenary Presentation
  - SID Standards activities
  - SID Display Booth
  - JTEC
  - Many other individual companies



E42

Conclusions

... a new model for Government/Industry collaboration ...

- **NIDL is a Center of Excellence in Softcopy Technology**
- **Goal: develop bold new way to satisfy the needs of Government Users through both:**
  - **Aggressive User support**
  - **Advanced technology**
- **Focus key softcopy and display technology on the interface to Users, to make them much more productive**
- **NIDL is a "Distributed Laboratory" with world-leading partners**
- **For additional information, call NIDL at 609-951-0150**

E43

WORKING PANEL #4

TECHNOLOGY TRANSFER TO THE BROADER ECONOMY

GORDON DYER & ROBERT CLARK

TRANSFER TO/FROM THE BROADER ECONOMY

SUBTOPIC A: HARVESTING COMMERCIALLY DEVELOPED TECHNOLOGIES FOR THE CIVIL SPACE MISSION:

- NEW PARADIGMS FOR RELATIONSHIPS
- CHALLENGES TO THE "COMPLEX" AND "PRIMITIVE" PROCUREMENT PROCESS

RAPPORTEUR: JIM MORRISON - BDM

TRANSFER TO/FROM THE BROADER ECONOMY

SUBTOPIC B: COMMERCIAL APPLICATION OF NASA/GOVT. (LABS) DEVELOPED CIVIL SPACE TECHNOLOGY

- SIGNIFICANT ISSUE:

  HOW TO MEASURE SUCCESS?

RAPPORTEUR: ANN RYDALCH - IDAHO NATL. RESEARCH LAB.

TRANSFER TO/FROM THE BROADER ECONOMY

SUBTOPIC C: COMMERCIAL APPLICATIONS OF GOVT. FUNDED CIVIL SPACE TECHNOLOGY

SIGNIFICANT ISSUES:

- HOW TO MEASURE SUCCESS?
- CONTRACTOR INVOLVEMENT

RAPPORTEUR: BOB CLARK - NATL. MEDIA LAB.

"HARVESTING" COMMERCIALLY DEVELOPED TECHNOLOGIES

OVERVIEW

A- NARROW VIEW - "HARVESTING" MEANS TECHNOLOGY IS ALREADY DEVELOPED (A PRODUCT)

B- BROADER VIEW - SOME GOVERNMENT DEVELOPMENT IS NEEDED TO MEET NASA APPLICATION

STATEMENT OF THE PROBLEM

A-ON THE GOVERNMENT SIDE:
- NEED AN OPEN DOOR
- NEED TO KNOW WHAT'S OUT THERE
- RFP IS A PRIMITIVE, POOR PROCESS FOR COMMERCIAL

B- ON THE COMMERCIAL SIDE:
- MANY COMPANIES DO NOT WANT GOV'T. BUSINESS
- MANY THAT DO -- NEVER READ RFP'S

"HARVESTING" COMMERCIALLY AVAILABLE TECHNOLOGIES

STATEMENT OF THE PROBLEM (CONT.)

TYPE OF PROBLEM DEPENDS ON TIME-FRAME INVOLVED:

ADVANCED TECHNOLOGY (PRE-PHASE A): THERE ARE PROCESSES TO DO THIS, SUCH AS RFP, JOINT PARTNERSHIPS, ETC.

DURING PHASES A, B, C: GOVERNMENT FOCUS CHANGES TO TECHNOLOGY NEEDED TO DO THE JOB (I.E., : BEST TECHNOLOGY, LOWEST PRICE)

(THE LATER IN THE CYCLE THE COMMERCIAL SECTOR IS INVOLVED, THE LESS THE CHANCE OF A SUCCESSFUL TRANSFER.)

"HARVESTING" COMMERCIALLY AVAILABLE TECHNOLOGY

LESSONS LEARNED

- NEED TO SPACE QUALIFY COMMERCIAL PRODUCTS (MAY BE A ROLE FOR GOVERNMENT ASSISTANCE HERE)
- GOVERNMENT DEVELOPMENT CYCLE AND COMMERCIAL DEVELOPMENT CYCLE ARE WAY OUT OF SYNC.
- GOVERNMENT NOT AWARE OF COMMERCIAL STANDARDS.
- GOVERNMENT SPEC.S ARE NOT "REAL WORLD".
- GOVERNMENT HAS A PROCESS AND POLITICAL ORIENTATION; PRIVATE SECTOR HAS A PRODUCT AND ROI ORIENTATION.
- NASA DOES NOT HAVE THE RESOURCES IN TECHNOLOGY TRANSFER TO BE ABLE TO COPE WITH SUCCESS. PEOPLE ARE BEING TURNED OFF NOW BECAUSE OF NON-RESPONSIVE, NON-USER FRIENDLY SYSTEMS.

"HARVESTING" COMMERCIALLY DEVELOPED TECHNOLOGY

CURRENT PROGRAMS

- A GOVERNMENT PROCUREMENT SYSTEM IS IN PLACE (IT HAS PROBLEMS, BUT...)
- THE SYSTEM NEEDS TO BE MADE AS FLEXIBLE AS POSSIBLE
- THE COMMERCIAL SECTOR NEEDS TO BE EDUCATED ON HOW TO ENTER THE SYSTEM

SPECIFIC EXAMPLE:

- WORKSHOPS INVOLVING NASA CENTERS AND INDUSTRY TRADE ASSOCIATIONS HAVE BEEN FOUND TO BE VERY FRUITFUL

"HARVESTING" COMMERCIALLY DEVELOPED TECHNOLOGY

NEW/INNOVATIVE APPROACHES

- NATIONAL INFORMATION DISPLAY LABORATORY (NITL)
  (C/O DAVID SARNOFF RESEARCH CENTER - PRINCETON)
  AND
- NATIONAL (RECORDING) MEDIA LABORATORY (NML)
  (C/O 3M, ST. PAUL, MN)

- THE SRI/DARPA "INNOVATION SEARCH" PROCESS

- THE SDI/MMC OPTICS INDUSTRY INITIATIVE

"HARVESTING" COMMERCIALLY DEVELOPED TECHNOLOGIES

WHO SHOULD ACT?

- KEEP THE PRESSURE ON EVERYONE.
  - MANAGEMENT NEEDS TO ACT AS IF THIS IS IMPORTANT
  - THE RESOURCES NEED TO BE APPLIED TO MAKE IT IMPORTANT
  - THE SYSTEM NEEDS TO BE MADE RESPONSIVE

- THE PROCUREMENT SYSTEM: CAN IT BE MADE TO BE HALF-WAY BETWEEN CIA/DARPA/SDIO AND THE REST OF THE GOVERNMENT?

QUESTION: HOW CAN YOU GET THE "SUN SYSTEMS" OF THIS WORLD, WHICH DON'T READ RFP'S, INVOLVED?

REPORT FROM WORKING PANEL 4

TRANSFER WITH THE BROADER ECONOMY

SUB-TOPIC: TRANSFER FROM NASA TO THE BROADER ECONOMY

PROBLEMS:

- NASA should be pro-active in supporting NTTC and the nationwide technology transfer network.
- Measurement of success is necessary and needs to be built into a program or process.
- Industry is not aware for the most part that technology or Federal labs is accessible for a technology interchange.
- Make sure resources at Federal labs are such to handle industry inquiries.
- Civil space needs to be more visible and network more.
- General perception that NASA is singly focused on space.
- When developing technology on a broad base, get industry involved up front.

REPORT FROM WORKING PANEL 4

TRANSFER WITH THE BROADER ECONOMY

SUBTOPIC: TRANSFER FROM NASA TO THE BROADER ECONOMY

Suggestions/ Lessons Learned:

* NASA has a good program already in place for doing technology transfer, including RTTCs, although NASA divisions and organizations could interact better among themselves.

* Because of changes in federal laws, licensing and other tech transfer mechanisms are making it better.

* NASA civil space and others should continue promoting the idea of tech transfer, explaining what it is, and communicating to industry that industry can participate.

* Technology transfer includes technical assistance problem solving, exchange of knowledge, and use of facilities, etc.

* Caution was expressed in putting the same for-profit motivators to non-profits or labs on tech transfer.

* NASA needs to develop a more pro-active program and let the public know that many technologies being used originated within NASA.

* Success cannot be measured totally based on licensing or flowback.

TRANSFER TO/FROM THE BROADER ECONOMY

COMMERCIAL APPLICATIONS OF GOVT. FUNDED CIVIL SPACE TECHNOLOGY

INSIGHT: WITH NO COMMERCIAL INTEREST, THERE CAN BE NO TRANSFER

ISSUES: AWARENESS

USER-FRIENDLY INTERACTIONS

MOTIVATION OF CONTRACTOR SUPPORT

SUPPORT TO SMALL VS. LARGE COMMERCIALIZATION EFFORTS

CURRENT SUCCESSES:

SUPPORTED INDUSTRY CONSORTIA SUCH AS NML, NIDL, the optics industry

ACTION: GOVT. DEFINITION OF WHICH INDUSTRIES

COMMITMENT TO FINANCIALLY SUPPORT TECH TRANSFER

Working Panel #1: Strategic Directions and Mechanisms in Tech Transfer

Michael Weingarten
NASA - Office of Aeronautics and Space Technology

The following participants of the workshop were members of this panel:

Individual	Organization
Mr. Joel Greenberg	Princeton Synergetics, Inc.
Ms. Laura R. Gilliom	Sandia National Labs
Mr. Neil Helm	George Washington Univ.
Roger A. Lewis	Department of Energy
Dr. Robert Mackin	Jet Propulsion Laboratory
Mr. George Millburn	Aerospace Industries Assoc.
Mr. Jon Paugh	Department of Commerce
Dr. Syed Shariq	AmTech
Mr. Marty Sokoloski	NASA Headquarters
Mr. Randolph Steer	OMB
Mr. J. Ronald Thornton	University of Florida
Mr. Michael Weingarten	NASA Headquarters

The panel focused on the following topics related to strategic directions for tech transfer:

A. Measuring Success

B. Management of Technology

C. Innovation and Experimentation in the Tech Transfer Process

D. Integration of Tech Transfer into R&D Planning

E. Institutionalization of Tech Transfer

F. Policy/Legislative Resources

Dr. Mackin served as chair of the panel. Dr. Shariq was Rapporteur for the session. Mr. Weingarten, meanwhile, served as the facilitator of the panel.

The panel focused directly on developing recommendations in each of the topic areas. The recommendations follow:

Measuring Success

The panel agreed that it was crucial to develop both effectiveness measures and activity measures for tracking the success of technology transfer. In particular, government should look

for those indicators which measure the impact on the national economy and jobs. Short term measures could include gauging activity at the government labs. Mid-term measures could include gauging the number of follow-up licenses at companies. Long-term indicators, meanwhile, should focus on quantitative economic and other national level measures. The group agreed that success measures must be built into each technology transfer plan from the start of of a program.

Management of Technology

Mr. Thornton gave a short presentation which served as the basis of the group's recommendations in this area. Panelists agreed that effective management of technology required a balanced strategy in which tech transfer was only one element. Tech transfer depends on effective communication between the firm's strategic planning, marketing, finance, R&D, and tech transfer service providers. Panelists recommended that NASA explore the commercial possibilities inherent in their research at an early stage.

Innovation and Experimentation in Tech Transfer

Panelists agreed that all government agencies should have a conscious program to promote innovation and risk taking in the tech transfer process. One potential idea was for the government to fund small pilot experiments in tech transfer, such as an ongoing program for sabbaticals to industry for government workers.

Integration of Tech Transfer into Planning

Members expressed their belief that tech transfer had to be integrated within the organization's strategic planning, training, R&D, and marketing efforts at the earliest possible date. This belief applies to tech transfer both within the organization and outside. User roles and tech transfer mechanisms should also be defined for each stage of R&D.

Institutionalization

Institutionalization of tech transfer is crucial to achieving success. Human factors, cultural change, and increased efficiency are all key ingredients in this area. In the human factors arena, the panel recommended three courses of action: 1) Personnel mobility should be simplified and improved. 2) Personnel involved in the tech transfer process should be rewarded. 3) Individuals participating in personnel exchange programs with industry should be rewarded.

Culture change, meanwhile, required several other changes in government's mode of operation: 1) Tech transfer should be stressed as one of the key criteria in performance evaluation for senior managers. 2) Tech transfer should be defined as an explicit goal of each organization and program. 3) Entrepreneurial values should be promoted and collaboration with industry encouraged. 4) A client/customer service orientation should be promoted.

Finally, in the area of increased efficiency, the panel recommended that government encourage risk taking and innovation, and move to expedite the patenting process for new technologies

Policy/Legislative/Resources

There were several key recommendations concerning this topic. First, members suggested that government adopt commercial practices in its procurement process. Government has to discover methods of speeding up the process for selecting contractors. Second, NASA should consider making tech transfer an explicit mission of the agency and establishing that a percentage of lab work hours be allocated to tech transfer. Third, the appropriate parties should encourage the White House to release a directive with guidelines for funding technology transfer delivery activities. Fourth, NASA should explore multi-year funding possibilities for tech transfer projects. Fifth, NASA should experiment with the various authorities provided under the Federal Technology Transfer Act. Sixth, an OMB tiger team should be established to evaluate policies that would enable the speeding up of tech transfer agreements. Seventh, a Presidential Award should be created to reward private sector individuals who participate in tech transfer for government projects.

WORKING PANEL #5

STRATEGIC DIRECTIONS and MECHANISMS in TECH TRANSFER

Dr. ROBERT MACKIN

MEASURING SUCCESS

"Effectiveness Measures" vs. "Activity Measures"

1. Impact on National Economy
2. Reducing Cost of Government Operations
3. Jobs and Quality of Life
   - Wealth, $'s
4. Short Term
   - Measures of activity at labs

   Mid Term
   - Quantitative and qualitative measures, i.e. follow-up licenses at companies

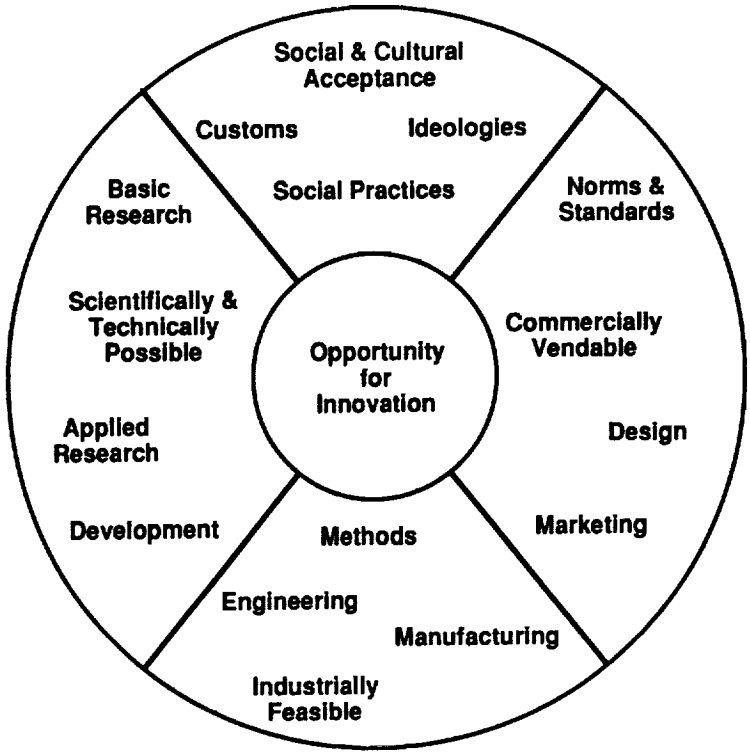
   Long Term
   - Quantitative economic and other national level measures

Recommendation

Effective Measures must be Determined and Publicized

Note: Success measures must be built into each Technology Transfer Plan/Program from the start.

EFFECTIVE MANAGEMENT OF TECHNOLOGY REQUIRES A COMPREHENSIVE, BALANCED STRATEGY



INNOVATION AND EXPERIMENTATION IN THE TECHNOLOGY TRANSFER PROCESS

- Each agency should have a conscious program to promote innovation and risk-taking in the Technology Transfer process.
- Method of funding small pilot experiments in technology transfer: Build in evaluation methods
  - Example: Sabbaticals to industry
- DOE has asked OMB to create "idea notebooks" for automotive industry as a follow-on to the GM "garage-show."

INTEGRATION OF TECHNOLOGY TRANSFER IN R&D PLANNING

1. A comprehensive list of action items should be included in the planning at the earliest possible opportunity.
   - Strategic Planning
   - Management
   - Technology Transfer
   - Education
   - Training
   - Human Resources
   - R&D
   - Commercialization
   - Marketing
   - Manufacturing
   - Capital Services

2. This applies to both internal and external technology transfer.

3. Involve users, both internal and external.
   - Define user roles and technology transfer mechanisms for each stage of R&D.

INSTITUTIONALIZATION

1. Human Factors
   - Personal mobility be improved/simplified.
   - Industrial sabbatical be supported.
   - Personnel involved in technology transfer process be rewarded. Create special rewards.
   - Reward people for participating in personnel/exchange programs with industry.

2. Culture change
   - Include technology transfer in the top senior management performance evaluation.
   - Technology transfer must be an explicit goal of each center/lab/ program/institution.
   - Promote entrepreneurial values.
     - Active interaction with industry
     - Encourage collaborative R&D with industry
     - Simplify "red-tape"
   - Promote client/customer service orientation.

INSTITUTIONALIZATION (cont.)

3. Efficiency
   - Examine technology transfer mechanisms for efficiency
   - Implement cost-effective processes
   - Encourage risk-taking, innovation
   - Explore new technology transfer processes to gain efficiencies
   - Training to improve skills of technology transfer professionals
   - Expedite patenting process

POLICY/LEGISLATIVE/RESOURCES

1. Intellectual Property
   - Expedite patent filing process in U.S. and foreign countries

2. Government should adopt commercial practices in its procurement process

3. Put sunset clause in each technology "classification"

4. Discuss making technology transfer a mission of NASA
   - Establish that a percentage of lab work hours be allocated to technology transfer

5. Provide increased funding to cover higher patent filing fees

6. Create a statement within Presidential technology transfer policy on guidelines for funding technology transfer delivery activities

POLICY/LEGISLATIVE/RESOURCES (cont.)

7. Explore multiyear funding possibilities for the technology transfer/commercialization projects

8. NASA should pursue experimentation under FTTA

9. OMB tiger team be established to fast track responses to precedent setting policy/legal issues (to enable speeding up signing of technology agreements):
   - Intellectual policy
   - Product liability
   - Conflict of interest
   - etc.

10. Create Presidential Award (to be given by agencies) for Private Sector technology transfer participants* in the government projects/programs

*Rank and file

OMIT

P. Peterson
Remarks - Thursday, March 19, 1992
Technology Transfer and the Civil Space Program Workshop

I'd thank you for participating in this workshop on technology transfer and the civil space program.

I trust that you're found the last couple of days to be both constructive and thought-provoking. Most of all, I hope you'll see this meeting as a starting point for future efforts by all of us to improve the success with which technology developed for civil space applications is transferred.

I know that on Tuesday, Greg Reck, the OAST Director for Space Technology described for you the scope of OAST's space research and technology efforts. I want to reaffirm the commitment he stated regarding our intention to improve the process of civil space technology transfer.

As you've heard, in response to the recommendations of the Augustine Committee, last year OAST developed an Integrated Technology Plan for the civil space program. Working closely with the prospective users of space technology was a hall-mark of the "ITP" effort. Moreover, after a major, external review of the initial ITP, Dr. Joseph Shea of MIT - Chair of the SSTAC - urged that OAST put added emphasis on Technology Transfer improvement. This meeting is an important part of our response to that recommendation.

However, success in Technology Transfer cannot be achieved by any one organization. As you've discussed at this meeting, technology must be transferred within NASA, within the government, with the aerospace industry (and universities) and the general economy. All of these levels are of vital importance if we are to insure that the U.S. investment in space technology yields the greatest possible benefit to the U.S. public.

Although we in OAST feel a special responsibility to provide leadership in the area of civil space technology, transferring that technology must involve offices across all of NASA - including both the NASA program offices and especially the Office of Commercial Programs.

In addition, coordinated efforts across the government are vital. You've discussed some of the government's efforts-so-far at this meeting. Even more so, U.S. industry must help lead future technology transfer efforts. Both aerospace and non-aerospace companies should focus senior management attention on technology transfer.

Thank you again for your participation. I'm looking forward to seeing the results of this workshop that you'll be discussing this morning.

Office of
Aeronautics,
Exploration and
Technology

Workshop Conclusions

Technology Transfer and the Civil Space Program

John C. Mankins
OAST Space Technology Directorate
Program Integration Office

March 19, 1992

NASA
National Aeronautics and
Space Administration

WORKSHOP OBJECTIVES

- WORKSHOP OBJECTIVESINCLUDED:
  - REVIEW THE INTEGRATED TECHNOLOGY PLAN (ITP) AND CIVIL SPACE RESEARCH AND TECHNOLOGY PLANNING, AS WELL AS CURRENT CIVIL SPACE TECHNOLOGY TRANSFER ACTIVITIES
  - DEVELOP A COMMON FRAMEWORK FOR ANALYSIS AND DISCUSSION OF THE PROBLEM
  - IDENTIFY GENERAL ISSUES, SPECIFIC TECHNOLOGY TRANSFER BARRIERS AND OPPORTUNITIES FOR IMPROVEMENT
  - IDENTIFY CURRENT & POTENTIAL ROLES IN TECHNOLOGY TRANSFER
  - ASSESS EXPERIENCES AND OPTIONS ACROSS A BROAD RANGE OF PARTICIPANTS, AND IDENTIFY ALTERNATIVES FOR ACTION

WORKSHOP PARTICIPANTS

- **NASA**
  - OAST, OAST/Space Technology Directorate, OAST/HPCC, OAST/NASP
  - Office Of Commercial Programs
  - NASA Field Centers: LeRC, LaRC, JPL, GSFC, JSC, MSFC, SSC, KSC
- **GOVERNMENT**
  - Department of Commerce (Tech., Space)
  - Department of Transportation (Space)
  - Department of Energy (Tech., Space)
  - Department of Defense (SDIO, USAF, ONT, DDR&E)
  - DOE Labs (SNLA, LANL, ORNL, INEL)
  - DOC Organizations (NIST, NOAA)
  - Office of Management and Budget
  - Congressional Budget Office
- **EXTERNAL**
  - Boeing
  - Rockwell
  - Lockheed
  - McDonnell Douglas
  - General Dynamics
  - GE & GE Aerospace
  - Allied Signal, Inc.
  - David Sarnoff Research Center
  - 3M/National Media Laboratory
  - Grumman
  - TRW
  - Futron
  - Hughes
  - Aerospace Industries Association
  - University of Texas, Austin
  - George Washington University
  - University of Florida (RTTC)
  - National Technology Transfer Center
  - Johns Hopkins University (APL)
  - Harvard/Smithsonian Center for Astrophysics
  - Electric Power Research Institute
  - Chemical Waste Management, Inc.
  - PSI
  - BDM
  - Martin Marietta

WORKSHOP RESULTS SUMMARY

- *THE WORKSHOP WAS A "SUCCESS"*
  - EACH OF THE WORKING GROUPS PROVIDED SIGNFICANT NEW INSIGHTS
  - A CONSENSUS WAS REACHEDON SUMMARY FINDINGS AND RECOMMENDATIONS FOR A "PLAN OF ACTION"
- SOME OF THE RESULTS OF THE WORKSHOP ARE SUMMARIZED IN A MATRIX. IT PROVIDES CURRENT OR POTENTIAL MECHANISMS DISCUSSED AT THE WORKSHOP MAPPED INTO:
  (1) TECHNOLOGY TRANSFER SECTORS (E.G., NASA TO NASA, GOVERNMENT TO GOVERNMENT, ETC.), AND
  (2) AREAS OF TECHNOLOGY TRANSFER STRATEGIES (E.G., INFORMATION & COMMUNICATIONS, INSTITUTIONAL, ETC.)
- IN ADDITION, STRUCTURAL (OR PROCEDURAL) FACTORS ARE LISTED WHICH CUT ACROSS MULTIPLE SCTORS AND STRATEGY AREAS

STRATEGIES AND MECHANISMS
SUMMARY MATRIX

	COMMUNICATIONS	INSTITUTIONAL	COORDINATED R&T	DIRECTED INVESTMENT
TRANSFER WITHIN NASA	STRATEGIC PLAN'G (ITP) SYSTEMS ANALYSES	GUEST RESEARCHERS GUEST 'PROFESSORS'	DEMONSTRATIONS FLIGHT EXPERIMENTS TECH*TRANSFER PILOT EXPERIMENTS	GUEST INVESTIGATORS
TRANSFER WITHIN THE GOVERNMENT	SPACE TECHNOLOGY INTERDEPENDENCY GRP PLANNING COORD. DATABASES	TRANSFER-FOCUSED INSTITUTIONS	FACILITY UPGRADES DEMONSTRATIONS FLIGHT EXPERIMENTS	SPACE TECHNOLOGY INTERDEPENDENCY GRP JOINT R&T (WITH NASA)
TRANSFER WITH THE AEROSPACE INDUSTRY	PUBLICATIONS IR&D REVIEWS SYSTEMS STUDIES	CLEAR TECH*TRANSFER CHARTER SBIR PROGRAM R&T FACILITIES POLICY TECH*TRANSFER TRAIN'G	DEMONSTRATIONS FINANCIAL INCENTIVES CONTRACT R&D TECH*TRANSFER FUNDS	PERSONNEL EXCHANGE
TRANSFER WITH THE GENERAL ECONOMY	INFO. ON COMMERCIAL TECHNOLOGIES WORKSHOPS RFPs INQUIRY SUPPORT	TRANSFER-FOCUSED INSTITUTIONAL EXAMPLES: NIDL, NML, AMTECH SDIO/IMC OPTICS LAB NTTC, RTTC'S	SPACE QUALIFICATION OF COMMERCIAL TECH. CRADA'S TECH*TRANSFER FUNDS	DIRECT TECHNICAL ASSISTANCE
STRUCTURAL FACTORS	REWARDS PERSONNEL ISSUES/POLICY INTELLECTUAL PROPERTY RIGHTS	TECH*TRANSFER MEASUREMENT PROCUREMENT PRACTICES STANDARDS		

SUMMARY FINDINGS

PRINCIPAL FINDINGS

- **TECHNOLOGY TRANSFER, INCLUDING THAT SUPPORTING U.S. COMMERCIAL COMPETITIVENESS, NEEDS TO BE A MISSION OF NASA AND CIVIL SPACE PARTICIPANTS FROM ALL SECTORS**
  - **— THIS IMPLIES A NEED FOR BOTH NEAR-TERM ACTIONS AND A LONG-TERM COMMITTMENT TO TECHNOLOGY TRANSFER EFFORTS**

- **A COMMITTMENT MUST BE MADE TO PLAN TECHNOLOGY TRANSFER INTO SPACE R&T EFFORTS — INCLUDING:**
  - **— POTENTIAL RESOURCES**
  - **— MEASUREMENT SYSTEMS**
  - **— SENIOR MANAGEMENT FOCUS**
  - **— CUSTOMER INVOLVEMENT**
  - **— PERSONNEL TRAINING**

SUMMARY FINDINGS
(CONTINUED)

ADDITIONAL FINDINGS

- TECHNOLOGY TRANSFER REQUIRES MEANINGFUL CUSTOMER INVOLVEMENT EARLY AND THROUGHOUT THE TECHNOLOGY DEVELOPMENT PROCESS
  - INCLUDING ALL TYPES OF 'CUSTOMER" (E.G., INDUSTRY)

- THERE IS A REQIREMENT TO PROVIDE REAL INCENTIVES/REWARDS TO MOTIVATE TECHNOLOGY TRANSFER (AT ALL LEVELS OF THE ORGANIZATION, AND WITHIN ALL SECTORS)

- THERE IS A NEED TO FOCUS MANAGEMENT ATTENTION AT ALL LEVELS ON REMOVING TECHNOLOGY TRANSFER IMPEDIMENTS, INCLUDING PERSONNEL, ORGANIZATIONAL, LEGAL FACTORS, AND PROCUREMENT PRACTICES
  - ORGANIZATIONS MUST AGRESSIVELY PURSUE IMPROVED COMMUNICATIONS RELATED TO TECHNOLOGY TRANSFER (BETWEEN ALL SECTORS)

- THERE IS A NEED FOR CLEAR POLICIES (AND MECHANISMS, AS APPROPRIATE) TO IMPLEMENT 'BRIDGING' EFFORTS — INCLUDING DEMONSTRATIONS, FLIGHT EXPERIMENTS, AND REQUIRED FACILITIES DEVELOPMENTS

WORKSHOP SUMMARY: OPTIONS FOR ACTION

- ALL PARTICIPANTS TO REVIEW WORKSHOP RESULTS WITH APPROPRIATE MANAGEMENT WITHIN PARTICIPANT'S ORGANIZATIONS

- CONSIDER OPPORTUNITIES FOR A FUTURE FORUM AND/OR MEETING ON TECHNOLOGY TRANSFER OF THE SAME (ADDITIONAL) ORGANIZATIONS

- CONSIDER CREATION OF TECHNOLOGY TRANSFER TEAMS WITHIN PARTICIPATING ORGANIZATIONS (E.G., TECHNOLOGY TRANSFER "PROCESS IMPROVEMENT TEAMS" APPROACH)
  - COULD INCLUDE AN INTERAGENCY "TIGER-TEAM" ON THE SUBJECT

- CREATE A WORKING "NETWORK" SPANNING THE SECTORS INVOLVED IN TECHNOLOGY TRANSFER TO FACILITATE CONTINUING COORDINATION

- REVIEW WORKSHOP RESULTS WITH THE NASA/OAST SPACE SYSTEMS TECHNOLOGY ADVISORY COMMITTEE (SSTAC) AND OTHER ADVISORY GROUPS (INCLUDING NAC, NRC, OTHERS)

- SEEK FORMAL, EXTERNAL REVIEW OF WORKSHOP RESULTS WORKSHOP (INCLUDING GROUPS SPECIALIZING IN POLICY EXPERTISE)

WORKSHOP SUMMARY: REPORT PLAN

- DRAFT WORKSHOP REPORT IS DUE TO THE PARTICIPANTS IN 45 DAYS OR LESS (STARTING ON MARCH 19, 1992)

- PARTICIPANTS WILL REVIEW AND RETURN COMMENTS WITHIN APPROXIMATELY THREE WEEKS FROM THE TIME THEY RECEIVE THE FIRST DRAFT

- GOAL: WORKSHOP REPORT WILL BE PUBLISHED WITHIN 120 DAYS

NASA Space Research & Technology Overview (ITP)

Presentation to:

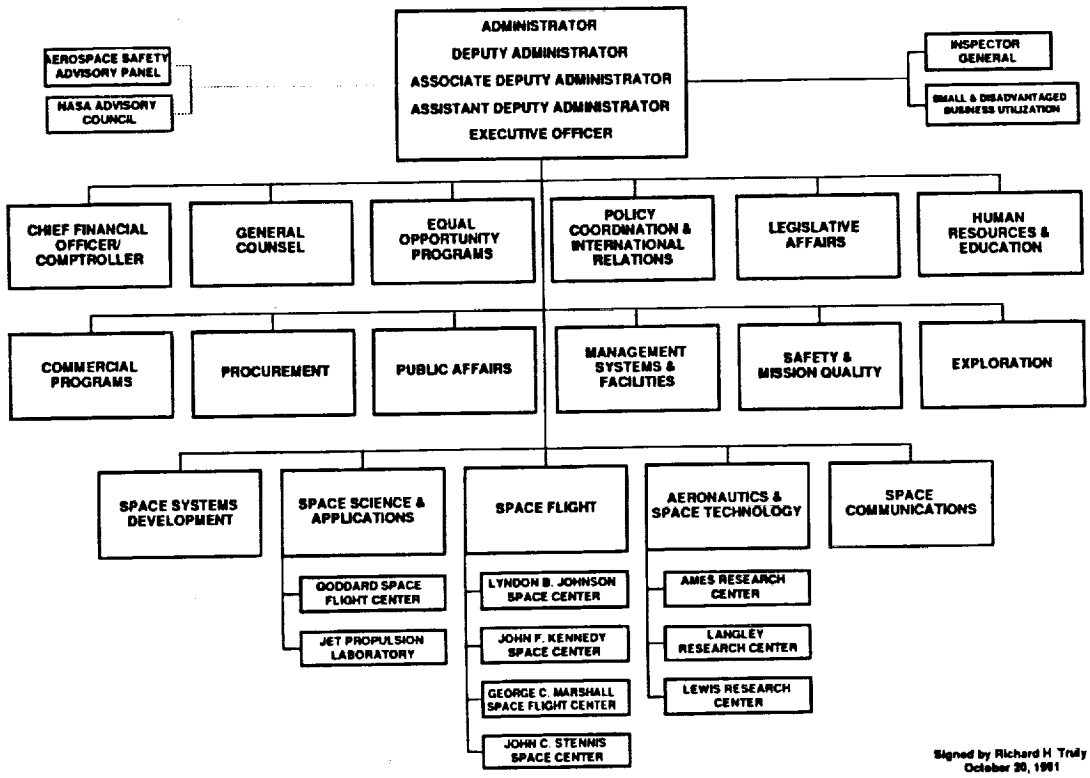
Civil Space Technology Development Technology Transfer Workshop

Gregory M. Reck
Director for Space Technology
Office of Aeronautics and Space Technology

March 17, 1992

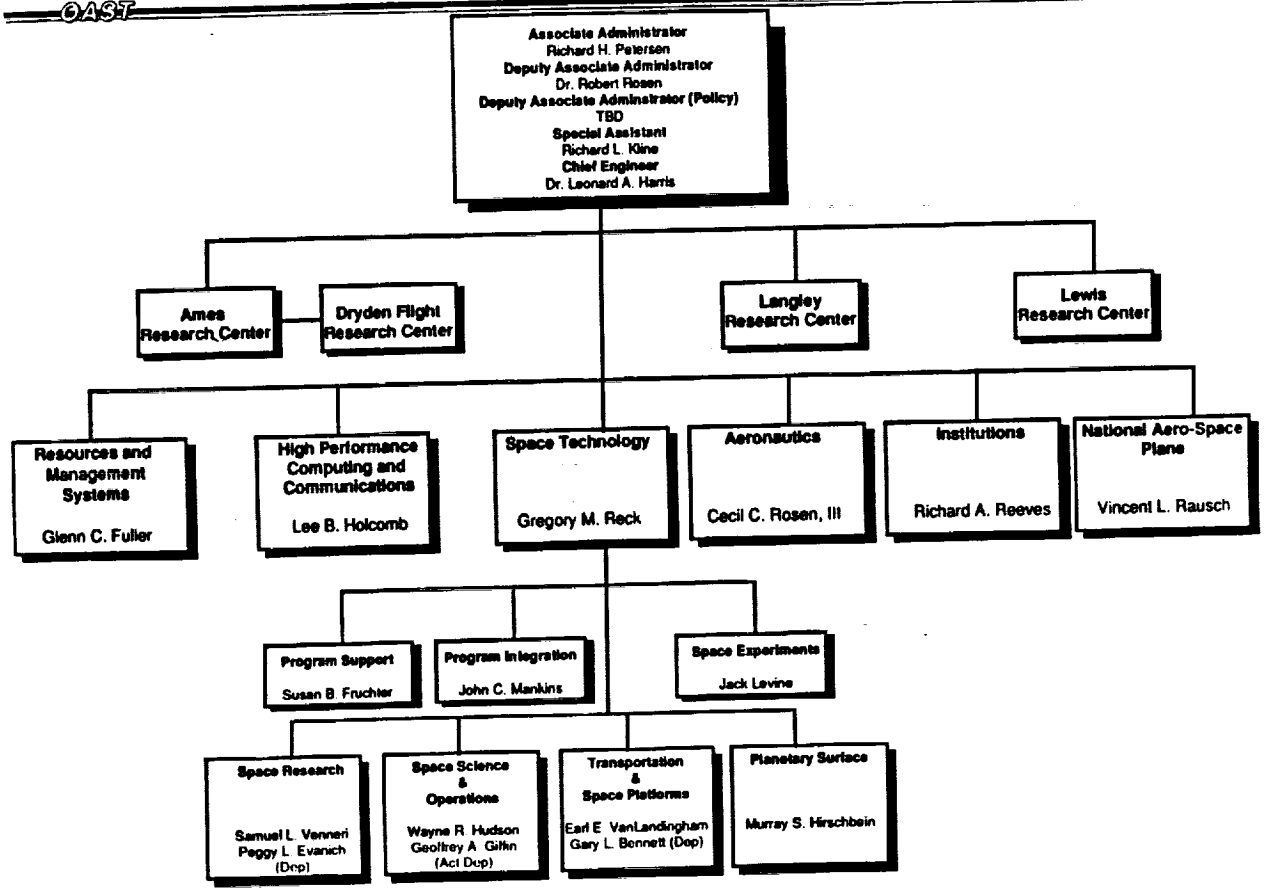
OAST

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

OAST



OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

FY 1992 BUDGET

OAST

($,M)

APPROP.	AERO	TRANSAT.	SPACE	TOTAL
R&D	574.2	5.0	309.3*	888.5
R&PM	273.1	16.1	138.4	427.6
CofF	42.3	-	-	42.3
SUBTOTAL	889.6	21.1	447.7	1358.4
RES. OPS. SUPP.				210.1
TOTAL				1568.5

* SPACE EXCLUDES MISSION STUDIES ($5.0M)

92-1038
Rev 2/26/92

SPACE R&T MISSION STATEMENT

OAST

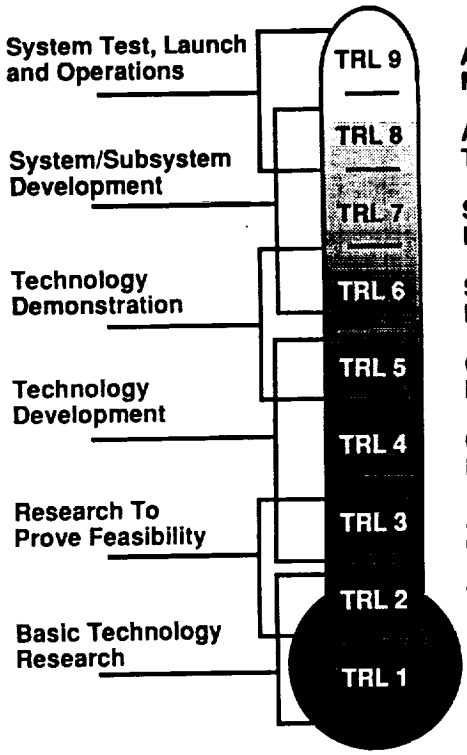
OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS

- *IDENTIFY, DEVELOP, VALIDATE AND TRANSFER TECHNOLOGY TO:*
  - INCREASE MISSION SAFETY AND RELIABILITY
  - REDUCE PROGRAM DEVELOPMENT AND OPERATIONS COST
  - ENHANCE MISSION PERFORMANCE
  - ENABLE NEW MISSIONS
- *PROVIDE THE CAPABILITY TO:*
  - ADVANCE TECHNOLOGY IN CRITICAL DISCIPLINES
  - RESPOND TO UNANTICIPATED MISSION NEEDS

LBF4194B

TECHNOLOGY READINESS LEVELS

OAST



ACTUAL SYSTEM "FLIGHT PROVEN" THROUGH SUCCESSFUL MISSION OPERATIONS

ACTUAL SYSTEM COMPLETED AND "FLIGHT QUALIFIED" THROUGH TEST AND DEMONSTRATION (Ground or Flight)

SYSTEM PROTOTYPE DEMONSTRATION IN A SPACE ENVIRONMENT

SYSTEM/SUBSYSTEM MODEL OR PROTOTYPE DEMONSTRATION IN A RELEVANT ENVIRONMENT (Ground or Space)

COMPONENT AND/OR BREADBOARD VALIDATION IN RELEVANT ENVIRONMENT

COMPONENT AND/OR BREADBOARD VALIDATION IN LABORATORY ENVIRONMENT

ANALYTICAL & EXPERIMENTAL CRITICAL FUNCTION AND/OR CHARACTERISTIC PROOF-OF-CONCEPT

TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED

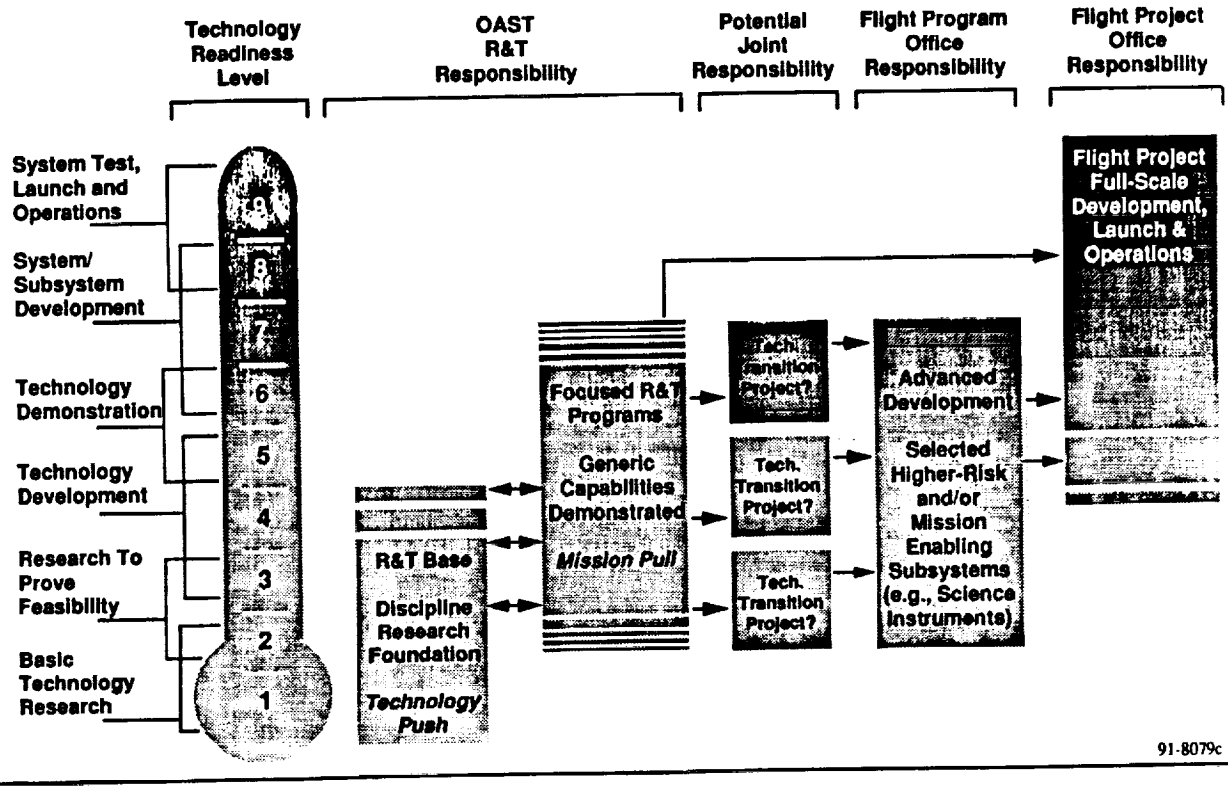
BASIC PRINCIPLES OBSERVED AND REPORTED

91-8080A

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY

OAST



INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH
Aerothermodynamics
Space Energy Conversion
Propulsion
Materials & Structures
Information and Controls
Human Support
Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY
Science Sensing
Observatory Systems
Science Information
In Situ Science
Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY
Surface Systems
Human Support
Technology Flight Expts.

TRANSPORTATION TECHNOLOGY
ETO Transportation
Space Transportation
Technology Flight Expts.

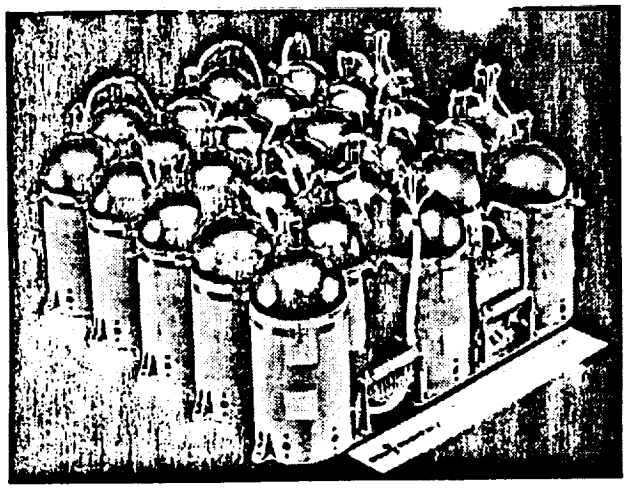
SPACE PLATFORMS TECHNOLOGY
Earth-Orbiting Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

OPERATIONS TECHNOLOGY
Automation & Robotics
Infrastructure Operations
Info. & Communications
Technology Flight Expts.

LBF40319

DISCIPLINE RESEARCH

CONCEIVE, DEVELOP AND VALIDATE NEW TECHNOLOGY CONCEPTS AND APPROACHES FOR ENHANCING OR ENABLING FUTURE SPACE MISSIONS, INCLUDING REVOLUTIONARY IMPROVEMENTS IN SPACE CAPABILITY



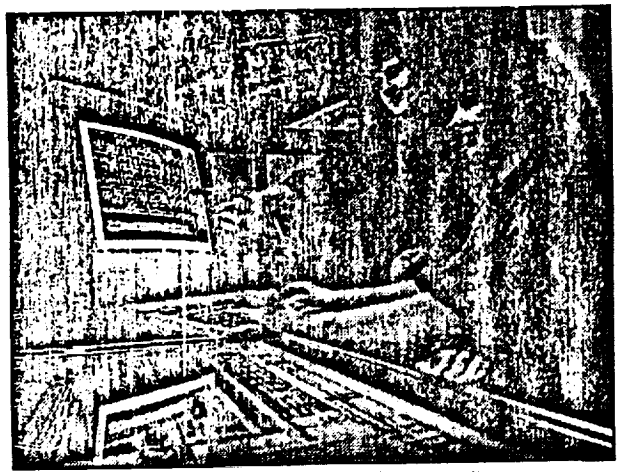
- DISCIPLINE RESEARCH TECHNOLOGY
  - AEROTHERMODYNAMICS
  - SPACE ENERGY CONVERSION
  - PROPULSION
  - MATERIALS & STRUCTURES
  - INFORMATION & CONTROLS
  - HUMAN SUPPORT
  - ADVANCED COMMUNICATIONS

Office of Aeronautics and Space Technology

91-8064

UNIVERSITY PROGRAMS

BROADEN THE CAPABILITIES OF THE NATION'S ENGINEERING COMMUNITY TO PARTICIPATE IN THE U.S. CIVIL SPACE PROGRAM THROUGH UNIVERSITY-BASED RESEARCH AND EDUCATION



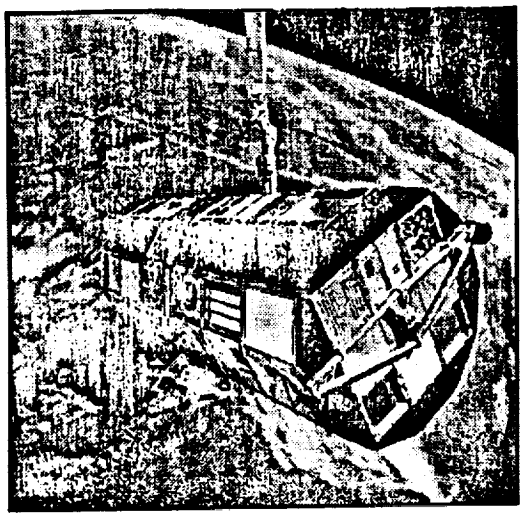
- UNIVERSITY SPACE ENGINEERING RESEARCH CENTERS
  - FOSTER CREATIVE AND INNOVATIVE CONCEPTS OF FUTURE SPACE SYSTEMS
  - EXPAND THE NATION'S ENGINEERING TALENT BASE FOR RESEARCH AND DEVELOPMENT
- UNIVERSITY INVESTIGATORS RESEARCH
  - SPONSOR INDIVIDUAL RESEARCH ON HIGHLY INNOVATIVE SPACE TECHNOLOGY CONCEPTS AND APPROACHES
- UNIVERSITY ADVANCED DESIGN
  - FOSTER INTERDISCIPLINARY ENGINEERING DESIGN EDUCATION

Office of Aeronautics and Space Technology

91-8061

SPACE FLIGHT RESEARCH & TECHNOLOGY

PROVIDE FOR EXPERIMENT STUDIES, DEVELOPMENT AND SUPPORT FOR IN-SPACE FLIGHT RESEARCH AND VALIDATION OF ADVANCED SPACE TECHNOLOGIES

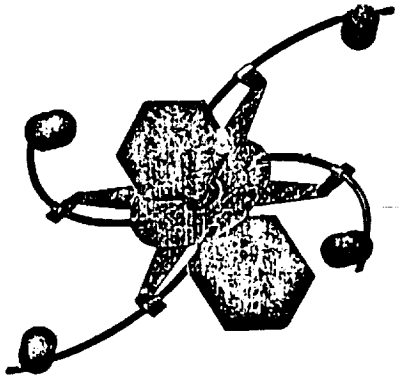


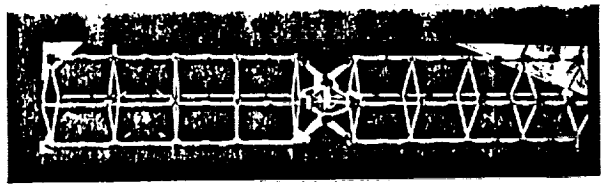
- IN-SPACE TECHNOLOGY EXPERIMENT PROGRAM (IN-STEP)
  - DESIGN, DEVELOP AND FLIGHT TEST INDUSTRY, UNIVERSITY AND NASA TECHNOLOGY FLIGHT EXPERIMENTS
- FLIGHT OPPORTUNITIES VIA
  - SPACE SHUTTLE
  - EXPENDABLE LAUNCH VEHICLES
  - SPACE STATION FREEDOM

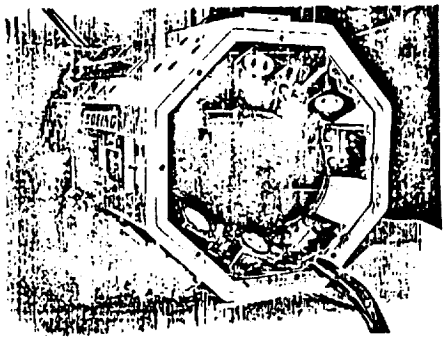
91-8063

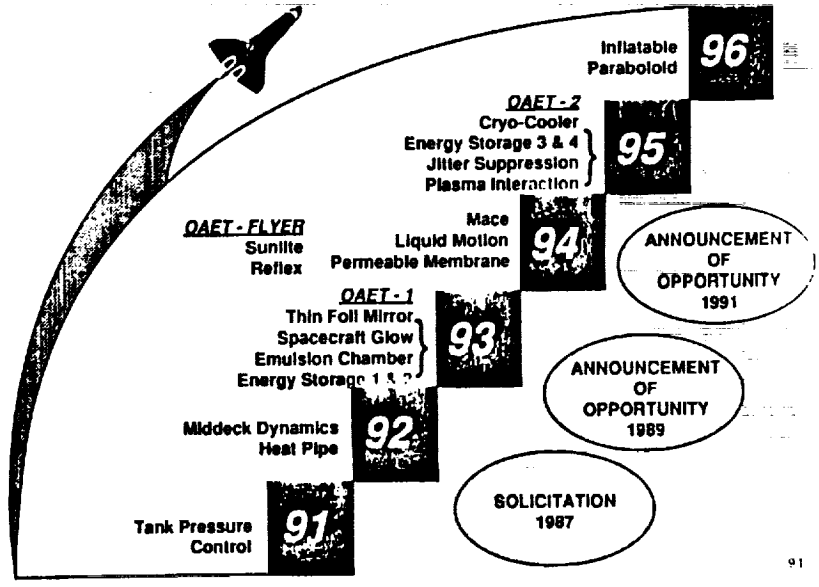
Office of Aeronautics and Space Technology

IN-SPACE TECHNOLOGY EXPERIMENTS





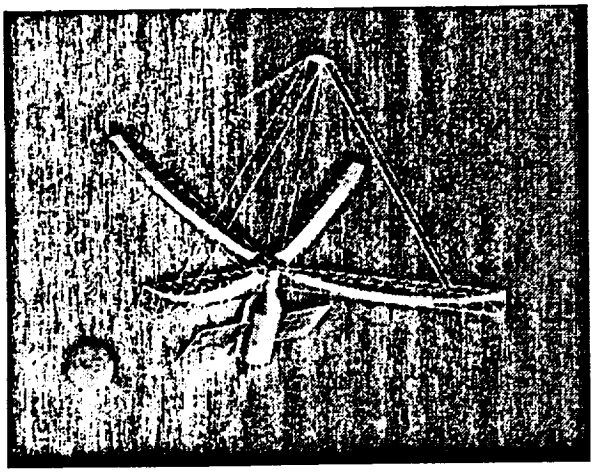




91

SYSTEMS ANALYSIS

CONDUCT INTERDISCIPLINARY SYSTEM STUDIES TO IDENTIFY AND PRIORITIZE NEW TECHNOLOGY REQUIREMENTS AND OPPORTUNITIES AND DEVELOP MODELING AND ANALYSIS TOOLS



- **FOCUSED PROGRAMS**
  - IDENTIFY CRITICAL TECHNOLOGY ISSUES OF FUTURE MISSION CONCEPTS
    - TRANSPORTATION
    - SPACE SCIENCE
    - SPACE PLATFORMS
    - SPACE EXPLORATION
    - OPERATIONS
- **BREAKTHROUGH**
  - IDENTIFY BENEFITS OF HIGHLY INNOVATIVE SPACE TECHNOLOGY IDEAS AND SPACE APPLICATIONS OF NEW TECHNOLOGY FRONTIERS
- **EXTERNAL**
  - SUPPORT SPACE COMMERCIALIZATION
  - IMPROVE USE OF INDUSTRY INDEPENDENT R&D (IRAD)
  - PLAN FOR MULTI-AGENCY PROGRAMS

Office of Aeronautics and Space Technology

91-8065

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH
Aerothermodynamics
Space Energy Conversion
Propulsion
Materials & Structures
Information and Controls
Human Support
Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T
IN SPACE TECHNOLOGY EXPTS

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY
Science Sensing
Observatory Systems
Science Information
In Situ Science
Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY
Surface Systems
Human Support
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TRANSPORTATION TECHNOLOGY
ETO Transportation
Space Transportation
Technology Flight Expts.

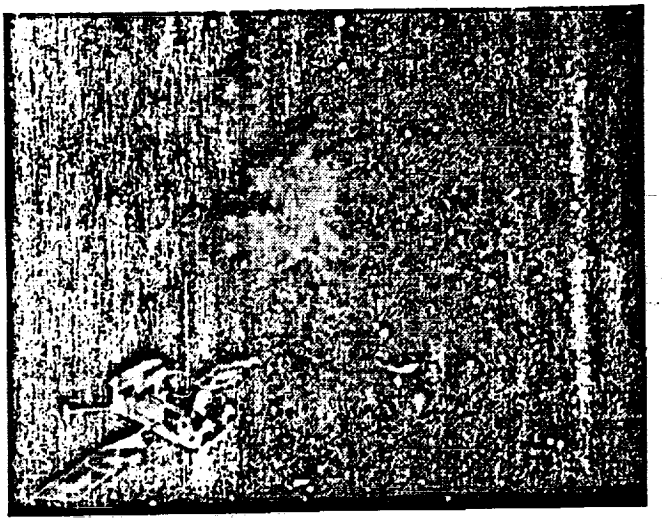
SPACE PLATFORMS TECHNOLOGY
Earth-Orbiting Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

OPERATIONS TECHNOLOGY
Automation & Robotics
Infrastructure Operations
Info. & Communications
Technology Flight Expts.

LBF40319

SCIENCE TECHNOLOGY

DEVELOP ADVANCED INSTRUMENT, OBSERVATION, INFORMATION, AND IN SITU MEASUREMENT TECHNOLOGIES TO MAXIMIZE THE RETURN FROM NASA SPACE AND EARTH SCIENCE MISSIONS OVER THE NEXT TWENTY YEARS



- EXPAND CAPABILITY AND REDUCE COSTS THROUGH DISCIPLINARY ADVANCEMENTS WHICH INCREASE SCIENCE INFORMATION RETURN AND SPACECRAFT PERFORMANCE
  - INSTRUMENT
  - OBSERVATION
  - DATA & INFORMATION
  - IN SITU MEASUREMENT
- ENABLE THE NEXT GENERATION OF SPACE SCIENCE MISSIONS
  - ASTROPHYSICS
  - SOLAR SYSTEM EXPLORATION
  - SPACE PHYSICS
  - EARTH SCIENCE
  - LIFE SCIENCES/MICROGRAVITY

Office of Aeronautics and Space Technology

91-8046

PLANETARY SURFACE TECHNOLOGY

PROVIDE KEY TECHNOLOGIES FOR ROBOTIC AND MANNED PLANETARY SURFACE EXPLORATION SYSTEMS INCLUDING CAPABILITIES FOR AN OUTPOST ON THE MOON AND EXPLORATION OF THE PLANET MARS

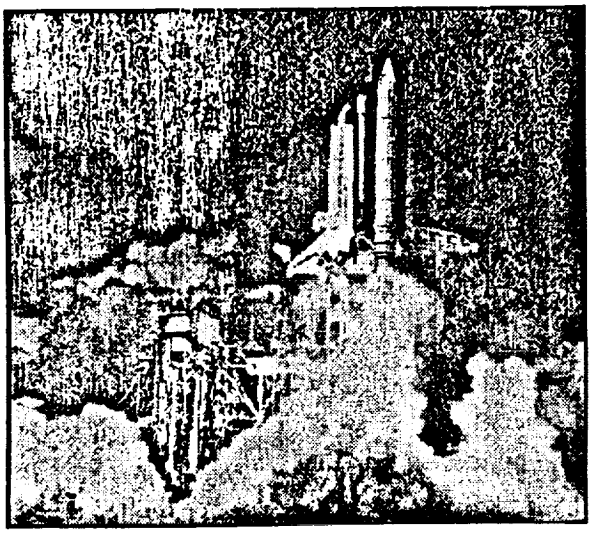
- INCREASE RELIABILITY AND REDUCE RISK; REDUCE DEVELOPMENT AND OPERATIONS COST; AND ENABLE NEW AND INNOVATIVE CAPABILITIES IN THE AREAS OF:
  - ADVANCED SURFACE SYSTEM OPERATIONS ON THE MOON AND MARS
  - TECHNOLOGIES FOR HUMAN SUPPORT DURING VERY LONG DURATION PILOTED MISSIONS IN DEEP-SPACE AND ON PLANETARY SURFACES

Office of Aeronautics and Space Technology

91-8050A
rev 8/23/91

TRANSPORTATION TECHNOLOGY

PROVIDE TECHNOLOGIES THAT SUBSTANTIALLY INCREASE OPERABILITY, IMPROVE RELIABILITY, PROVIDE NEW CAPABILITIES, WHILE REDUCING LIFE CYCLE COSTS



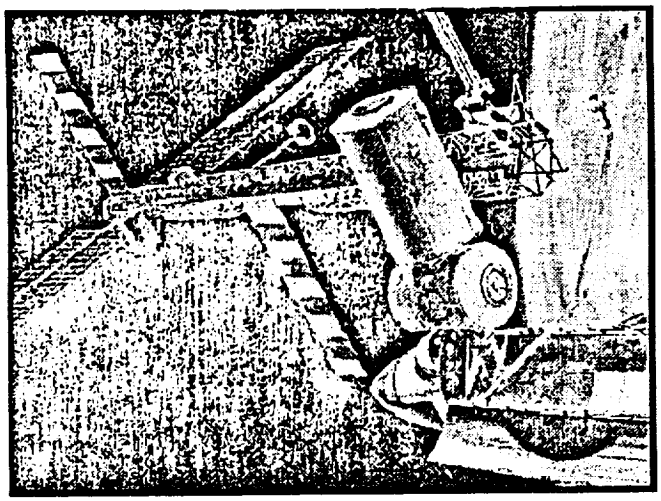
- ENHANCE SAFETY, RELIABILITY, AND SERVICEABILITY OF CURRENT SPACE SHUTTLE
- PROVIDE TECHNOLOGY OPTIONS FOR NEW MANNED SYSTEMS THAT COMPLEMENT THE SHUTTLE AND ENABLE NEXT GENERATION VEHICLES WITH RAPID TURNAROUND AND LOW OPERATIONAL COSTS
- SUPPORT DEVELOPMENT OF ROBUST, LOW-COST HEAVY LIFT LAUNCH VEHICLES
- DEVELOP AND TRANSFER LOW-COST TECHNOLOGY TO SUPPORT COMMERCIAL ELV's AND UPPER STAGES
- IDENTIFY AND DEVELOP HIGH LEVERAGE TECHNOLOGIES FOR IN-SPACE TRANSPORTATION, INCLUDING NUCLEAR PROPULSION, THAT WILL ENABLE NEW CLASSES OF SCIENCE AND EXPLORATION MISSIONS

Office of Aeronautics and Space Technology

91-8048

SPACE PLATFORMS TECHNOLOGY

DEVELOP TECHNOLOGIES TO INCREASE ON-ORBIT MISSION EFFICIENCY AND DECREASE LIFE CYCLE COSTS FOR FUTURE MANNED AND UNMANNED SCIENCE, EXPLORATION & COMMERCIAL MISSIONS.



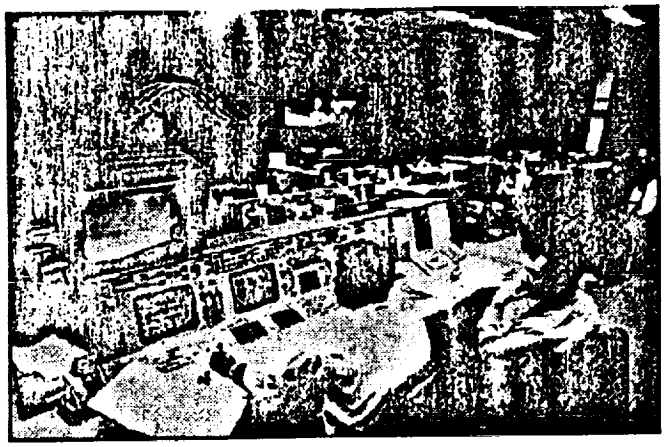
- DEVELOP TECHNOLOGIES THAT WILL DECREASE LAUNCH WEIGHT AND INCREASE THE EFFICIENCY OF SPACE PLATFORM FUNCTIONAL CAPABILITIES
- DEVELOP TECHNOLOGIES THAT WILL INCREASE HUMAN PRODUCTIVITY AND SAFETY OF MANNED MISSIONS
- DEVELOP TECHNOLOGIES THAT WILL INCREASE MAINTAINABILITY AND REDUCE LOGISTICS RESUPPLY OF LONG DURATION MISSIONS
- IDENTIFY AND DEVELOP FLIGHT EXPERIMENTS IN ALL TECHNOLOGY AND THRUST AREAS THAT WILL BENEFIT FROM THE UTILIZATION OF SSF FACILITIES

Office of Aeronautics and Space Technology

91-8052

OPERATIONS TECHNOLOGY

DEVELOP AND DEMONSTRATE TECHNOLOGIES TO REDUCE THE COST OF NASA OPERATIONS, IMPROVE THE SAFETY AND RELIABILITY OF THOSE OPERATIONS, AND ENABLE NEW, MORE COMPLEX ACTIVITIES TO BE UNDERTAKEN



- THE OPERATIONS THRUST SUPPORTS THE FOLLOWING MAJOR ACTIVITIES:
  - IN-SPACE OPERATIONS
  - FLIGHT SUPPORT OPERATIONS
  - GROUND SERVICING AND PROCESSING
  - PLANETARY SURFACE OPERATIONS
  - COMMERCIAL COMMUNICATIONS
- THE FOLLOWING TECHNOLOGY AREAS ARE INCLUDED:
  - AUTOMATION & ROBOTICS
  - INFRASTRUCTURE OPERATIONS
  - INFORMATION & COMMUNICATIONS
  - FLIGHT EXPERIMENTS

Office of Aeronautics and Space Technology

91-8055

INTEGRATED TECHNOLOGY PLAN PROCESS

OAST

- **INTERNAL NEEDS**
  - AGENCY PROGRAM OFFICES REQUESTED TO DEFINE AND PRIORITIZE MISSION TECHNOLOGY NEEDS AS RECOMMENDED BY AUGUSTINE
- **EXTERNAL NEEDS**
  - SSTAC/ARTS MEMBERS REQUESTED TO PROVIDE INPUTS ON OVERALL CIVIL SPACE TECHNOLOGY NEEDS
  - COMSTAC RECOMMENDATIONS ON ELVs, COMMUNICATIONS ADVISORY GROUP RECOMMENDATIONS AND OTHER KEY TECHNOLOGY ASSESSMENTS UNDER EVALUATION
- **DEVELOPMENT OF INTEGRATED TECHNOLOGY PLAN**
  - TEAMS FORMED TO PREPARE TECHNOLOGY PLANS
  - APPLIED DECISION RULES FOR BASE AND FOCUSED PROGRAMS
- **EXTERNAL REVIEW**
  - SSTAC/ARTS CONDUCTED REVIEW WITH PARTICIPATION BY ASEB, OTHER EXTERNAL EXPERTS IN JUNE
- **STRUCTURE FOR ANNUAL PLANNING AND REVIEW PROCESS ESTABLISHED**

SBF-0169b

National Aeronautics and
Space Administration

Washington, D.C.
20546

RECEIVED
DEC 11 2 23 PM '91

DEC 10 1991

Attn of: OP

TO: R/Associate Administrator for
Aeronautics and Space Technology

FROM: O/Associate Administrator for Space Communications

SUBJECT: Space Technology Needs Update for FY 1994 Program

This responds to your memorandum, same subject, dated November 15, 1991. We have reviewed our needs and find that the technology areas previously identified to you on April 1, 1991, are still valid. The following general technology areas are all high priority for Code O.

1. High Data Rate Communications. This includes optical and millimeter wave radio frequencies for both space-to-ground and space-to-space applications to handle the high volumes of data transported in future programs. An example of space-to-space communication might be future communications cross links between our tracking and data relay satellites.

2. Advanced Data Systems. This includes development of advanced data storage, data compression, and information management systems, which are required to meet the sophisticated needs of future planetary and exploration programs.

3. Advanced Navigation Techniques. This includes development of new techniques for navigation and their application to cruise, approach, and in-orbit navigation for manned and unmanned planetary missions.

4. Mission Operations. This includes incorporation of artificial intelligence, expert systems, neural networks, and increased automation in mission operations. Other work includes development of test beds to check out advanced software, coordination of distributed software, and automated performance analysis of networked computing environments.

We will be pleased to assist you if further definition of our requirements is needed.

Charles F. Force

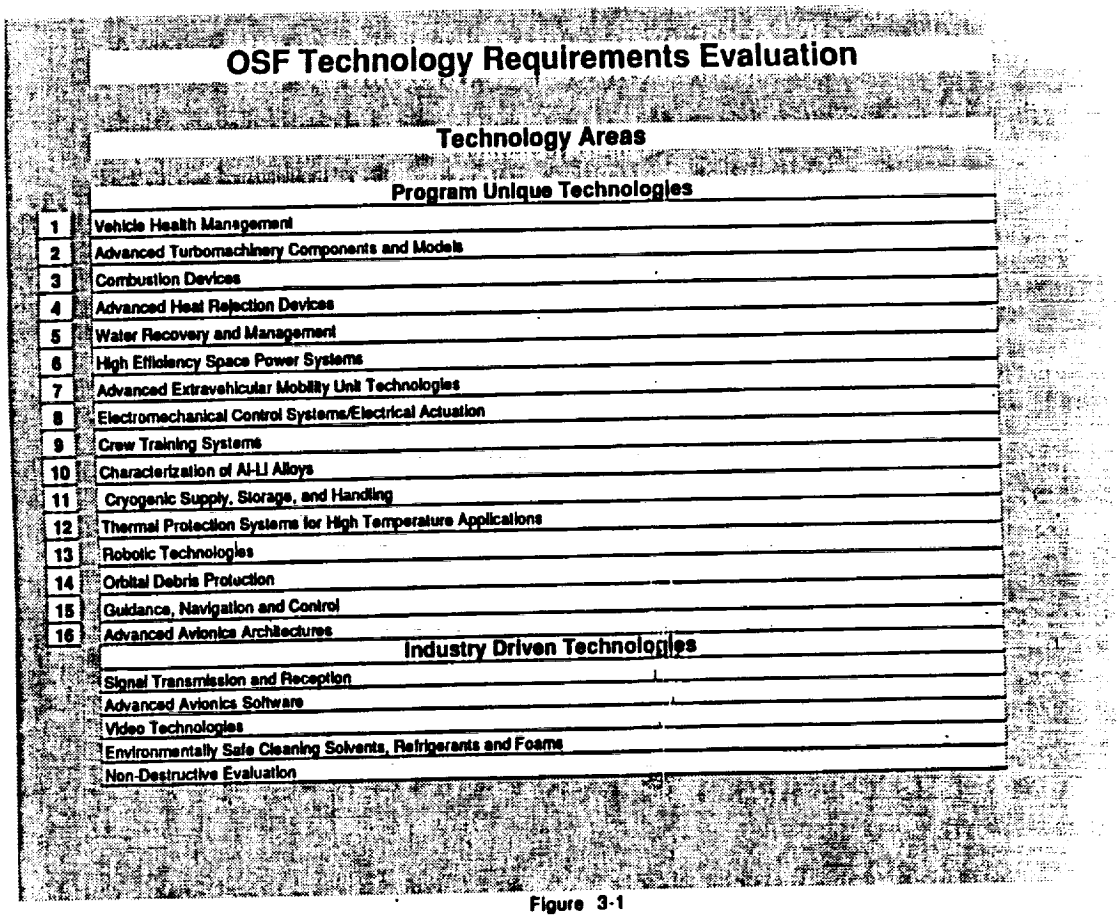


Figure 3-1

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

EXTERNAL TECHNOLOGY NEEDS SOURCES

OAST

- BOEING AEROSPACE & ELECTRONICS
- GENCORP-AEROJET
- GENERAL ELECTRIC-PHILADELPHIA
- GENERAL ELECTRIC-VALLEY FORGE
- GRUMMAN
- HUGHES
- MARTIN MARIETTA
- MCDONNELL DOUGLAS
- RCA
- SPACE SYSTEMS/LORAL
- SPARTA
- STANFORD TELECOM
- TRW
- UNITED TECHNOLOGIES CORPORATION
- *PLUS — DIRECT INPUTS FROM SSTAC/ARTS MEMBERS, EARLIER NRC SURVEY DATA*

SEPTEMBER 9, 1991
JCM-6430

EXTERNAL TECHNOLOGY PERSPECTIVES SUMMARY

OAST

SPACE SCIENCE

Precision Space Structures and Pointing Accuracy

PLANETARY SURFACE

Regnerative Life Support Systems
Radiation Protection for Long Missions
Utilization of In Situ Materials/Propellants
Artificial Intelligence Techniques
Robotic & Microrobotic Systems
Advanced EMUs
Surface Rover Technologies (Pressurized and Unpressurized)
Nuclear Electric Power
High-Efficiency Lunar Radiators & Thermal Energy Storage
Power Beaming
Human Health Maintenance
Reduced Gravity Countermeasures/Artificial Gravity
Bioprocess-Grade Fluid Management Systems

SPACE PLATFORMS

Composite Lightweight Structures
Micrometeoroid and Debris Protection
Long-Life Structures and Mechanisms
Regnerative Life Support Systems
Advanced EMUs
Expanded Atomic Oxygen Database
High-Efficiency, Radiation-Resistant, Lightweight PV Arrays
High-Efficiency Power Processing Units
Lightweight Batteries

TRANSPORTATION

Economical Launch Systems (Manned and Unmanned)
Software Productivity Enhancers
Integrated Vehicle Health Monitoring and Maintenance
Advanced Cryogenic (Oxygen/Hydrogen) Engines
Fault-Tolerant Advanced Avionics with Open Architectures
High-Performance/Composite Lightweight Structures
Long-Life Structures and Mechanisms
High-Performance, Storable Space Thrusters
High-Power Electric Propulsion
Nuclear Thermal Propulsion for Manned Interplanetary Missions
Cryogenics Long-Duration Storage and Management
Gun-Type Launch Systems
Aerobraking (Thermal Protection Systems)
Integrated RCS/Auxiliary Propulsion
Lightweight, Fuel-Efficient Airbreather Propulsion Systems

OPERATIONS

Data Management System Architecture and Software
Systems Integration technologies (Software, etc.)
Artificial Intelligence Techniques
Safe Robotic Systems
Advanced Communications (e.g., Laser & Millimeter Wave Technology)

JUNE 24, 1991
JCM:7660d

USER PRIORITIZED TECHNOLOGY NEEDS - UPDATE

OAST

- **OFFICE OF SPACE SCIENCE & APPLICATIONS**
  - **WOODS HOLE REVISIONS TO OSSA STRATEGIC PLAN HAVE BEEN INCLUDED**
- **OFFICE OF SPACE EXPLORATION**
  - **REVISIONS RECEIVED IN FEBRUARY 1992**
- **OFFICE OF SPACEFLIGHT**
  - **SOME ADJUSTMENT IN EMPHASIS**
- **OFFICE OF SPACE OPERATIONS**
- **EXTERNAL (INDUSTRY) NEEDS**

LBF40389a

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

RESEARCH & TECHNOLOGY STRATEGY

OAST

FLIGHT PROGRAMS FORECAST

- **5-YEAR FORECAST INCLUDES**

'93 THRU '97: LIMITED NEW STARTS

- COMPLETION OF INITIAL SSF
- SOME SHUTTLE IMPROVEMENTS
- INITIAL EOS & EOSDIS
- SELECTED SPACE SCIENCE STARTS
- NLS DEVELOPMENT
- INITIAL SEI ARCHITECTURE SELECTION
- EVOLVING GEO COMMERCIAL COMMSATS
- MINOR UPGRADES OF COMMERCIAL ELVS

- **10-YEAR FORECAST INCLUDES**

'98 THRU '03: MULTIPLE NEW STARTS TO BE LAUNCHED IN 2003 THRU 2010

- SSF EVOLUTION/INFRASTRUCTURE
- FINAL SHUTTLE ENHANCEMENTS
- ADVANCED LEO EOS PLATFORMS/FULL EOSDIS
- MULTIPLE SPACE SCIENCE STARTS
- NLS OPERATIONS/EVOLUTION
- EVOLVING LAUNCH/OPERATIONS FACILITIES
- INITIAL SEI/LUNAR OUTPOST START
- DSN EVOLUTION (KA-BAND COMMUNICATIONS)
- NEW GEO COMMERCIAL COMMSATS
- NEW COMMERCIAL ELVS

- **20-YEAR FORECAST INCLUDES**

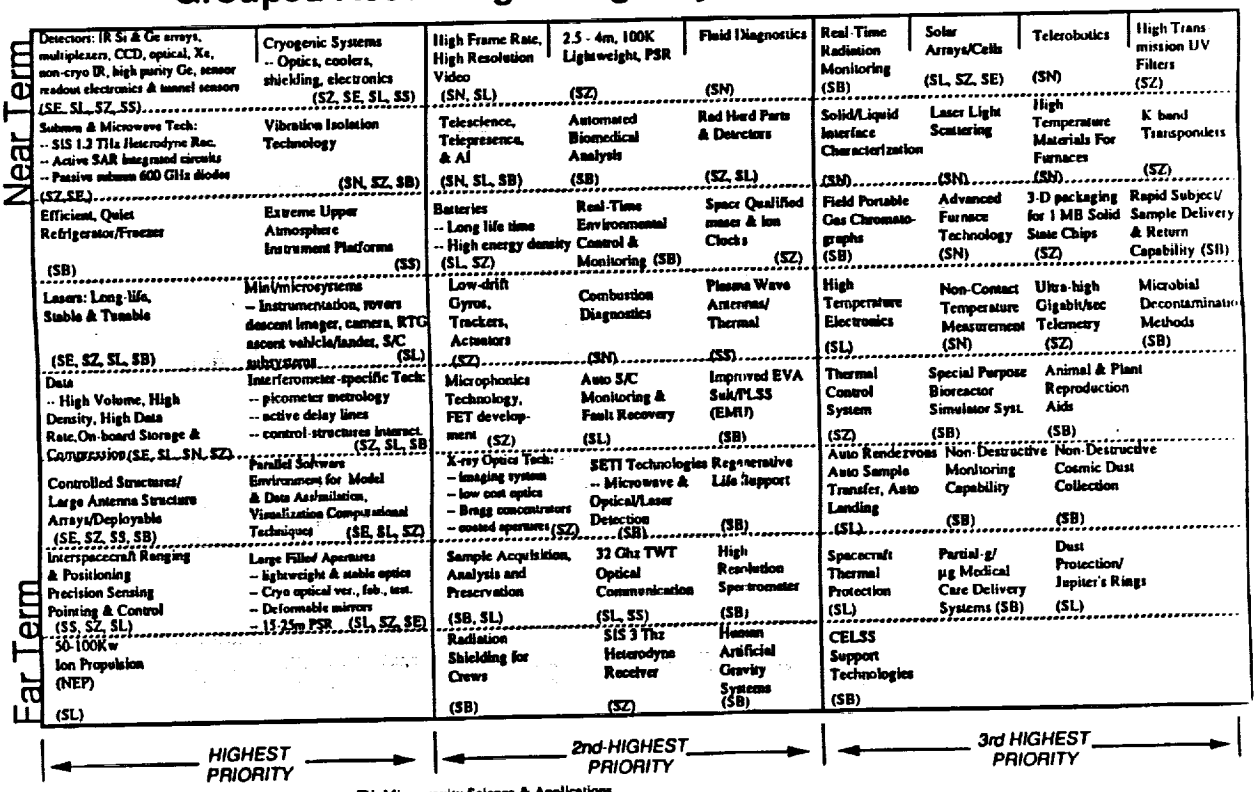
'04 THRU '11 MULTIPLE OPTIONS FOR NEW STARTS TO BE LAUNCHED IN 2009 THRU 2020

- SSF-MARS EVOLUTION
- BEGINNING OF AMLS/PLS DEVELOPMENT
- MULTIPLE SPACE SCIENCE STARTS
- DSN EVOLUTION (OPTICAL COMM)
- INITIAL MARS HLLV DEVELOPMENT
- EVOLVING LUNAR SYSTEMS
- MARS SEI ARCHITECTURE CHOSEN
- LARGE GEO COMMSATS
- NEW COMMERCIAL ELVS

LBF40305
(JCM-7692)

OSSA TECHNOLOGY NEEDS
Grouped According to Urgency & Commonality

REVISED
NOVEMBER 15, 1991



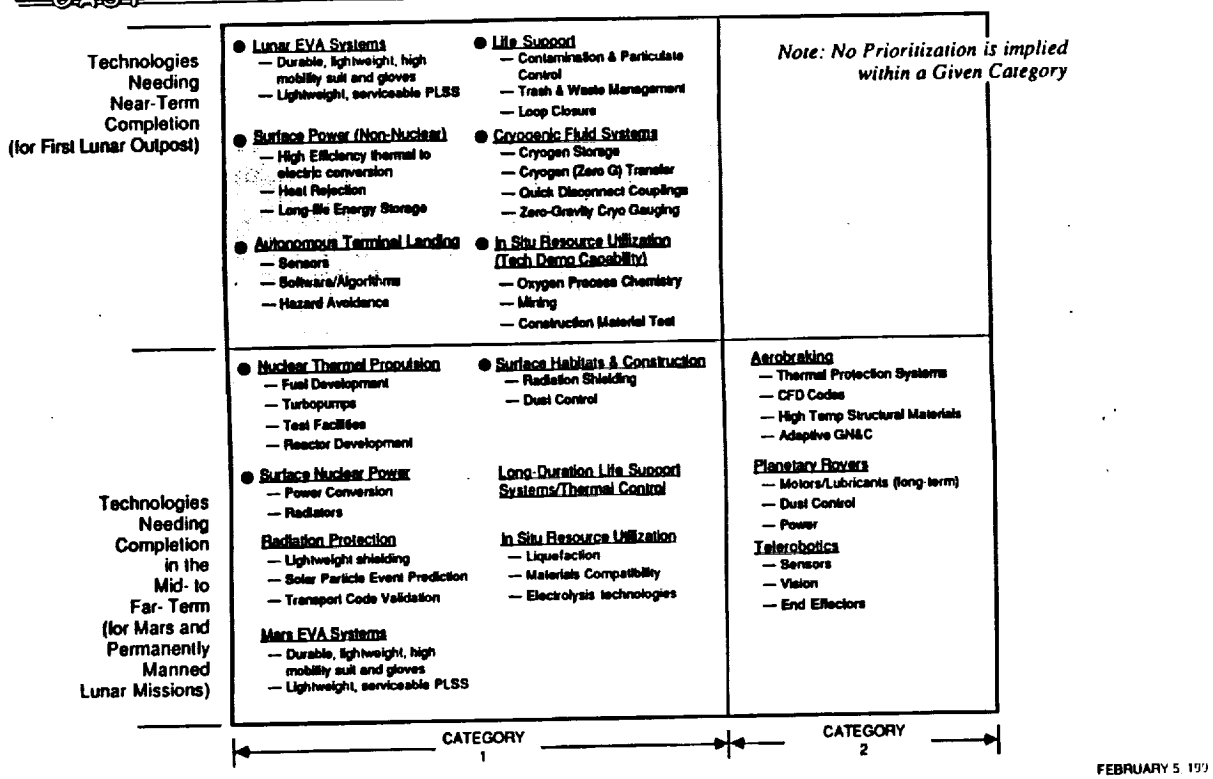
SB: Life Sciences
SE: Earth Sciences & Applications
SL: Solar System Exploration
SN: Microgravity Science & Applications
SS: Space Physics
SZ: Astrophysics

SPACE RESEARCH AND TECHNOLOGY PROGRAM

DRAFT

SEI TECHNOLOGY NEEDS (for FY 1994 planning)

OAST



FEBRUARY 5, 199
JCM 7041

● Near-Term Investment Recommended by OEXP

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

DECISION RULES: R&T BASE

OAST

GENERAL RULES

- USE EXTERNAL REVIEWS TO AID IN ASSURING PROGRAM TECHNICAL QUALITY
- PROVIDE STABILITY BY COMPLETING ON-GOING DISCRETE EFFORTS

DISCIPLINE RESEARCH

- ASSURE ADEQUATE SUPPORT TO MAINTAIN HIGH-QUALITY IN-HOUSE RESEARCH IN AREAS CRITICAL TO FUTURE MISSIONS
  - PROVIDE CAPABILITIES FOR AD HOC SUPPORT R&T FOR FLIGHT PROGRAMS
- PROVIDE GROWTH IN R&T BASE AREAS NEEDED FOR FUTURE FOCUSED PGMS
  - COORDINATE WITH ANNUAL FOCUSED PROGRAM PLANNING
- CREATE ANNUAL OPPORTUNITIES FOR THE INSERTION OF NEW R&T CONCEPTS
  - GOAL: PROVIDE APPROXIMATELY 15-20% "ROLL-OVER" PER YEAR
- SUPPORT TECHNOLOGY PUSH FLIGHT EXPERIMENTS WHERE SPACE VALIDATION IS REQUIRED.

FLIGHT PROGRAMS

- MAINTAIN COMPETITIVELY-SELECTED STUDIES/IMPLEMENTATION OF IN-HOUSE AND INDUSTRY/UNIVERSITY SMALL-SCALE FLIGHT EXPTS, ORIENTED ON NASA'S TECHNOLOGY NEEDS

UNIVERSITY PROGRAMS

- EVALUATE TO FOCUS PARTICIPATION IN NASA SPACE R&T BY U.S. UNIVERSITIES AND COLLEGES - USING COMPETITIVE SELECTION

LBF40318
(JCM 6803)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

R&T Base Discipline Programs Content

OAST

	BASE CAPABILITIES			ADVANCED TECHNOLOGIES			"BREAKTHROUGH" TECHNOLOGIES		
Aerothermo-dynamics	Hypersonic Flowfield Sim.	Hypersonic Vehicle Synth.	—	Flt. Environ. Instrument'n	Configuration Design/Optimiz.	—	—	—	—
	Fundamental Data Bases	—	—	Aerothermo. Design Tools	—	—	—	—	—
Space Communications	Travelling Wave Tubes (TWTs)	—	—	KaBand TWT	Digital Switching Processors	Ground Terminals	Laser Comm. Components	—	—
	MMICs	—	—	Solid State MMIC Systems	Direct Broadcast (Audio)	—	Mobile Comm. Systems (Personal)	—	—
Space Energy Conversion	Photovoltaic Perf. Validation	Solar Dynamics Design/Analysis	—	Adv. Solar Cells (GaAs, In-P)	Adv. Batteries (Rechg/Life)	Thermoelectric Conv. Systems	Laser Power Components	Alkali Metal T-E Conversion	Diamond Film Pwr Electronics
	Electrochemical Diagn./Models	—	—	Concentrators and Arrays	Solar Dynamics Conv. Systems	Power Mgt. & Distribution	Adv. Fuel Cells (Li/CO2)	Liquid Sheet Radiators	—
Human Support	Extravehicular Activity Suit	—	—	EVA Gloves	EMU Components	Life Support Models	Visualization Research	AI Computer Associates	—
	Human Modeling (Cogn./Physical)	—	—	PLSS Components	Interactive EVA Displays	Life Support Sensors/Cntrls	Virtual Reality Environments	—	—
Information and Controls	Electro-optic Mat'e/Sensors	—	—	Advanced AI Research	Computational Controls	—	Micromachines	Photonics	Multiple Interactive Robots
	—	—	—	—	Software Develop. Tools	—	Neural Networks	High-Temp Superconductors	—
Materials and Structures	Materials Synthesis	Space Durable Materials	Sp. Environ. Effects (Mat'e)	Optics	High Precision Struct.	Durable Polymers	Intermetallics & Metal Matrix	Computational Materials	Adaptive Materials
	High Temp. TPS	Advanced Space Struct. Concepts	Tribology	Mechanisms	Lg./Deployed Struct.	High Temp. Veh. Struct.	Computational Chemistry	"Smart" Materials	—
				Extreme TPS	Debris Shielding				
Propulsion	Combustion Models/Diagn.	Internal Pump Flow CFD	—	Ion Thrusters	Water Resistojets	H-O Engines	High Energy Density Propell.	Laser Rocket Propulsion	Superconduct Bearings
	Engine Analysis Expert Systems	Cryo. Fluid Modeling	—	Hydrogen Arcjets	Iridium-Rhenium Engine Liners	Propulsion Health Mgt.	Electrodeless Thrusters (ECR)	Fission/Fusion Propulsion	—
				MPD Thrusters					

NOVEMBER 13, 1991
JCM 6800+

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

DECISION RULES: FOCUSED PROGRAMS

OAST

GENERAL

- ANNUALLY ASSESS AND FUND PROJECTS IN ORDER OF PRIORITY AGAINST MISSION-DERIVED INVESTMENT CRITERIA
  - EXTERNAL REVIEW WILL BE USED TO AID IN ASSURING QUALITY
  - REVIEW WITH USER OFFICES WILL BE USED TO AID IN ASSURING RELEVANCE AND TIMELINESS
- PROVIDE STABILITY BY COMPLETING ON-GOING DISCRETE EFFORTS
- START A MIX OF TECHNOLOGY PROJECTS WITH SHORT-, MID- AND LONG-TERM OBJECTIVES EACH YEAR
- ASSURE BALANCED INVESTMENTS TO SUPPORT THE FULL RANGE OF SPACE R&T USERS
- FUND NEW TECHNOLOGY PROJECTS THAT HAVE PASSED INTERNAL REVIEWS AS REQUIRED (E.G., NON-ADVOCATE REVIEW FOR MAJOR EXPERIMENTS)

MAJOR FLIGHT EXPERIMENTS

- SUPPORT COMPETITIVELY-SELECTED IMPLEMENTATION OF IN-HOUSE AND INDUSTRY MAJOR TECHNOLOGY FLIGHT EXPTS IN ACCORDANCE WITH MISSION-DERIVED PRIORITIZATION CRITERIA
- FUND MAJOR FLIGHT EXPERIMENTS WHERE ADEQUATE GROUND-BASED R&T IS UNDERWAY OR HAS BEEN COMPLETED

LBF40287a
(JCM 6804)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

INVESTMENT PRIORITIZATION CRITERIA

OAST

MISSION NEED

Engineering Leverage
- Performance (Including Reliability) Leverage of the Technology to A System
- Importance of That Technology/System Performance To A Mission And Its Objectives

Cost Leverage
- Projected Cost Reduction For A Given System/Option
- Projected Cost Reduction for A Mission of That Savings

Breadth Of Application
- Commonality Across Missions/Systems Options
- Commonality Across Systems in Alternative Mission Designs

PROGRAMMATICS & TIMING

Timeliness Of Planned Deliverables
- Timing of the Mission Need for Technology Readiness
- Projected Duration of R&T Needed To Bring Technology to Readiness

Criticality Of Timely R&T Results To Mission Decisions
- Timing of Mission Planning Need for Technology Results
- Importance of Technology To Mission Objectives/Selection

Uncertainty in Planned R&T Program Success/Schedule

SPECIAL ISSUES

- Readiness to Begin A Focused Technology Project
- Commitment To An Ongoing R&T Program
- Interrelationships To Other Government Program(s)
- Projected "National Service" Factors

LBF40285
(JCM-6684a)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

Strategic Plan ITP: CSTI Element Categorization

OAST

	HIGHEST PRIORITY ◊◊◊			2nd-HIGHEST PRIORITY ◊◊			3rd-HIGHEST PRIORITY ◊		
Space Science Technology	Submillimeter Sensing	Direct Detectors	Active µwave Sensing	Sample Acq., Analysis & Preservation	Passive Microwave Sensing	---	Optoelectrncs Sensing & Processing	Probes and Penetrators	---
	Cooler and Cryogenics	Sensor Electronics Microprecision CSI	Laser Sensing Telescope Optical Systems	Data Archiving and Retrieval	Data Visualization and Analysis	---	Precision Instrument Pointing	Sensor Optical Systems	---
Planetary Surface Technology	Radiation Protection	Regenerative Life Support (Phys-Chem.)	Space Nuclear Power (SP-100)	High Capacity Power	Planetary Rovers	Surface Habitats and Construction	Exploration Human Factors	---	Artifical Gravity
	---	---	Extravehicular Activity Systems	Surface Solar Power and Thermal Mgt.	In Situ Resource Utilization	Laser-Electric Power Beaming	Medical Support Systems	---	---
Transportation Technology	ETO Propulsion	Nuclear Thermal Prop. Aeroassist Flight Expt	Aeroassist/ Aerobraking	Transfer Vehicle Avionics	ETO Vehicle Avionics	ETO Vehicle Structures & Materials	Autonomous Rendezvous & Docking	COHE	Auxiliary Propulsion
	Cryogenic Fluid Systems	Advanced Cryo. Engines	Low-Cost ETO Transport	Nuclear Electric Propulsion	CONE	---	Autonomous Landing	TV Structures and Cryo Tankage	HEAb
Space Platforms Technology	Platform Structures & Dynamics	Platform Power and Thermal Mgt.	Zero-G Life Support	Platform Materials & Environ. Effects	Station-Keeping Propulsion	---	Spacecraft On-Board Propulsion	Earth-Orbiting Platform Controls	Advanced Refrigerator Systems
	---	---	Zero-G Advanced EMU	Platform NDE-NDI	Deep-Space Power and Thermal	---	Spacecraft GN&C	Debris Mapping Experiment	---
Operations Technology	Space Data Systems	High-Rate Comm.	Artificial Intelligence	Ground Data Systems	Optical Comm Flight Expt Flt. Telerobotic Servicer/DTF-1	Flight Control and Operations	Space Assembly & Construction	Space Processing & Servicing	Photonics Data Systems
	---	CommSat Communicat'ns	TeleRobotics	Operator Syst./Training	Navigation & Guidance	CommSat Communicat'ns Flight Expts	---	Ground Test and Processing	---

LBF40343 FINA

FY 1992 Program ITP: CSTI Element Categorization

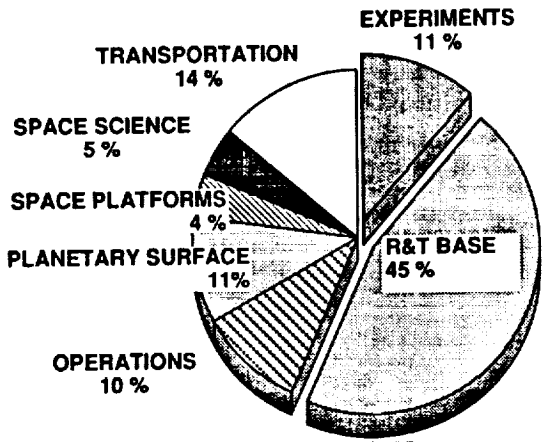
OAST

	HIGHEST PRIORITY ooo			2nd-HIGHEST PRIORITY oo			3rd-HIGHEST PRIORITY o		
Space Science Technology	Submillimeter Sensing	Direct Detectors	Laser Sensing	---	---	---	---	---	---
	Cooler and Cryogenics	Microprecision CSI	---	---	---	---	---	---	---
Planetary Surface Technology	Radiation Protection	Regenerative Life Support (Phys-Chem.)	Space Nuclear Power (SP-100)	High Capacity Power	---	---	---	---	---
	---	---	Extravehicular Activity Systems	---	---	Laser Electric Power Beaming	---	---	---
Transportation Technology	ETO Propulsion	---	---	---	---	---	---	---	---
	---	Advanced Cryogenic Engines	Nuclear Thermal Propulsion	Nuclear Electric Propulsion	---	---	---	---	---
Space Platforms Technology	Platform Structures & Dynamics	Platform Power & Thermal Mgt.	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---
Operations Technology	Space Data Systems	---	Artificial Intelligence	---	---	---	---	---	---
	---	---	TeleRobotics	---	---	---	---	---	---

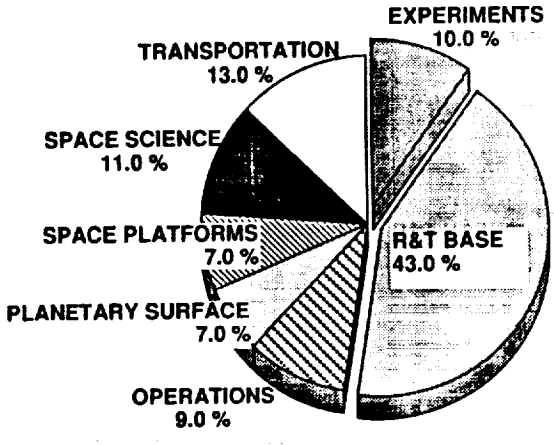
LBF40363.1

SPACE RESEARCH & TECHNOLOGY PROGRAM

OAST



FY 1992
$309.3M

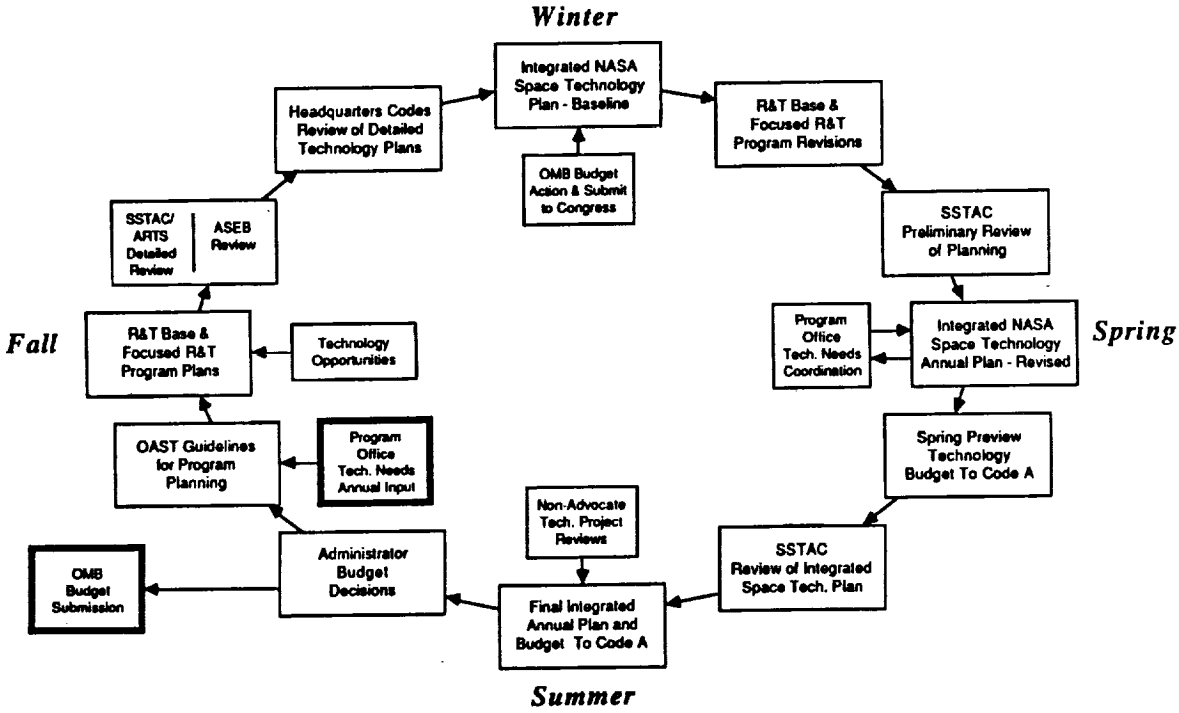


FY 1993
$332.0M

LBF 40423c

SPACE TECHNOLOGY PLANNING CYCLE

OAST



March 25, 1991
JCM-7207b

WHY SHOULD SPACE TECHNOLOGY BE A NATIONAL PRIORITY?

OAST

- OVER THE PAST 29 YEARS, U.S. LEADERSHIP HAS ERODED AS THE SPACE ACTIVITIES OF OTHER NATIONS HAVE EXPANDED IN SCOPE AND QUALITY
- OVER THE SAME PERIOD, U.S. SPACE PROGRAMS HAVE ENCOUNTERED COST, SCHEDULE AND TECHNICAL DIFFICULTIES
- IN ADDITION, THE U.S. STABLE OF VEHICLES AND TELECOMMUNICATIONS SATELLITES ARE BEING CHALLENGED ON THE WORLD MARKET
- FINALLY, THE TECHNOLOGIES WE MUST HAVE TO ACHIEVE PREEMINENCE IN SPACE FOR THE 21ST CENTURY DO NOT YET EXIST
- A WELL MANAGED AND FOCUSED PROGRAM WILL PROVIDE BENEFITS FOR THE NATION AND THE SPACE PROGRAM

Ref: SSTAC ITP Review

BENEFITS FOR THE NATION

OAST

- IMPROVING NATIONAL COMPETITIVENESS
  - COMMERCIAL SPACE MARKETS
  - BROAD RANGE OF CRITICAL TECHNOLOGIES
- STIMULATING QUALITY SCIENCE AND ENGINEERING EDUCATION
  - EXCITING AND MEANINGFUL UNDERGRADUATE AND GRADUATE OPPORTUNITIES
  - INVOLVES GOVERNMENT, INDUSTRY AND ACADEMIA
  - SUPPLIES INDUSTRY AND ACADEMIA, NOT JUST NASA
  - ATTRACTS BEST AND BRIGHTEST INTO TECHNICAL FIELDS
- DEVELOPING BROADLY APPLICABLE NEW TECHNOLOGIES
  - NASA MISSION TECHNOLOGIES APPLICABLE TO COMMERCIAL AND DOD
  - ALL FUTURE NATIONAL SPACE ENDEAVORS ENHANCED BY NASA SPACE R&T

Ref: SSTAC ITP Review

BENEFITS FOR FUTURE U.S. SPACE ENDEAVORS

OAST

- IMPROVING THE QUALITY OF FUTURE U.S. FLIGHT PROGRAMS
  - PROVIDES NEW CAPABILITIES WITH MINIMUM COST OR SCHEDULE RISK
  - REDUCES ERROR IN COST PROJECTIONS
- TWO-FOLD REDUCTION IN THE COST OF ACCESS TO SPACE
  - COST REDUCTION WITHOUT REDUCING SCOPE
  - REDUCED SPACECRAFT SIZE
  - INCREASED AUTONOMY
- INCREASING SAFETY AND RELIABILITY
  - ACHIEVING SAFETY AND RELIABILITY WITH CURRENT TECHNOLOGY CAN BE COSTLY
  - NEW TECHNOLOGIES CAN SIGNIFICANTLY REDUCE THESE COSTS
- ENABLING NEW SPACE MISSIONS
- SUSTAINING NASA EXPERTISE

Ref: SSTAC ITP Review

REVIEW TEAM RECOMMENDATIONS

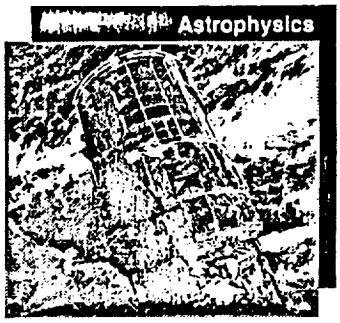
OAST

ACCEPT RECOMMENDATION 8 OF THE AUGUSTINE REPORT AND INITIATE PLANNING FOR THE NEEDED FUNDING GROWTH TO TRIPLE THE CURRENT LEVEL OF INVESTMENT IN ADVANCED SPACE RESEARCH AND TECHNOLOGY

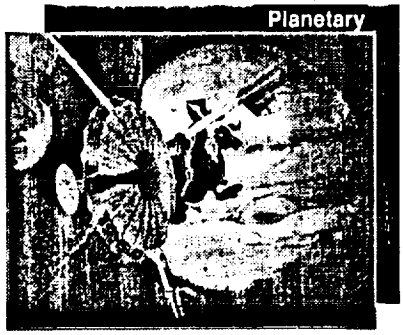
- CONTINUE TO IMPROVE THE INTEGRATED TECHNOLOGY PLAN
- DEVELOP NATIONAL TEAMS
- DEVELOP NATIONAL TESTBEDS
- REVITALIZE SPACE R&T FACILITIES
- INCREASE THE USE OF TECHNOLOGY FLIGHT DEMONSTRATIONS
- IMPROVE TECHNOLOGY TRANSFER

LBF40492

TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

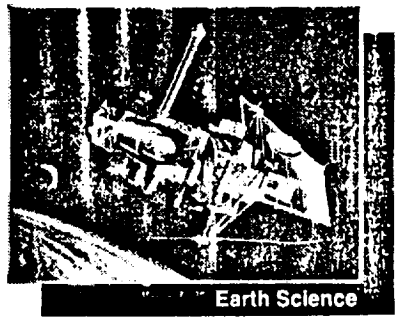


- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration



- Galileo (& Hubble) - CCD Array
- Voyager - Spacecraft Health Monitoring
- Magellan - Radar Ground Processor

- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging

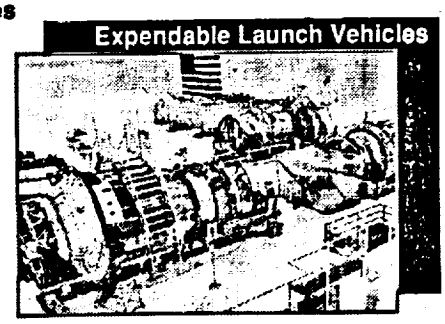


Office of Aeronautics and Space Technology

92-8013

TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION

- Structural Analysis for Solid Rocket Motor (SRM) Redesign
- Vacuum Plasma Spray Coatings & Chambers
- Health Monitoring (Test Facilities)
- Thermal Protection System
- Bearing Cooling Analysis
- Real Time Data System
- Orbiter Experiments
- Damping Seals
- Modified Tires

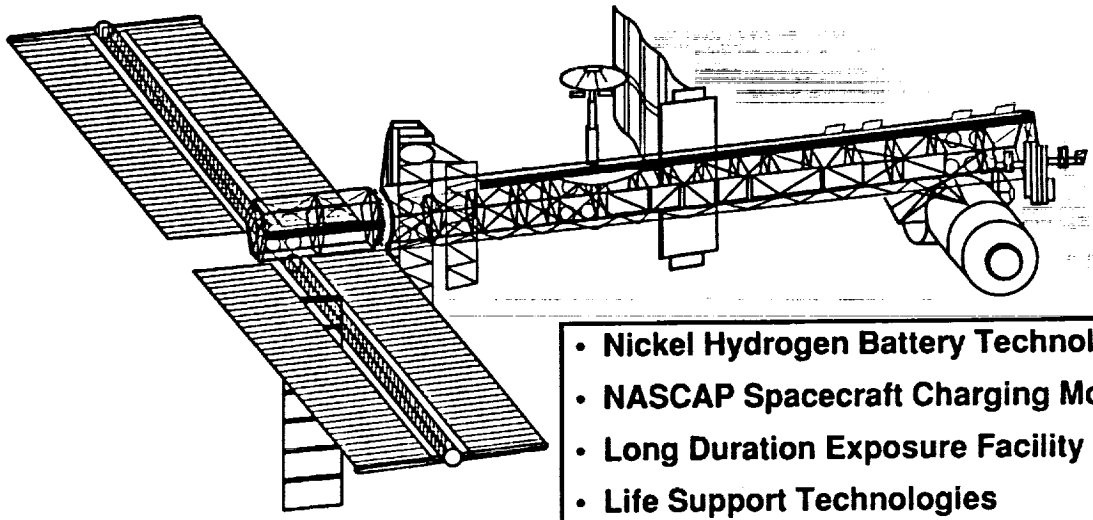


- Advanced Primary Battery

Office of Aeronautics and Space Technology

92-8023a

TECHNOLOGY CONTRIBUTIONS TO SPACE PLATFORMS



- Nickel Hydrogen Battery Technology
- NASCAP Spacecraft Charging Model
- Long Duration Exposure Facility
- Life Support Technologies
- Multipropellant Resistojet
- Large Area Solar Cells
- Arcjet Thruster

Office of Aeronautics and Space Technology

92-8024

SCIENCE TECHNOLOGY

INSTRUMENT

- IR Detectors
- Active Microwave
- Optoelectronics
- Submillimeter Detectors
- High Energy Detectors
- Passive Microwave
- Laser Sensors
- Sensor Readouts

OBSERVATION

- Cryocoolers
- Micro Precision CSI
- Precision Pointing
- Telescope Systems
- Sensor Optics

IN SITU MEASUREMENT

- Sample Acquisition, Analysis, and Preservation
- Probes and Penetrators

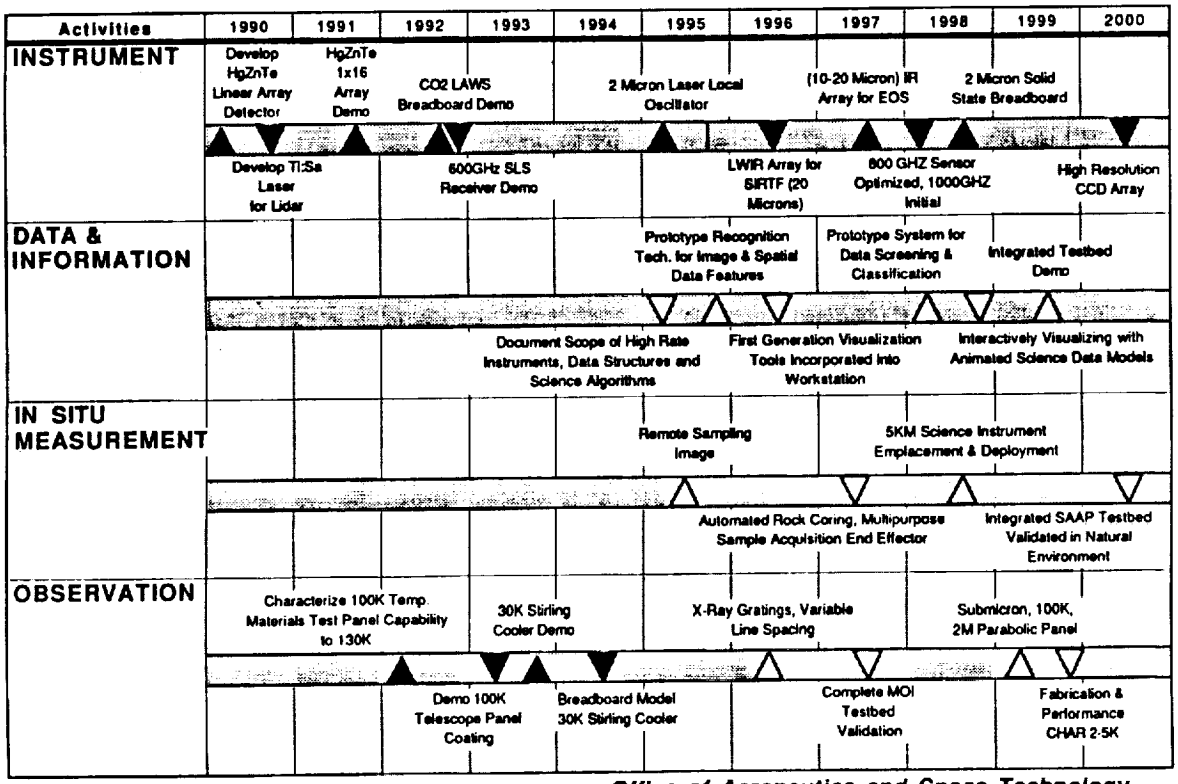
DATA & INFORMATION

- Data Archives
- Information Visualization

91-8047

Office of Aeronautics and Space Technology

SPACE SCIENCE MILESTONES

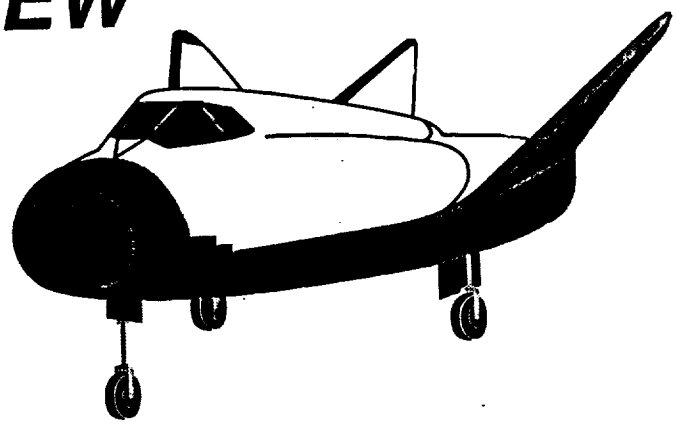


▲ Indicates Funded
△ Indicates NonFunded

Office of Aeronautics and Space Technology

NASA
National Aeronautics and Space Administration

SPACE R&T OVERVIEW



Gregory M. Reck
Director for Space Technology
Office of Aeronautics and Space Technology

OAST

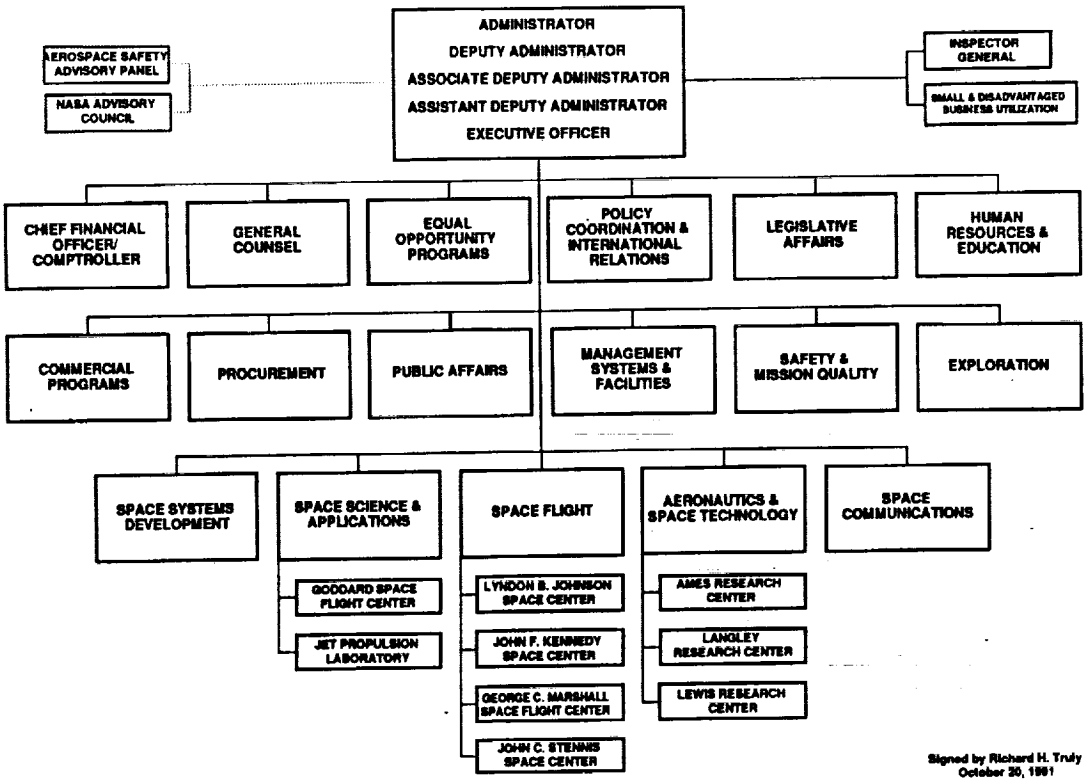
March 1992

SPACE RESEARCH & TECHNOLOGY OVERVIEW

OAST

- ORGANIZATION
- OBJECTIVES AND STRUCTURE
- PROGRAM ELEMENTS AND MILESTONES
- PLANNING AND RESOURCES
- ACCOMPLISHMENTS
- CENTER ROLES

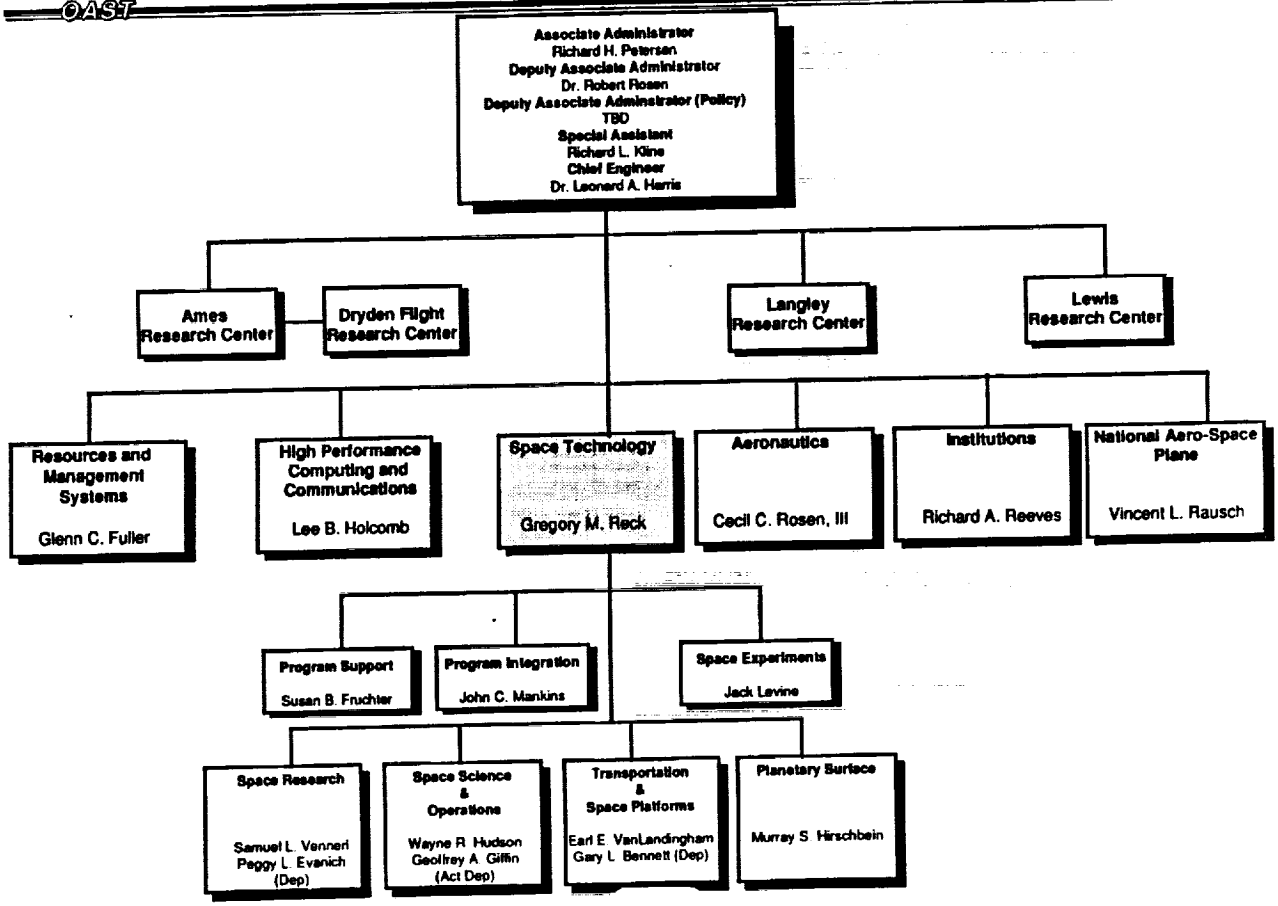
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



Signed by Richard H. Truly
October 30, 1991

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

OAST



OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
FY 1992 BUDGET

OAST

($,M)

APPROP.	AERO	TRANSAT.	SPACE	TOTAL
R&D	574.2	5.0	309.3*	888.5
R&PM	273.1	16.1	138.4	427.6
CofF	42.3	-	-	42.3
SUBTOTAL	889.6	21.1	447.7	1358.4
RES. OPS. SUPP.				210.1
TOTAL				1568.5

* SPACE EXCLUDES MISSION STUDIES ($5.0M)

92-1038
Rev 2/26/92

SPACE R&T MISSION STATEMENT

OAST

OAST SHALL PROVIDE TECHNOLOGY FOR FUTURE CIVIL SPACE MISSIONS AND PROVIDE A BASE OF RESEARCH AND TECHNOLOGY CAPABILITIES TO SERVE ALL NATIONAL SPACE GOALS

- *IDENTIFY, DEVELOP, VALIDATE AND TRANSFER TECHNOLOGY TO:*
  - INCREASE MISSION SAFETY AND RELIABILITY
  - REDUCE PROGRAM DEVELOPMENT AND OPERATIONS COST
  - ENHANCE MISSION PERFORMANCE
  - ENABLE NEW MISSIONS
- *PROVIDE THE CAPABILITY TO:*
  - ADVANCE TECHNOLOGY IN CRITICAL DISCIPLINES
  - RESPOND TO UNANTICIPATED MISSION NEEDS

LBF4194B

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

RESEARCH & TECHNOLOGY STRATEGY

OAST

FLIGHT PROGRAMS FORECAST

- **5-YEAR FORECAST INCLUDES**

'93 THRU '97: LIMITED NEW STARTS

COMPLETION OF INITIAL SSF
SOME SHUTTLE IMPROVEMENTS
INITIAL EOS & EOSDIS
SELECTED SPACE SCIENCE STARTS
NLS DEVELOPMENT
INITIAL SEI ARCHITECTURE SELECTION
EVOLVING GEO COMMERCIAL COMMSATS
MINOR UPGRADES OF COMMERCIAL ELVS

- **10-YEAR FORECAST INCLUDES**

'98 THRU '03: MULTIPLE NEW STARTS TO BE LAUNCHED IN 2003 THRU 2010

SSF EVOLUTION/INFRASTRUCTURE
FINAL SHUTTLE ENHANCEMENTS
ADVANCED LEO EOS PLATFORMS/FULL EOSDIS
MULTIPLE SPACE SCIENCE STARTS
NLS OPERATIONS/EVOLUTION
EVOLVING LAUNCH/OPERATIONS FACILITIES
INITIAL SEI/LUNAR OUTPOST START
DSN EVOLUTION (KA-BAND COMMUNICATIONS)
NEW GEO COMMERCIAL COMMSATS
NEW COMMERCIAL ELVS

- **20-YEAR FORECAST INCLUDES**

'04 THRU '11 MULTIPLE OPTIONS FOR NEW STARTS TO BE LAUNCHED IN 2009 THRU 2020

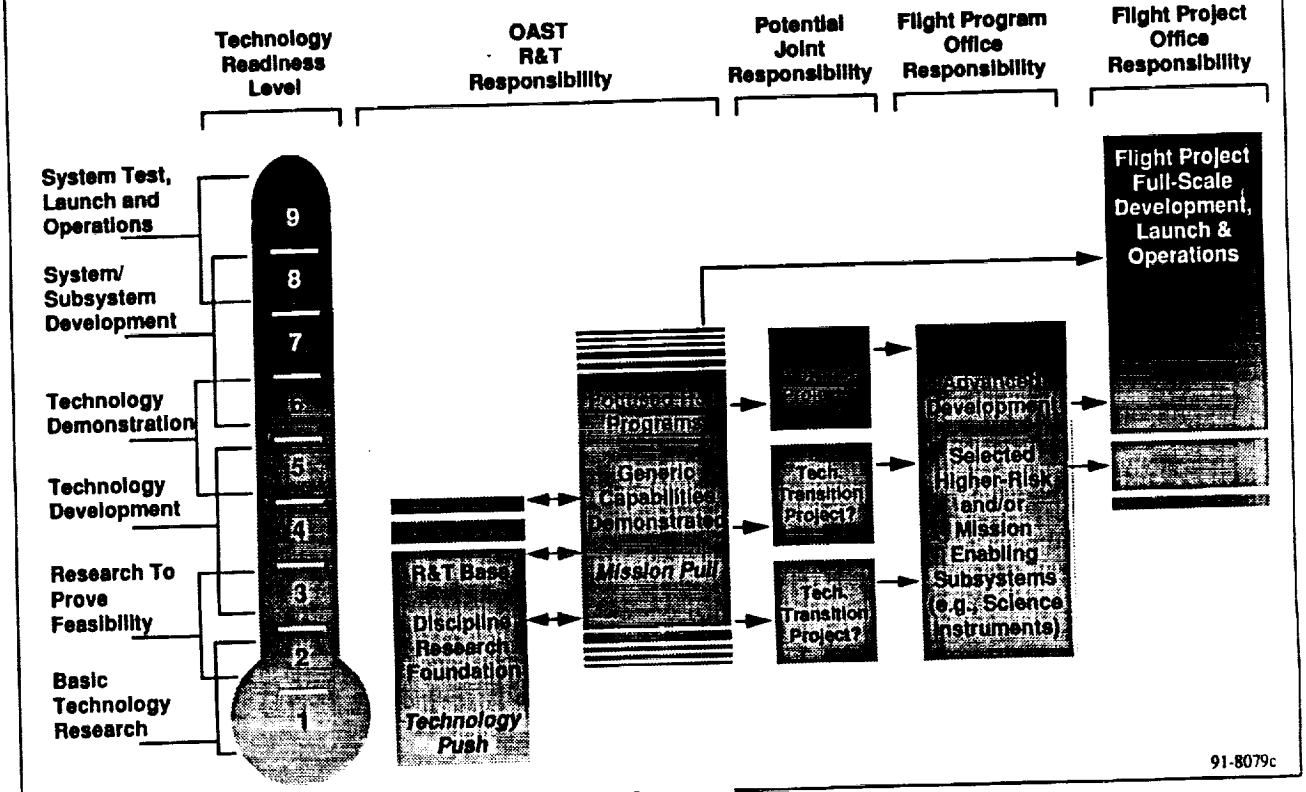
SSF-MARS EVOLUTION
BEGINNING OF AMLS/PLS DEVELOPMENT
MULTIPLE SPACE SCIENCE STARTS
DSN EVOLUTION (OPTICAL COMM)
INITIAL MARS HLLV DEVELOPMENT
EVOLVING LUNAR SYSTEMS
MARS SEI ARCHITECTURE CHOSEN
LARGE GEO COMMSATS
NEW COMMERCIAL ELVS

LBF40305
(JCM-7692)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY MATURATION STRATEGY

OAST



INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH

Aerothermodynamics
Space Energy Conversion
Propulsion
Materials & Structures
Information and Controls
Human Support
Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY

Science Sensing
Observatory Systems
Science Information
In Situ Science
Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY

Surface Systems
Human Support
Technology Flight Expts.

TRANSPORTATION TECHNOLOGY

ETO Transportation
Space Transportation
Technology Flight Expts.

SPACE PLATFORMS TECHNOLOGY

Earth-Orbiting Platforms
Space Stations
Deep-Space Platforms
Technology Flight Expts.

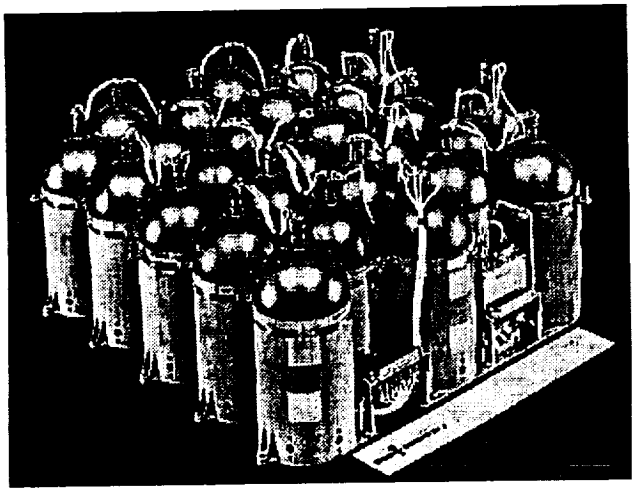
OPERATIONS TECHNOLOGY

Automation & Robotics
Infrastructure Operations
Info. & Communications
Technology Flight Expts.

LBF40319

DISCIPLINE RESEARCH

CONCEIVE, DEVELOP AND VALIDATE NEW TECHNOLOGY CONCEPTS AND APPROACHES FOR ENHANCING OR ENABLING FUTURE SPACE MISSIONS, INCLUDING REVOLUTIONARY IMPROVEMENTS IN SPACE CAPABILITY



- **DISCIPLINE RESEARCH TECHNOLOGY**
  - **AEROTHERMODYNAMICS**
  - **SPACE ENERGY CONVERSION**
  - **PROPULSION**
  - **MATERIALS & STRUCTURES**
  - **INFORMATION & CONTROLS**
  - **HUMAN SUPPORT**
  - **ADVANCED COMMUNICATIONS**

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91-8064

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

R&T Base Discipline Programs Content

OAST

	BASE CAPABILITIES	ADVANCED TECHNOLOGIES	"BREAKTHROUGH" TECHNOLOGIES
Aerothermo-dynamics	Hypersonic Flowfield Sim. Hypersonic Vehicle Synth. Fundamental Data Bases	Flt. Environ. Instrument'n Configuration Design/Optimiz. Aerothermo. Design Tools	—
Space Communications	Traveling Wave Tubes (TWTs) MMICs	KaBand TWT Digital Switching Processors Ground Terminals Solid State MMIC Systems Direct Broadcast (Audio)	Laser Comm. Components Mobile Comm. Systems (Personal)
Space Energy Conversion	Photovoltaic Perf. Validation Solar Dynamics Design/Analysis Electrochemical Diagn./Models	Adv. Solar Cells (GaAs, In-P) Adv. Batteries (Rechg/Life) Thermoelectric Conv. Systems Concentrators and Arrays Solar Dynamics Conv. Systems Power Mgt. & Distribution	Laser Power Components Alkali Metal T-E Conversion Diamond Film Pwr Electronics Adv. Fuel Cells (Li/CO2) Liquid Sheet Radiators
Human Support	Extravehicular Activity Suit Human Modeling (Cogn./Physical)	EVA Gloves EMU Components Life Support Models PLSS Components Interactive EVA Displays Life Support Sensors/Cntrls	Visualization Research AI Computer Associates Virtual Reality Environments
Information and Controls	Electro-optic Mat'ls/Sensors	Advanced AI Research Computational Controls Software Develop. Tools	Micromachines Photonics Multiple Interactive Robots Neural Networks High-Temp Superconductors
Materials and Structures	Materials Synthesis Space Durable Materials Sp. Environ. Effects (Mat's) High Temp. TPS Advanced Space Struct. Concepts Tribology	Optics High Precision Struct. Durable Polymers Mechanisms Lg./Deployed Struct. High Temp. Veh. Struct. Extreme TPS Debris Shielding	Intermetallics & Metal Matrix Computational Materials Adaptive Materials Computational Chemistry "Smart" Materials
Propulsion	Combustion Models/Diagn. Internal Pump Flow CFD Engine Analysis Expert Systems Cryo. Fluid Modeling	Ion Thrusters Water Resistojets H-O Engines Hydrogen Arcjets Iridium-Rhenium Engine Liners Propulsion Health Mgt. MPD Thrusters	High Energy Density Propell. Laser Rocket Propulsion Superconduct Bearings Electrodeless Thrusters (ECR) Fission/Fusion Propulsion

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SPACE FLIGHT RESEARCH & TECHNOLOGY

PROVIDE FOR EXPERIMENT STUDIES, DEVELOPMENT AND SUPPORT FOR IN-SPACE FLIGHT RESEARCH AND VALIDATION OF ADVANCED SPACE TECHNOLOGIES

- IN-SPACE TECHNOLOGY EXPERIMENT PROGRAM (IN-STEP)
  - DESIGN, DEVELOP AND FLIGHT TEST INDUSTRY, UNIVERSITY AND NASA TECHNOLOGY FLIGHT EXPERIMENTS
- FLIGHT OPPORTUNITIES VIA
  - SPACE SHUTTLE
  - EXPENDABLE LAUNCH VEHICLES
  - SPACE STATION FREEDOM

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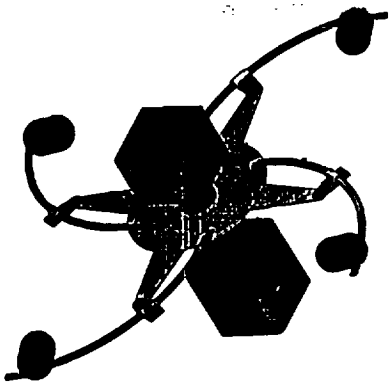
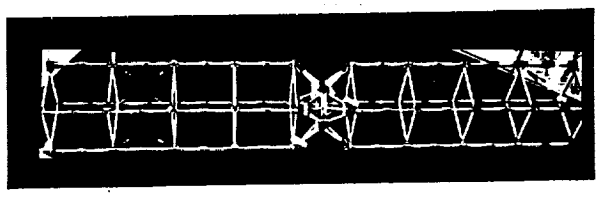
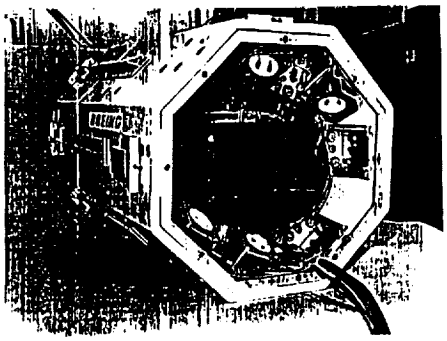
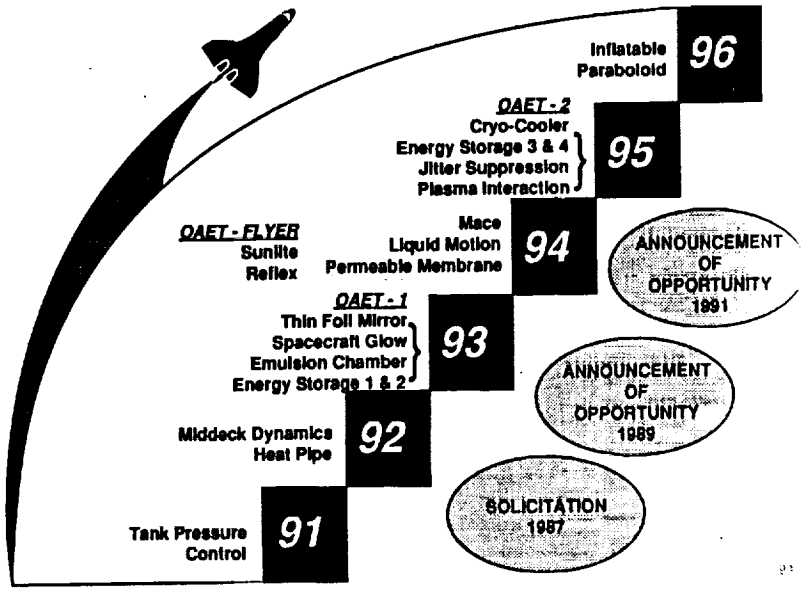
IN-SPACE TECHNOLOGY EXPERIMENTS



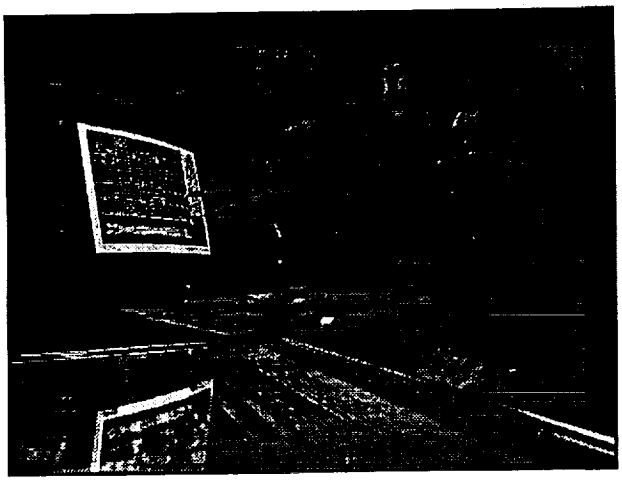






UNIVERSITY PROGRAMS

BROADEN THE CAPABILITIES OF THE NATION'S ENGINEERING COMMUNITY TO PARTICIPATE IN THE U.S. CIVIL SPACE PROGRAM THROUGH UNIVERSITY-BASED RESEARCH AND EDUCATION



- UNIVERSITY SPACE ENGINEERING RESEARCH CENTERS
  - FOSTER CREATIVE AND INNOVATIVE CONCEPTS OF FUTURE SPACE SYSTEMS
  - EXPAND THE NATION'S ENGINEERING TALENT BASE FOR RESEARCH AND DEVELOPMENT
- UNIVERSITY INVESTIGATORS RESEARCH
  - SPONSOR INDIVIDUAL RESEARCH ON HIGHLY INNOVATIVE SPACE TECHNOLOGY CONCEPTS AND APPROACHES
- UNIVERSITY ADVANCED DESIGN
  - FOSTER INTERDISCIPLINARY ENGINEERING DESIGN EDUCATION

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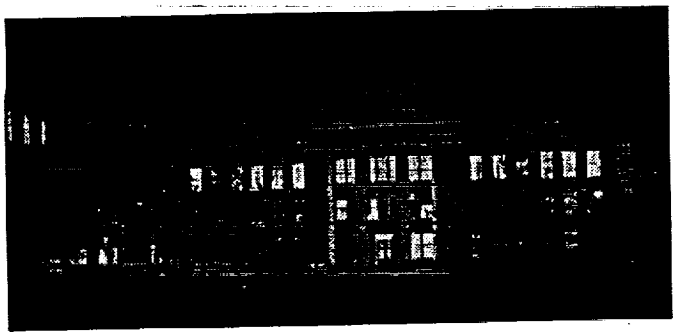
UNIVERSITY SPACE ENGINEERING RESEARCH PROGRAM



- UNIVERSITY OF ARIZONA
  - Planetary Resources
- UNIVERSITY OF CINCINNATI
  - Propulsion Monitoring Systems
- UNIVERSITY OF COLORADO, BOULDER
  - Space Construction
- UNIVERSITY OF IDAHO
  - VLSI hardware
- MASSACHUSETTS INSTITUTE OF TECHNOLOGY
  - Controlled Structures Technology
- UNIVERSITY OF MICHIGAN
  - Space TeraHertz Sensing Technologies
- NORTH CAROLINA STATE AT RALEIGH & NORTH CAROLINA AGRICULTURAL & TECHNICAL STATE UNIVERSITIES
  - Mars Mission Technologies
- PENNSYLVANIA STATE UNIVERSITY
  - Propulsion
- RENSSELAER POLYTECHNIC INSTITUTE
  - Robotics

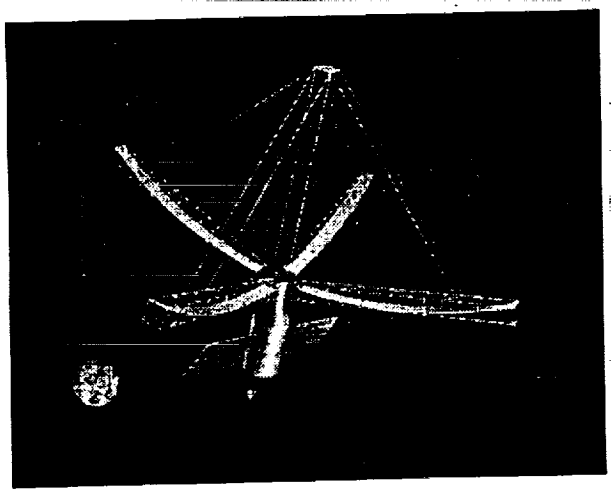
UNIVERSITY-BASED CENTERS

- ATTRACT AND RETAIN STUDENT AND INDUSTRY SUPPORT
- SUPPORT AND EXPAND THE NATION'S ENGINEERING TALENT BASE
- FOSTER INNOVATIVE, MULTI-DISCIPLINARY RESEARCH

91-2118

SYSTEMS ANALYSIS

CONDUCT INTERDISCIPLINARY SYSTEM STUDIES TO IDENTIFY AND PRIORITIZE NEW TECHNOLOGY REQUIREMENTS AND OPPORTUNITIES AND DEVELOP MODELING AND ANALYSIS TOOLS



- FOCUSED PROGRAMS
  - IDENTIFY CRITICAL TECHNOLOGY ISSUES OF FUTURE MISSION CONCEPTS
    - TRANSPORTATION
    - SPACE SCIENCE
    - SPACE PLATFORMS
    - SPACE EXPLORATION
    - OPERATIONS
- BREAKTHROUGH
  - IDENTIFY BENEFITS OF HIGHLY INNOVATIVE SPACE TECHNOLOGY IDEAS AND SPACE APPLICATIONS OF NEW TECHNOLOGY FRONTIERS
- EXTERNAL
  - SUPPORT SPACE COMMERCIALIZATION
  - IMPROVE USE OF INDUSTRY INDEPENDENT R&D (IRAD)
  - PLAN FOR MULTI-AGENCY PROGRAMS

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91-8065

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH
- Aerothermodynamics
- Space Energy Conversion
- Propulsion
- Materials & Structures
- Information and Controls
- Human Support
- Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T
IN SPACE TECHNOLOGY EXPTS

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY
- Science Sensing
- Observatory Systems
- Science Information
- In Situ Science
- Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY
- Surface Systems
- Human Support
- Technology Flight Expts.

TRANSPORTATION TECHNOLOGY
- ETO Transportation
- Space Transportation
- Technology Flight Expts.

SPACE PLATFORMS TECHNOLOGY
- Earth-Orbiting Platforms
- Space Stations
- Deep-Space Platforms
- Technology Flight Expts.

OPERATIONS TECHNOLOGY
- Automation & Robotics
- Infrastructure Operations
- Info. & Communications
- Technology Flight Expts.

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SCIENCE TECHNOLOGY

DEVELOP ADVANCED INSTRUMENT, OBSERVATION, INFORMATION, AND IN SITU MEASUREMENT TECHNOLOGIES TO MAXIMIZE THE RETURN FROM NASA SPACE AND EARTH SCIENCE MISSIONS OVER THE NEXT TWENTY YEARS

- **EXPAND CAPABILITY AND REDUCE COSTS THROUGH DISCIPLINARY ADVANCEMENTS WHICH INCREASE SCIENCE INFORMATION RETURN AND SPACECRAFT PERFORMANCE**
  - **INSTRUMENT**
  - **OBSERVATION**
  - **DATA & INFORMATION**
  - **IN SITU MEASUREMENT**
- **ENABLE THE NEXT GENERATION OF SPACE SCIENCE MISSIONS**
  - **ASTROPHYSICS**
  - **SOLAR SYSTEM EXPLORATION**
  - **SPACE PHYSICS**
  - **EARTH SCIENCE**
  - **LIFE SCIENCES/MICROGRAVITY**

91-8046

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SCIENCE TECHNOLOGY

INSTRUMENT

- IR Detectors
- Active Microwave
- Optoelectronics
- Submillimeter Detectors
- High Energy Detectors
- Passive Microwave
- Laser Sensors
- Sensor Readouts

OBSERVATION

- Cryocoolers
- Micro Precision CSI
- Precision Pointing
- Telescope Systems
- Sensor Optics

IN SITU MEASUREMENT

- Sample Acquisition, Analysis, and Preservation
- Probes and Penetrators

DATA & INFORMATION

- Data Archives
- Information Visualization

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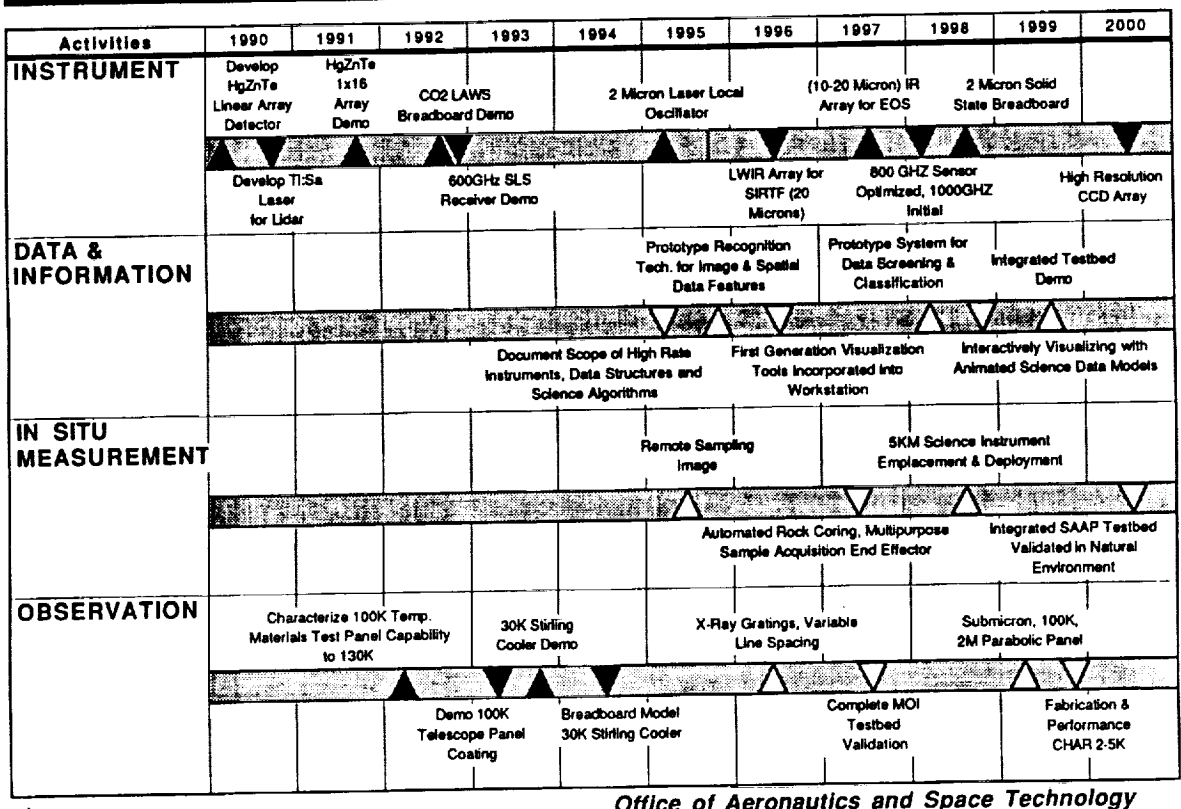
SPACE SCIENCE MILESTONES



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▲ Indicates Funded
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PLANETARY SURFACE TECHNOLOGY

PROVIDE KEY TECHNOLOGIES FOR ROBOTIC AND MANNED PLANETARY SURFACE EXPLORATION SYSTEMS INCLUDING CAPABILITIES FOR AN OUTPOST ON THE MOON AND EXPLORATION OF THE PLANET MARS

- **INCREASE RELIABILITY AND REDUCE RISK; REDUCE DEVELOPMENT AND OPERATIONS COST; AND ENABLE NEW AND INNOVATIVE CAPABILITIES IN THE AREAS OF:**
  - **ADVANCED SURFACE SYSTEM OPERATIONS ON THE MOON AND MARS**
  - **TECHNOLOGIES FOR HUMAN SUPPORT DURING VERY LONG DURATION PILOTED MISSIONS IN DEEP-SPACE AND ON PLANETARY SURFACES**

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rev 8/23/91

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PLANETARY SURFACE TECHNOLOGY

SURFACE SYSTEMS

- Space Nuclear Power
- In Situ Resource Utilization
- Planetary Rover
- High Capacity Power
- Surface Power and Thermal Management
- Surface Habitats & Construction
- Laser-Electric Power Beaming

HUMAN SUPPORT

- Regenerative Life Support
- Radiation Protection
- Extravehicular Activity Systems
- Exploration Human Factors
- Artificial Gravity
- Remote Medical Care Systems

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rev 8/23/91

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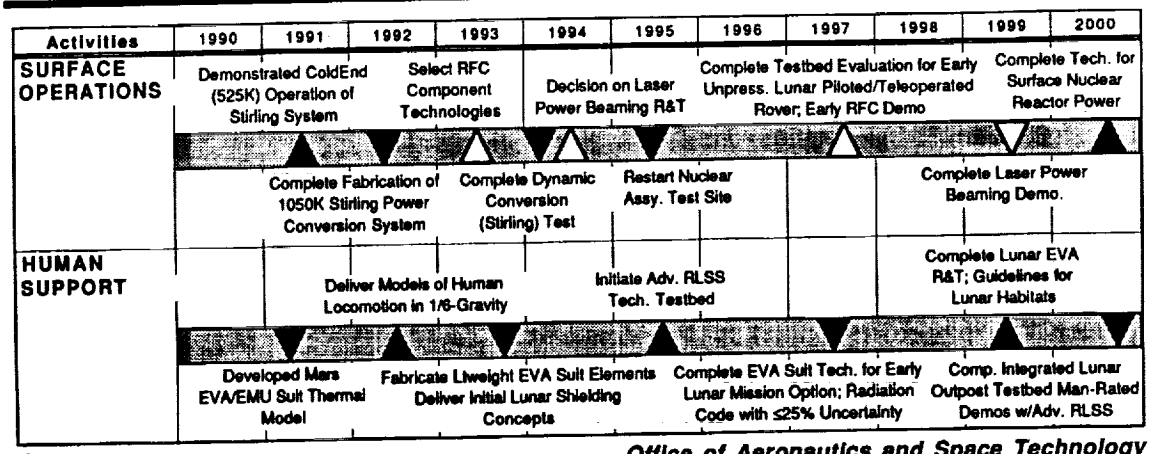
PLANETARY SURFACE MILESTONES



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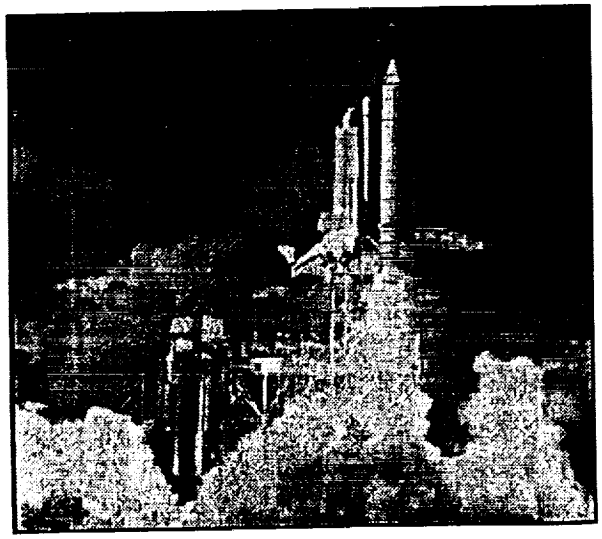
TRANSPORTATION TECHNOLOGY

PROVIDE TECHNOLOGIES THAT SUBSTANTIALLY INCREASE OPERABILITY, IMPROVE RELIABILITY, PROVIDE NEW CAPABILITIES, WHILE REDUCING LIFE CYCLE COSTS



- ENHANCE SAFETY, RELIABILITY, AND SERVICEABILITY OF CURRENT SPACE SHUTTLE
- PROVIDE TECHNOLOGY OPTIONS FOR NEW MANNED SYSTEMS THAT COMPLEMENT THE SHUTTLE AND ENABLE NEXT GENERATION VEHICLES WITH RAPID TURNAROUND AND LOW OPERATIONAL COSTS
- SUPPORT DEVELOPMENT OF ROBUST, LOW-COST HEAVY LIFT LAUNCH VEHICLES
- DEVELOP AND TRANSFER LOW-COST TECHNOLOGY TO SUPPORT COMMERCIAL ELV's AND UPPER STAGES
- IDENTIFY AND DEVELOP HIGH LEVERAGE TECHNOLOGIES FOR IN-SPACE TRANSPORTATION, INCLUDING NUCLEAR PROPULSION, THAT WILL ENABLE NEW CLASSES OF SCIENCE AND EXPLORATION MISSIONS

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TRANSPORTATION TECHNOLOGY

SHUTTLE ENHANCEMENT

- SSME Improvements
- Durable Thermal Protection Systems
- Improved Health Monitoring
- Light Structural Alloys
- Lidar-Based Adaptive Guidance & Control

NEXT GENERATION MANNED TRANSPORTS

- Configuration Assessment
- High Frequency, High Voltage Power Management/Distribution Systems
- LOX/LH2 Propellant for OMS/RCS
- Maintenance-free TPS
- Advanced Reusable Propulsion
- GPS-Based Autonomous GN&C
- Composites & Advanced Lightweight Metals
- Vehicle-Level Health Management For Autonomous Operations

HEAVY-LIFT CAPABILITY

- Advanced Fabrication (Forming & Joining)
- STME Improvements
- On-Vehicle Adaptive Guidance & Control
- Systems & Components for Electric Actuators
- Health Monitoring for Safe Operations
- AL-LI Cryo Tanks

LOW-COST COMMERCIAL

- Alternate Booster Concepts
- Advanced Cryogenic Upper Stage Engines
- Low-Cost Fab./Automated Processes/NDE
- Continuous Forging Processes for Cryogenic Tanks
- Fault-Tolerant, Redundant Avionics

IN-SPACE TRANSPORT

- High-Power Nuclear Thermal & Electric Propulsion
- High Performance, Multiple Use Cryogenic Chemical Engine
- Highly Reliable, Autonomous Avionics
- Low Mass, Space Durable Materials
- Long-Term, Low-Loss Management of Cryogenic Hydrogen
- Autonomous Rendezvous, Docking & Landing
- Aeroassist Technologies

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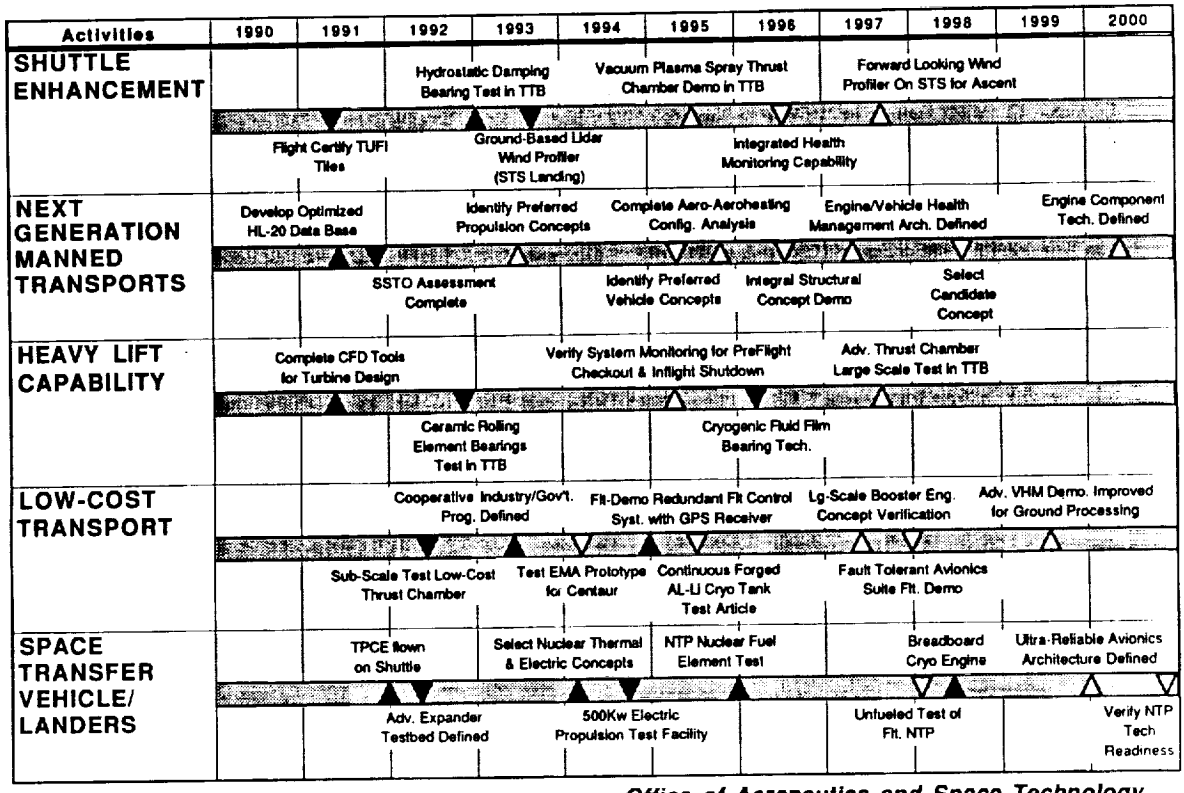
TRANSPORTATION MILESTONES



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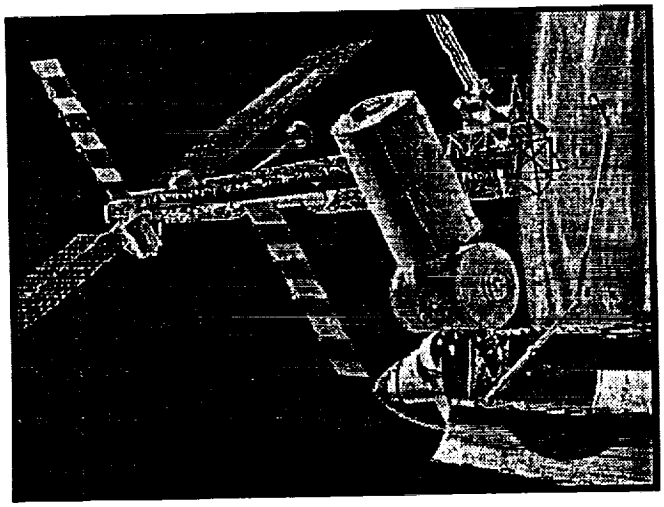
SPACE PLATFORMS TECHNOLOGY

DEVELOP TECHNOLOGIES TO INCREASE ON-ORBIT MISSION EFFICIENCY AND DECREASE LIFE CYCLE COSTS FOR FUTURE MANNED AND UNMANNED SCIENCE, EXPLORATION & COMMERCIAL MISSIONS.



- DEVELOP TECHNOLOGIES THAT WILL DECREASE LAUNCH WEIGHT AND INCREASE THE EFFICIENCY OF SPACE PLATFORM FUNCTIONAL CAPABILITIES
- DEVELOP TECHNOLOGIES THAT WILL INCREASE HUMAN PRODUCTIVITY AND SAFETY OF MANNED MISSIONS
- DEVELOP TECHNOLOGIES THAT WILL INCREASE MAINTAINABILITY AND REDUCE LOGISTICS RESUPPLY OF LONG DURATION MISSIONS
- IDENTIFY AND DEVELOP FLIGHT EXPERIMENTS IN ALL TECHNOLOGY AND THRUST AREAS THAT WILL BENEFIT FROM THE UTILIZATION OF SSF FACILITIES

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SPACE PLATFORMS TECHNOLOGY

EARTH-ORBITING PLATFORMS

- Structural Dynamics
- On-Orbit Non-Destructive Evaluation Techniques
- Space Environmental Effects
- Power Systems
- Thermal Management
- Advanced Information Systems

SPACE STATIONS

- Regenerative Life Support
- Integrated Propulsion and Fluid Systems Architecture
- Extravehicular Mobility
- Telerobotics
- Artificial Intelligence

SPACE-BASED LABORATORY AND TESTBED

- Exploit Microgravity and Crew Interactive Capability to Advance and Validate Selected Technologies

DEEP SPACE MISSIONS

- Power and Thermal Management
- Propulsion
- Guidance, Navigation and Control

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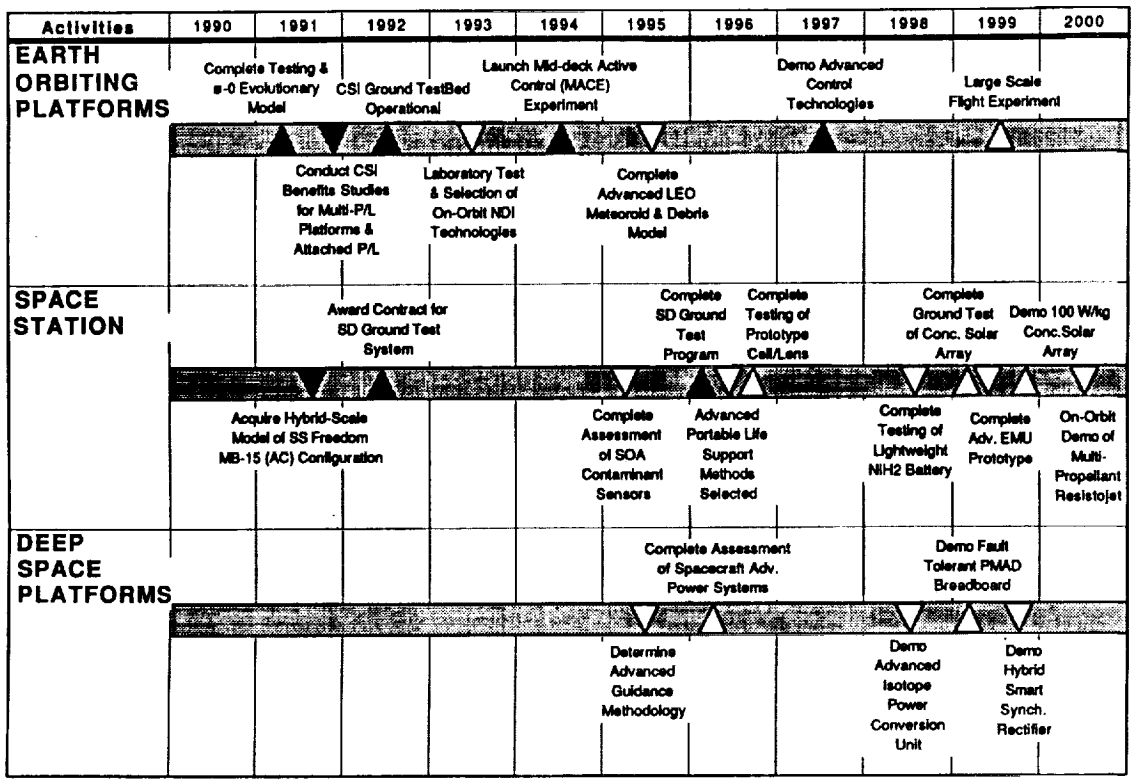
SPACE PLATFORMS MILESTONES



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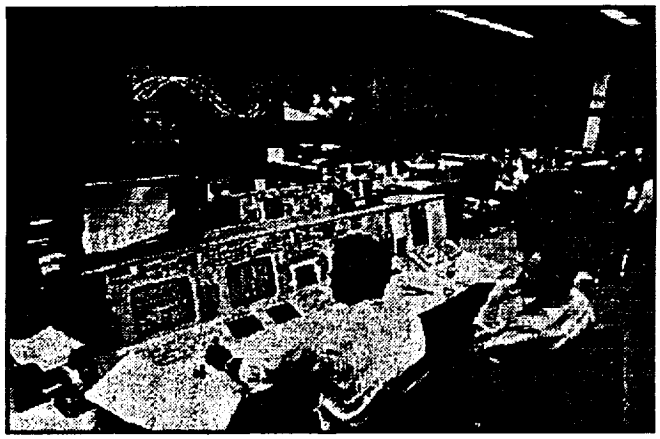
OPERATIONS TECHNOLOGY

DEVELOP AND DEMONSTRATE TECHNOLOGIES TO REDUCE THE COST OF NASA OPERATIONS, IMPROVE THE SAFETY AND RELIABILITY OF THOSE OPERATIONS, AND ENABLE NEW, MORE COMPLEX ACTIVITIES TO BE UNDERTAKEN



- THE OPERATIONS THRUST SUPPORTS THE FOLLOWING MAJOR ACTIVITIES:
  - IN-SPACE OPERATIONS
  - FLIGHT SUPPORT OPERATIONS
  - GROUND SERVICING AND PROCESSING
  - PLANETARY SURFACE OPERATIONS
  - COMMERCIAL COMMUNICATIONS
- THE FOLLOWING TECHNOLOGY AREAS ARE INCLUDED:
  - AUTOMATION & ROBOTICS
  - INFRASTRUCTURE OPERATIONS
  - INFORMATION & COMMUNICATIONS
  - FLIGHT EXPERIMENTS

91-8055

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OPERATIONS TECHNOLOGY

AUTOMATION & ROBOTICS

- Mission Control Support
- Planning & Scheduling
- Ground Servicing & Support Roles
- In-Space Teleoperation & Telerobotics

INFRASTRUCTURE OPERATIONS

- In-Space Assembly & Construction
- Space Processing & Servicing
- Training & Human Factors
- Ground Test & Processing
- Flight Control & Space Operations

INFORMATION & COMMUNICATIONS

- Space Data Systems
- Ground Data Systems
- Commercial Satellite Communications
- Photonics Systems
- High Rate Communications

FLIGHT EXPERIMENTS

- Commercial Satellite Communications
- Optical Communications

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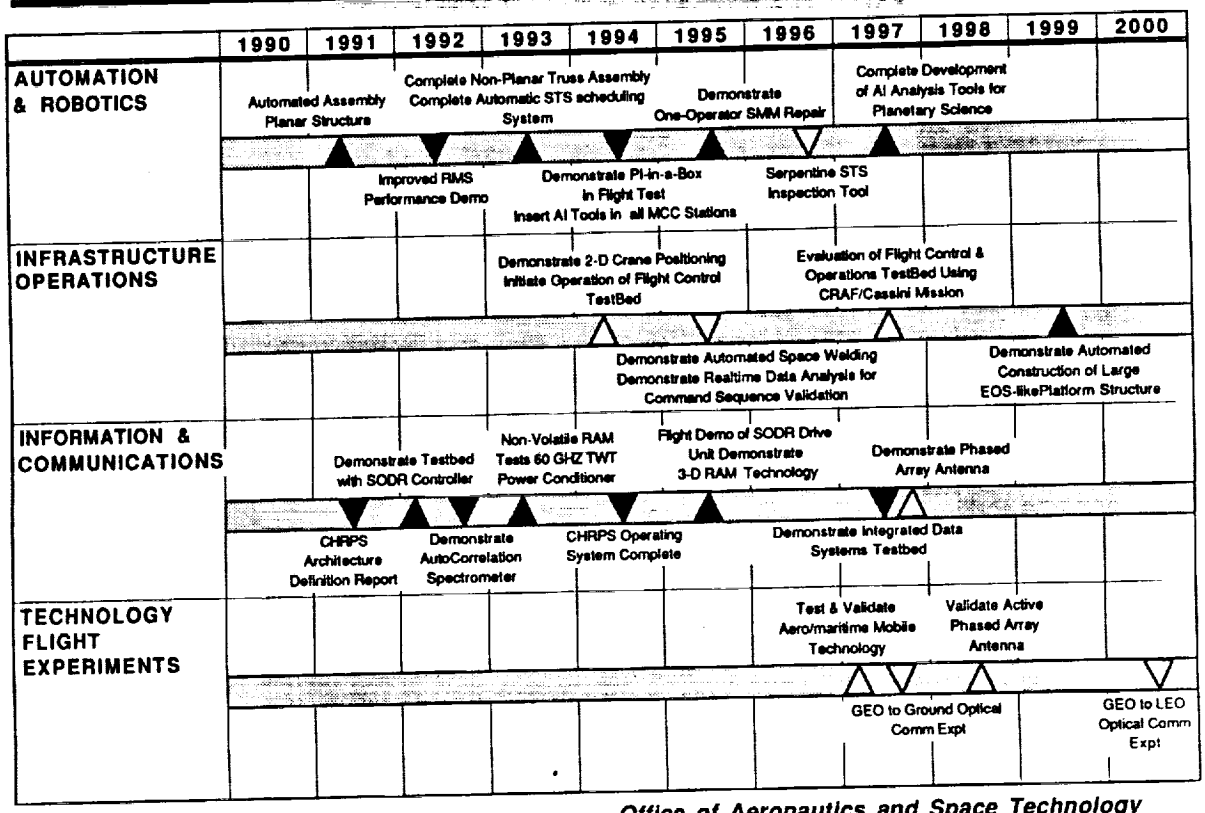
OPERATIONS MILESTONES



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INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

Strategic Plan ITP: CSTI Element Categorization

OAST

	HIGHEST PRIORITY ◊◊◊			2nd-HIGHEST PRIORITY ◊◊			3rd-HIGHEST PRIORITY ◊		
Space Science Technology	Submillimeter Sensing	Direct Detectors	Active µwave Sensing	Sample Acq., Analysis & Preservation	Passive Microwave Sensing	---	Optoelectrnics Sensing & Processing	Probes and Penetrators	---
	Cooler and Cryogenics	Sensor Electronics Microprecision CSI	Laser Sensing Telescope Optical Systems	Data Archiving and Retrieval	Data Visualization and Analysis	---	Precision Instrument Pointing	Sensor Optical Systems	---
Planetary Surface Technology	Radiation Protection	Regenerative Life Support (Phys-Chem.)	Space Nuclear Power (SP-100)	High Capacity Power	Planetary Rovers	Surface Habitats and Construction	Exploration Human Factors	---	Artifical Gravity
	---	---	Extravehicular Activity Systems	Surface Solar Power and Thermal Mgt.	In Situ Resource Utilization	Laser-Electric Power Beaming	Medical Support Systems	---	---
Transportation Technology	ETO Propulsion	Nuclear Thermal Prop. Aeroassist Flight Expt	Aeroassist/ Aerobraking	Transfer Vehicle Avionics	ETO Vehicle Avionics	ETO Vehicle Structures & Materials	Autonomous Rendezvous & Docking	COHE	Auxiliary Propulsion
	Cryogenic Fluid Systems	Advanced Cryo. Engines	Low-Cost ETO Transport	Nuclear Electric Propulsion	CONE	---	Autonomous Landing	TV Structures and Cryo Tankage	HEAb
Space Platforms Technology	Platform Structures & Dynamics	Platform Power and Thermal Mgt.	Zero-G Life Support	Platform Materials & Environ. Effects	Station-Keeping Propulsion	---	Spacecraft On-Board Propulsion	Earth-Orbiting Platform Controls	Advanced Refrigerator Systems
	---	---	Zero-G Advanced EMU	Platform NDE-NDI	Deep-Space Power and Thermal	---	Spacecraft GN&C	Debris Mapping Experiment	---
Operations Technology	Space Data Systems	High-Rate Comm.	Artificial Intelligence	Ground Data Systems	Optical Comm Flight Expt	Flight Control and Operations	Space Assembly & Construction	Space Processing & Servicing	Photonics Data Systems
	---	CommSat Communicat'ns	TeleRobotics	Operator Syst./Training	Flt. Telerobotic Servicer/DTF-1 Navigation & Guidance	CommSat Communicat'ns Flight Expts	---	Ground Test and Processing	---

LBF40343 FIG

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

FY 1992 Program ITP: CSTI Element Categorization

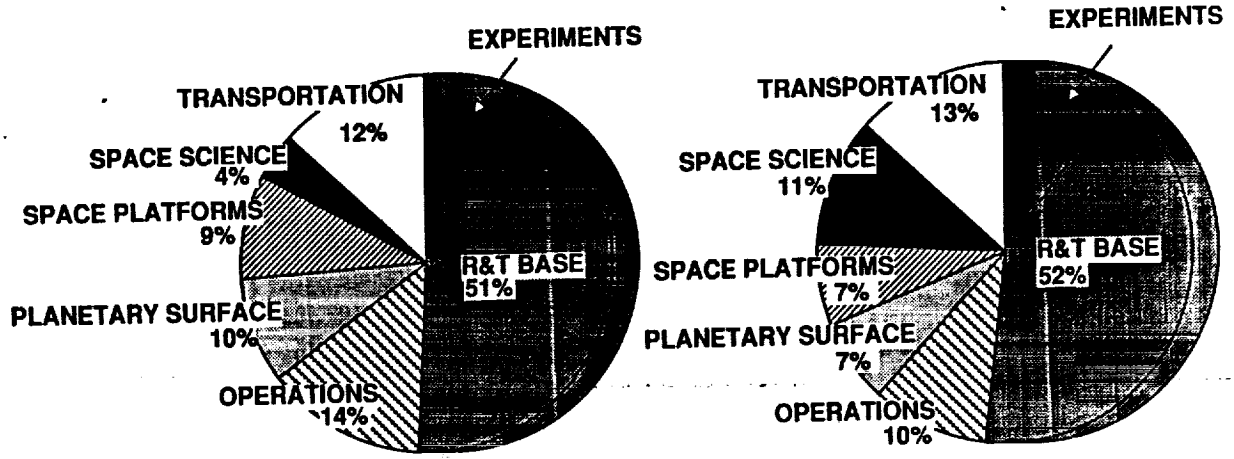
OAST

	HIGHEST PRIORITY ◊◊◊			2nd-HIGHEST PRIORITY ◊◊			3rd-HIGHEST PRIORITY ◊		
Space Science Technology	Submillimeter Sensing	Direct Detectors	Laser Sensing	---	---	---	---	---	---
	Cooler and Cryogenics	Microprecision CSI	---	---	---	---	---	---	---
Planetary Surface Technology	Radiation Protection	Regenerative Life Support (Phys-Chem.)	Space Nuclear Power (SP-100)	High Capacity Power	---	---	---	---	---
	---	---	Extravehicular Activity Systems	---	---	Laser Electric Power Beaming	---	---	---
Transportation Technology	ETO Propulsion	---	---	---	---	---	---	---	---
	---	Advanced Cryogenic Engines	Nuclear Thermal Propulsion	Nuclear Electric Propulsion	---	---	---	---	---
Space Platforms Technology	Platform Structures & Dynamics	Platform Power & Thermal Mgt.	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---
Operations Technology	Space Data Systems	---	Artificial Intelligence	---	---	---	---	---	---
	---	---	TeleRobotics	---	---	---	---	---	---

LBF40?

SPACE RESEARCH & TECHNOLOGY PROGRAM

OAST



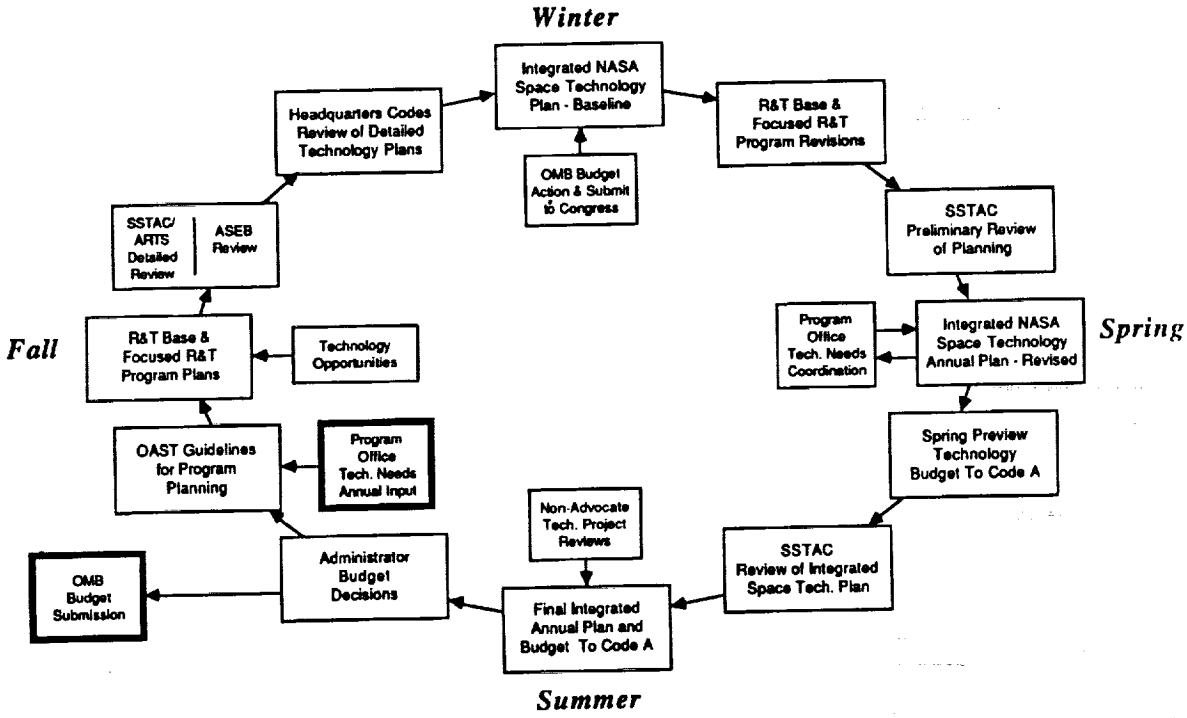
FY 1992
$309.3M

FY 1993
$332.0M

LBF 404

SPACE TECHNOLOGY PLANNING CYCLE

OAST



March 25, 1991
JCM-7207b

FY1991 SPACE TECHNOLOGY ACCOMPLISHMENTS

OAST

SCIENCE

HgZnTe 1x270 ARRAY
SILICON-COMPATIBLE INFRARED SENSORS
GeBIB DETECTOR ARRAYS
SIS MIXER ELEMENTS
2-MICRON LASER FOR LIDAR
MICRODYNAMIC COMPONENT TESTER
AOTF-BASED IMAGING SPECTROMETER

OPERATIONS

AUTOMATED ASSEMBLY OF SPACE STRUCTURES
ADVANCED TELEOPERATION
AUTONOMOUS MOBILE EXPLORATION ROBOT
MINI-ROVER TECHNOLOGY
ASTRONAUT SCIENCE ADVISOR
AUTOCLASS IV
REAL-TIME DATA SYSTEM
SPACECRAFT HEALTH AUTOMATED REASONING PROTOTYPE
SCIENTIFIC ANALYSIS ASSISTANT
LOSSLESS DATA COMPRESSOR
IMAGING SPECTROMETER FLIGHT PROCESSOR
HIGH SPEED FIBER OPTIC TRANSCEIVER
DIGITAL AUTOCORRELATOR SPECTROMETER
SPACEFLIGHT OPTICAL DISK RECORDER
INTELLIGENT DATA MANAGEMENT

PLANETARY SURFACE

STIRLING COLD END MOTORING TEST
REGENERATIVE LIFE SUPPORT

TRANSPORTATION

NEW CFD TOOLS FOR TURBINE BLADE DESIGN
NEW TECHNOLOGY MAIN COMPUSTION CHAMBER
HIGH-ASPECT-RATIO COOLING CHANNEL DESIGNS
LOW COST THRUST CHAMBER CRITICAL TEST
CERAMIC COMPOSITE ENGINE PARTS
CERAMIC BALLS FOR LONG-LIFE BALL BEARINGS

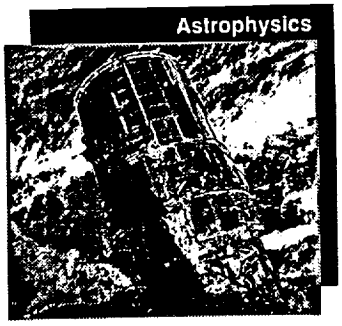
SPACE PLATFORMS

CONTROLS-STRUCTURES INTERACTION
HYBRID-SCALE MODEL OF SSF CONFIGURATION
SIMULATED EVA ASSEMBLY OF TRUSS STRUCTURE AND PANELS

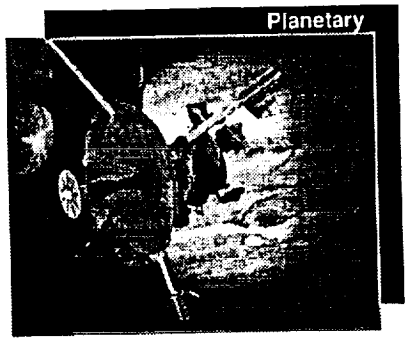
RESEARCH & TECHNOLOGY BASE

PERSONNEL LAUNCH SYSTEM BENCHMARK STUDY
OPTIMIZED PLS HL-20 DATABASE
PLS APPROACH & LANDING SIMULATION STUDY
CERAMIC MATRIX COMPOSITES
WIND TUNNEL AIR FLOW DENSITY MEASUREMENTS
MAGELLAN AEROBRAKE MANEUVER GAS FLOW PREDICTIONS
ADVANCED CONCENTRATOR PHOTOVOLTAIC SYSTEM
ADVANCED PHOTOVOLTAIC SOLAR ARRAY
HOT ROCKET TECHNOLOGY
HIGH POWER ELECTRIC PROPULSION
FOIL BEARING TECHNOLOGY
BRUSH SEAL TECHNOLOGY
MOLECULAR COMPUTATIONAL FLUID DYNAMICS
MULTILAYER INSULATION TECHNOLOGY
TOUGHENED UNI-PIECE FIBROUS INSULATION MATERIAL
ADAPTIVE UNSTRUCTURED MESHES
RADIATION RESISTANCE OF NOVEL TINJ-CONTAINING POLYIMIDE
LDEF SUMMARY
LDEF IONIZING RADIATION
LDEF METEROID AND DEBRIS
FIRST TERAHERTZ FOCAL PLANE ARRAY
MICRO-SENSOR FOR FLOW MEASUREMENTS
ORBITAL ACCELERATION RESEARCH EXPERIMENT
SHUTTLE INFRARED LEESIDE TEMPERATURE SENSING
MULTI-FLEXIBLE BODY DYNAMIC MODELING TOOLS
PHOTONIC DEVICES FOR PLANETARY LANDER
EVA EMU ELECTRONIC CUFF CHECKLIST
VIRTUAL ENVIRONMENT FACILITY

TECHNOLOGY CONTRIBUTIONS TO SCIENCE SPACECRAFT

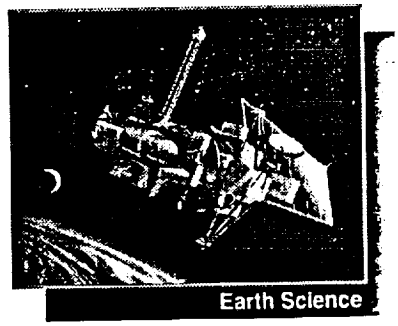


- Hubble - VLSI Data Processing
- Astro - Startracker
- Hubble - Battery Technology
- Hubble - Image Restoration



- Galileo (& Hubble) - CCD Array
- Voyager - Spacecraft Health Monitoring
- Magellan - Radar Ground Processor

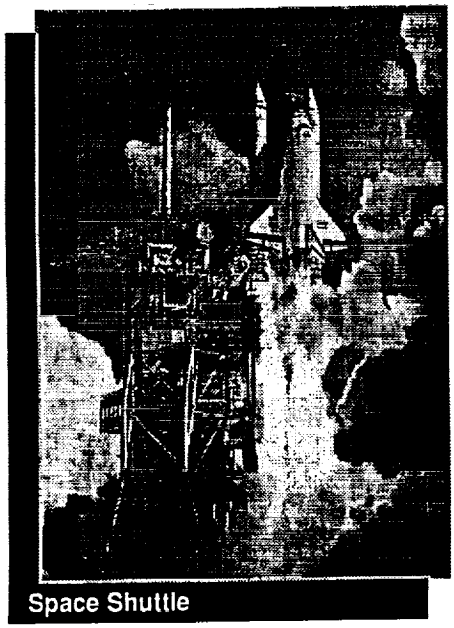
- UARS - 205 GHz Limb Sounder Technology
- Shuttle Imaging Radar - SAR Technologies
- TOPEX - Millimeter Accuracy Laser Ranging



Office of Aeronautics and Space Technology

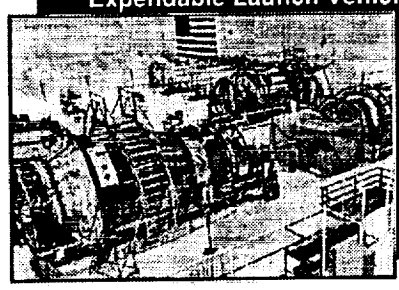
92-8011

TECHNOLOGY CONTRIBUTIONS TO TRANSPORTATION


Space Shuttle

- Structural Analysis for Solid Rocket Motor (SRM) Redesign
- Vacuum Plasma Spray Coatings & Chambers
- Health Monitoring (Test Facilities)
- Thermal Protection System
- Bearing Cooling Analysis
- Real Time Data System
- Orbiter Experiments
- Damping Seals
- Modified Tires

Expendable Launch Vehicles



- Advanced Primary Battery

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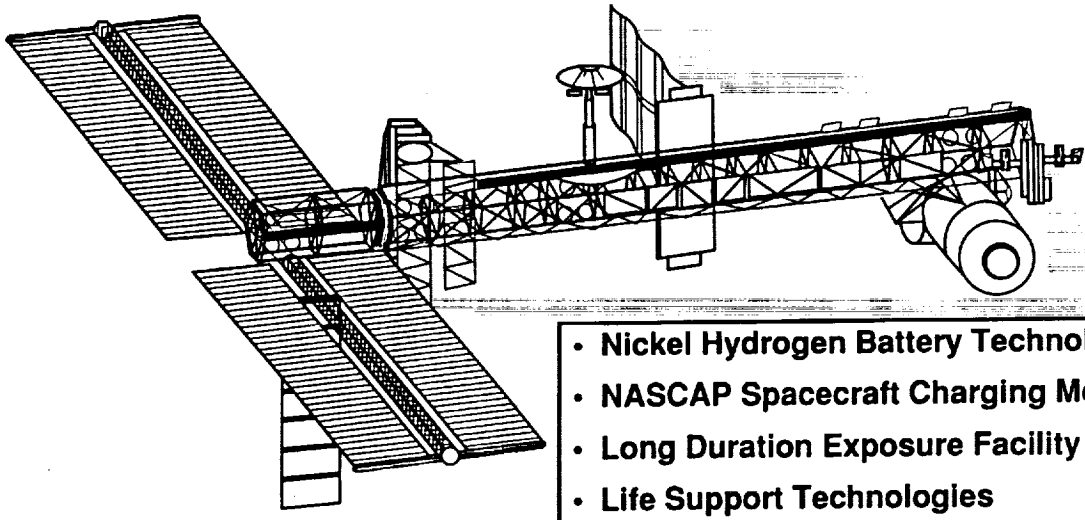
92-8023a

TECHNOLOGY CONTRIBUTIONS TO SPACE PLATFORMS



- Nickel Hydrogen Battery Technology
- NASCAP Spacecraft Charging Model
- Long Duration Exposure Facility
- Life Support Technologies
- Multipropellant Resistojet
- Large Area Solar Cells
- Arcjet Thruster

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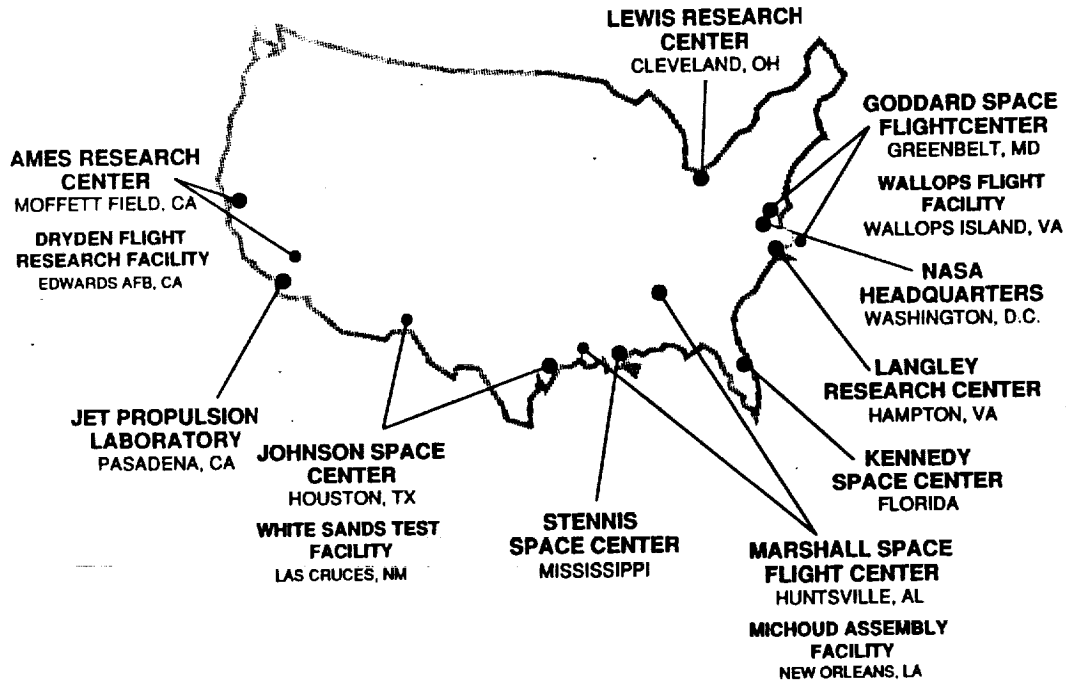
92-8024

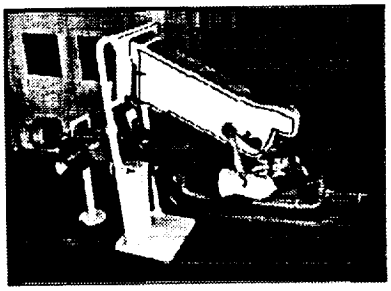
NASA INSTALLATIONS

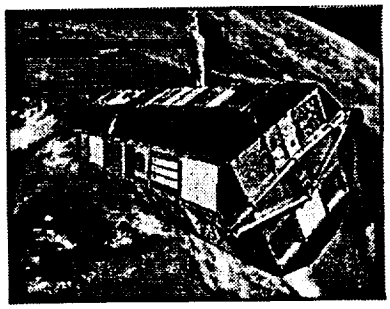


RESEARCH CENTERS

AMES

- Human Support
- Artificial Intelligence
- Aerothermodynamics
- Thermal Protection Systems
- Computer Science



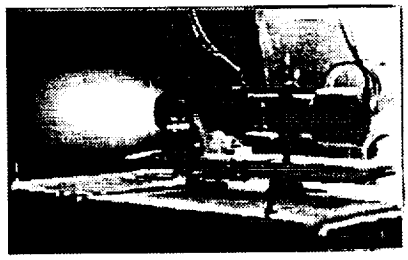


LANGLEY

- Large Space Systems
- Aerothermodynamics, Materials, Structures & Dynamics
- Remote Sensing
- Advanced Vehicle System Concept Studies
- Robotic Systems
- Space Data Systems
- Guidance, Navigation & Control

LEWIS

- Electric Propulsion
- Thermal Management
- Chemical Propulsion
- CryoFluid Systems
- Communications Systems
- Nuclear Propulsion
- Space Power Systems



Office of Aeronautics and Space Technology

91-8089

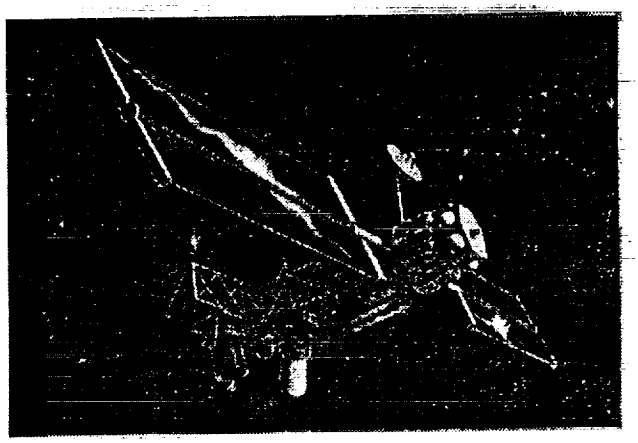
SPACE SCIENCE CENTERS

JET PROPULSION LABORATORY

- Autonomous Systems & Robotics
- Guidance, Navigation & Control
- Sensors
- Space Data & Information Systems
- Optical Systems
- Advanced Propulsion

GODDARD

- Sensors
- Space Data Systems
- Laser Communications
- Telerobotics



Office of Aeronautics and Space Technology

91-8090

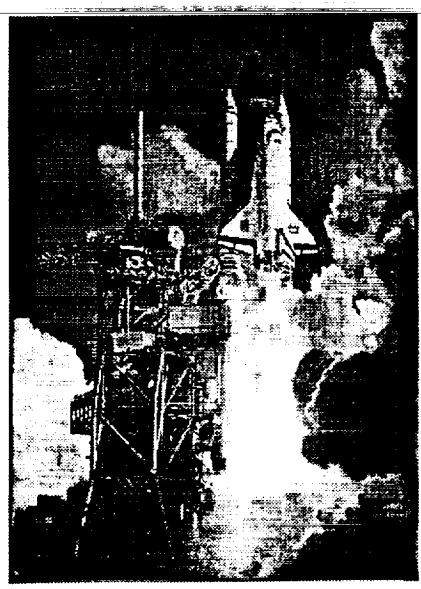
SPACE FLIGHT CENTERS

KENNEDY

- Telerobotics
- Artificial Intelligence

MARSHALL

- Chemical Propulsion
- Structures, Materials & Dynamics
- CryoFluid Systems
- Space Power Systems
- Controls & Avionics



STENNIS

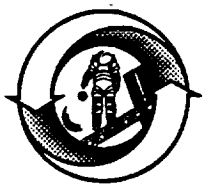
- Chemical Propulsion
- Vehicle Health Monitoring

JOHNSON

- Human Support
- Thermal Management
- Controls & Avionics
- Mission Operations
- InSitu Resource Utilization/Surface Systems

Office of Aeronautics and Space Technology

91-8091



NASA AMES RESEARCH CENTER
Advanced Life Support Division

Document No.: 92-SAS-R-004

TECHNOLOGY TRANSFER IN THE NASA AMES ADVANCED LIFE SUPPORT DIVISION

A Summary of Representative Activities

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Nelson Schlater
The Bionetics Corporation

Vincent Bilardo
NASA Ames Research Center

Paul Masson
Amtech Corporation

For the
OAST
TECHNOLOGY TRANSFER WORKSHOP

March 17-19, 1992
Tysons Corner, Virginia

FOREWORD

This white paper summarizes a representative set of technology transfer activities which are currently underway in the Advanced Life Support Division of NASA Ames Research Center. Five specific NASA-funded research or technology development projects are synopsized which are resulting in transfer of technology in one or more of four main "arenas:" (1) Intra-NASA, (2) Intra-Federal, (3) NASA-Aerospace Industry, and (4) Aerospace Industry-Broader Economy. Each project is summarized as a case history, specific issues are identified, and recommendations are formulated based on the lessons learned as a result of each project. More detailed information on each of the five cases is appended separately.

This collection of materials is offered to the participants of the 1992 NASA OAST workshop entitled "Civil Space Technology Development: A Workshop on Technology Transfer and Effectiveness," in order to stimulate discussion around some concrete examples, and to offer recommendations and lessons learned that might serve as a starting point for improving technology transfer as practiced by NASA.

For more information regarding the case studies, issues, or recommendations presented herein, please contact one of the following personnel:

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Advanced Life Support Division
NASA Ames Research Center
Moffett Field, California 94035

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APPENDICES

1.0 INTRODUCTION

This paper is intended as a summary of several technology transfer activities in the field of Advanced Life Support research and technology development. The activities summarized herein are taking place in the Advanced Life Support Division (ALSD) at NASA Ames Research Center (ARC). The information presented is intended to be an illustrative, rather than an exhaustive, review of various activities underway in the division. Recent ALSD technology transfer activities are summarized in the body of the paper, and supporting documentation is appended. The pertinent history, issues, and appropriate recommendations are summarized for each case discussed in the paper. In addition, a set of "lessons learned" from the composite of the technology transfer activities of the ALSD is presented, with the lessons grouped according to the four "arenas" of technology transfer that have been identified by the NASA Office of Aeronautics and Space Technology (OAST) (ref. 1):

- Intra-NASA transfer (from NASA research and technology development (R&TD) programs to NASA flight programs/projects);
- Intra-Federal transfer (between NASA and other federal laboratories/agencies);
- NASA - Aerospace Industry transfer (between NASA and its traditional aerospace industry contractors); and
- Aerospace - Broader Economy transfer (between aerospace government/contractor organizations and organizations in other sectors of the economy).

Note that in all of these arenas, technology can be transferred in both directions, although for Intra-NASA transfer, the usual mode is from the research center to the flight development center. At least one ALSD activity from each of the four arenas is discussed in this paper.

2.0 BACKGROUND

Shortly after the formation of the Division in 1989, Division management consciously sought to both analyze and pro-actively implement technology transfer in several arenas: internal to NASA; external to the private sector; external to other agencies, states, and institutions; and external to appropriate international settings.

In 1990, in response to a request from the Executive Director of the National Space Council, the ALSD published a preliminary survey of opportunities in commercial technology transfer, "Potential Spin-offs of Advanced Life Support Technologies," (Appendix A). This document identified several high impact areas for possible advanced life support technology transfer. Included among these are the following:

- Reduction of plastic solid waste in landfills.
- Superior yields in global agriculture.
- Software to manage hazardous materials and waste.
- Protective clothing and life support units for fire fighting and toxic waste management.
- Residential and commercial water clean-up and recycling.
- Sensor technology for "tight building" syndrome.
- Revolutionary technology for aquatic exploration and commercial undersea operations.

2.1 The Rationale for Advanced Life Support Research and Technology Development

The impetus for advanced life support R&TD is imbedded in the requirements for extended duration manned space exploration, as embodied in the President's proposed Space Exploration Initiative (SEI). Advanced life support, consisting of surface habitat/space transfer vehicle core life support systems and extravehicular mobility units, has been identified as an enabling technology for SEI by several recent studies (ref. 2-4, others). Advanced regenerative, or closed-loop, life support technology drastically reduces the amount of consumables (oxygen, water, food, etc.) required for human support, thereby minimizing the otherwise enormous cost of resupply. Specific advances in the state of the art of this technology have been identified which will enhance crew productivity, ensure crew safety, augment food supply with freshly-grown food, and bolster crew morale during long, arduous missions or planetary stays.

Advanced life support R&TD produces, by definition, technology for maintenance of human health. Air and water regeneration, waste disposal, and plant-based bioregeneration/food

production are all key areas of research. New processes for accomplishing these functions in space may be readily adaptable to performing these functions on earth. Thus, development of advanced life support technology has the inherent capability to generate terrestrial benefits.

Certainly other NASA technologies also have "spin-off" potential, but terrestrial applications of this technology would seem to be among the more easily understood in terms of direct benefit to individuals and the resolution of problems associated with human activity in an environment or habitat which is recognized to possess finite resources and/or non-infinite buffer volumes in which to discharge pollutants.

In addition to advancing technologies which benefit the public good, advanced life support technology is also capable of stimulating commercial activity, as the Foster Grant patent license case demonstrates (see Appendix E). The potential economic value of this technology, combined with the human relevance of the technology, also generates interest among the public, which may be translatable into political support during crucial budgetary times for civil space related programs.

The following cases illustrate tangible national and global benefits. To fully realize these, however, requires a systematic attempt to do so, while maintaining a focus on the principal mission of developing and delivering the technology. Serendipitous and "passive" transfer can and does occur (e.g., Foster Grant License Agreement, Appendix E), but managed or "active" technology transfer activities and projects, the authors contend, is likely to increase the occurrence, and hopefully, the success of the transfer. This is the primary motivation for the proposal to formalize and improve the Intra-NASA technology transfer process, which is summarized in Section 3.1 below (see also Appendix B for the Technology Transfer Process Improvement Task proposal).

2.2 The Rationale for Managed Technology Transfer

The restructuring of the global economy over the past twenty years has created new realities which the U.S. civil space program must contend with. It is persuasively argued that economic security has replaced national security as the driving force of American politics and policy (ref. 5). In this highly competitive global economy, public investment is now debated on the merits of the contribution a high technology project can make to "national competitiveness." The scales of competitiveness weigh, among other things, the potential transferability of technologies resulting from the funded program into other sectors of the national economy. Technology transfer is thus one of the major issues which R&TD principal investigators and managers in NASA and other federal labs must address (ref. 6).

The trend toward managed transfer is also spurred by the budgetary climate in Congress. Competing claims for education, environmental, and social programs are literally (through the placement of NASA's budget in the HUD-and-Independent-Agencies appropriations bill) and rhetorically pitted against the civil space program. As the rhetoric has increased in intensity in recent years, the specter of the major reductions in aerospace budgets during the post-Apollo years comes readily to mind. Given this situation, it is reasonable to assert that NASA's ability to produce technology for both space and terrestrial applications may be a key to survival in the coming years.

However, as an American Society of Mechanical Engineers publication notes (ref. 7):

> "...a director of licensing for a "Fortune 100" multinational corporation observed that they long ago concluded that dissemination (of information) did not produce results. He maintained that the only sure way to transfer (license) company developed technologies was to market, or sell, them in the same way any other commercial product is sold. Federal agency programs have not gone, or even plan to go, that far. Indeed, chances are that most federal agencies do not now have even a fair in-house capability to determine the potential commercial values of their own technologies."

This fundamental impediment to technology transfer, as well as others which are identified in the issues section of each case study below, must be overcome in order for NASA-sponsored research and technology development programs to produce maximum benefit for the U.S. economy.

3.0 CASE STUDIES

3.1 The Technology Transfer Process Improvement Task (TIPIT) Proposal (Appendix B)

3.1.1 Case History

The success of the Space Exploration Initiative (SEI) will depend on the development of several key enabling technologies, such as advanced life support (ref. 3). In programs, such as Apollo, the need for, and inherent risk in, developing new technologies was driven by required performance and schedule. The political necessity of mission success and the need to prudently manage risk resulted in large funding requirements. Often multiple, competing technologies were carried to flight readiness before down selection to the best candidate. Post-Apollo redirection in the nation's priorities, along with today's highly constrained discretionary federal budget situation, have resulted in reduced NASA budgets for research and technology development. Resources are no longer available to develop all the high priority new technologies that will be needed for the SEI, let alone funding two or more alternative technologies for a given function as was done during Apollo. Technology projects which are funded must be efficiently run, and they must address the key issues which the ultimate customer, i.e., the flight program, identifies. These realties require a fundamental re-examination of how effective the existing Intra-NASA technology development and transfer process is, and how it could become more cost-effective and customer-responsive without sacrificing ultimate system performance or safety.

The Advanced Life Support Division at NASA ARC, together with the Planet Surface Systems Office (PSSO) at NASA Johnson Space Center (JSC), are proposing the Technology Transfer Process Improvement Task (TTPIT). This task will address how NASA could improve technology transfer from the research lab to the flight program (Intra-NASA technology transfer). Since a research center (ARC) and a flight center (JSC) are represented on the TTPIT, the points of view of both technology developer (i.e., the "supplier") and technology user (i.e., the "customer") will be fairly represented. It is hoped that this teaming arrangement will result in the definition of an improved, more formalized Intra-NASA technology transfer process that can be readily incorporated into NASA programs.

The authors wish to acknowledge the contribution of William Morgan and David Petri of the PSSO for inspiring the TTPIT concept, and contributing to its development to date.

3.1.2 Issues

There are two primary issues that must be dealt with if the TTPIT is to become a reality. The first is the constrained budget environment itself. If funds are not available to support all the required high priority R&TD projects OAST has identified in its Integrated Technology Plan (ref. 3), then how can enough money be found to fund a project to improve the generic *process* by which technology is developed and transferred? The response to such a rhetorical question is obvious. A very small amount of funding (on the order of a tenth of one percent of the current annual OAST civil space technology budget, for two to three years) is estimated to be required to effectively analyze and develop an enhanced set of technology transfer mechanisms for the agency, with the team participants identified at ARC/ALSD and JSC/PSSO. The potential payoff is large if the project proves to be successful, and the investment is relatively small.

The second issue has to do with acceptance of the ultimate TTPIT products by the research project principal investigators and technologists and the flight project engineers and managers who will be responsible for improving how technology is transferred within the agency. Technology transfer from research to flight centers is currently handled on an informal, almost ad hoc, basis. Successful examples usually involve a Principal Inves-tigator (PI) or technologist who was motivated to "go on the road" or otherwise "sell" his technology concept(s) to a flight project customer. Other cases involving serendipity, or other such random factors, abound. One might ask how receptive the independent researcher will be to a directive to follow a prescribed technology development life cycle (see below, and Appendix B) and participate in a formalized Technology Readiness Review that customers from the flight project office would also attend. Clearly, the proposed TTPIT products will have to be sold to these personnel as part of getting them accepted, just as new technologies have to be sold to their customers today.

3.1.3 Recommendations

1. Analyze the existing Intra-NASA technology transfer process. The current OAST-sponsored Workshop is the first step in this analysis.

2. Rigorously define the Technology Readiness Level (TRL) and the activities and products associated with achieving a TRL rating.

3. Examine the approach to technology transfer in use at other government agencies, such as the Department of Defense, the Environmental Protection Agency, the Department of Transportation, and the Department of Energy.

4. Define and formalize the Technology Transfer Life Cycle (integrating both technology development and technology transfer).

5. Formalize the information flow (types and content) between technology suppliers and flight program customers that will provide for an effective decision making environment.

6. Advocate for adoption of a formalized technology development and transfer process, incorporating the TTPIT products, by NASA, using appropriate means, such as training courses, publications, workshops, etc.

3.2 International Cooperation and Technology Transfer of Closed Environment Life Support Systems to Antarctic Habitats (Appendix C)

3.2.1 Case History

The National Science Foundation (NSF) and NASA have had a long history of cooperative projects in the Antarctica. With respect to this tradition of collaboration, the NSF and NASA have prepared and approved a Memorandum of Agreement (MOA) to further formalize their mutually beneficial interests in Antarctic research activities applicable to space research and exploration (see Appendix C). As an example, under this MOA, NASA will be able to utilize the unique Antarctic environment to test prototype hardware systems and protocols in a setting analogous to Martian environmental conditions, while NSF will benefit from the transfer of space technology in many areas, including: improved power systems, telerobotics, automated systems, and life support technologies. In the case of life support systems, NSF will benefit from an improved quality of life for its stationed personnel, a reduction in resupply demand, and protection of the Antarctic environment by the implementation of NASA-developed Closed Environment Life Support Systems (CELSS).

The ALSD intends to participate in this collaboration by developing an operational CELSS. In close conjunction with the NSF, a plan is currently being developed to provide systems for food crop production and waste processing for the Amundsen-Scott South Polar Research Station (South Pole Station). This project is known as the CELSS Antarctic Analog Project (CAAP) and is composed of two phases. The first phase will deliver a crop production unit to the South Pole during the winter of 1993-1994. The second phase will provide to the NSF an integrated waste processing/crop production unit in the anticipated time frame of the winter of 1996-1997.

3.2.2 Issues

There are no specific issues as this time.

3.2.3 Recommendations

1. Specific, readily identifiable technology transfers should be tracked as a key component of the CAAP. In addition to enabling science via collaborative transfer of data, concepts, and technology, the emplacement of a CELSS unit in Antarctica is the first such application of this technology in an operational (versus a pure research) environment where it will be depended on to provide human support. It is expected that data gathered from this project will provide valuable information as to the usefulness and viability of CELSS technology in other remote, harsh environments. Thus, the contribution that technology transfer can make to this high priority project is of sufficient interest to warrant careful documentation.

3.3 Memorandum of Agreement for the NASA/Ames - McDonnell Douglas Research Associate Exchange Program (Appendix D)

3.3.1 Case History

Upon creation of ALSD in March 1990, the Systems Evaluation and Integration (SE&I) Branch was chartered to build a system engineering capability for the Division. Since the branch was built essentially from scratch with a limited pre-existing funding base, several methods for expanding the branch's scope of activities and access to system engineering tools were pursued that would not require NASA Headquarters funding. Two of these methods are documented in Appendix D. The first, a Memorandum of Agreement (MOA) between ARC and McDonnell Douglas Space Systems Company (MDSSC), established a cooperative Research Associate Exchange Program. To date, a MDSSC research engineer has served a nine month tour of duty at ARC assigned to the SE&I Branch of the ALSD working as an integrated member of the branch team under the lead of a civil servant project manager. In a reciprocal exchange, that civil servant project manager has just begun a similar assignment in residence at MDSSC in Huntington Beach, and will work under the lead of a senior MDSSC research scientist. In addition to providing an excellent vehicle for two-way technology transfer between NASA and MDSSC, this arrangement also provides an outstanding professional development experience for the personnel involved.

The second method employed a standard Non-Disclosure Agreement (NDA) between NASA ARC and MDSSC to allow ARC personnel exclusive use of several proprietary computer codes developed by MDSSC using Internal Research and Development (IRAD) funding. Intellectual property and proprietary ownership considerations require that this exchange of software be "temporary" in the sense of having a specified duration, and require that NASA personnel

exercise due caution to prevent the proprietary code from being transmitted to any organization who would gain a competitive benefit at the expense of MDSSC by possessing it. NASA retains the right to publish analysis produced with the code provided the confidentiality is not compromised. To date, use of the code modules obtained from MDSSC under the NDA shown in Appendix D are estimated to have saved ARC over $200K and 1-2 years in code development effort.

3.3.2 Issues

The only issue of any consequence was the time it took to draft, review, coordinate, and revise the MOA through both ARC and MDSSC management. From conception of the idea for an ARC/MDSSC researcher exchange, to final sign-off by the ARC Center Director, took almost ten months. However, this is not an unreasonable amount of time considering this MOA was the first one involving exchange of personnel that ARC had entered into in almost ten years (according to ARC External Relations Office files). It is hoped that in the future such agreements, at ARC and other NASA centers, could be formulated and approved more quickly by using this MOA as a model and precedent.

3.3.3 Recommendations

1. NASA should employ personnel exchange programs as a centerpiece of its technology transfer activities. Personnel exchanges are perhaps the optimum form of technology transfer, since transfer of the information that underpins the "technology" is assured to happen. Such exchanges are applicable to all four arenas identified earlier.

2. Utilize the ARC/MDSSC Research Associate Exchange Program MOA shown in Appendix D as a model for formulating similar agreements at other NASA centers and federal laboratories, as appropriate.

3.4 Exclusive License Agreement for the Foster Grant "Space Tech" Eyeglass Lens (Appendix E)

3.4.1 Case History

In 1978, Foster Grant learned of an ARC patent with commercial application to their product. Utilizing an exclusive license agreement, both NASA and the researcher receive royalties from the manufacture of lenses which bear the patented polymer coating. Several million units have been produced and sold thus far.

3.4.2 Issues

The NASA patent holder reports that the royalties received are significantly lower than the industry standard, because they were negotiated on the basis of one cent ($.01) per unit, as opposed to a percentage of the revenue stream. The patent holder also reports that there are no educational materials about patent applications, or the implications of royalties resulting from research conducted under NASA auspices, that the typical NASA researcher could benefit from reading. In 1990, Foster Grant dissolved and was bought out by a new company. The patent holder discovered this only coincidentally. In short, the tracking of royalty agreements is difficult due to limited support from the NASA institution.

3.4.3 Recommendations:

1. Provide commercial analysis services to determine the fair market value of NASA-developed technology, and the most advantageous basis for royalties negotiated with commercial organizations. The goal should be to provide increased financial incentives for researchers to consider the commercial potential of their research activities, with the ultimate goal of maximizing the benefit to the broader U.S. economy of the public's investment in their research.

2. Develop educational materials and training mechanisms for NASA researchers regarding commercial aspects of patents and royalties.

3. Increase the level of Intellectual Property support available to the NASA PI. An increased level of support from the NASA Patent Counsel should be provided in order to more closely track royalty agreements.

3.5 NASA and the National Solid Wastes Management Association (NSWMA) (Appendix F)

3.5.1 Case History

In 1989, industry representatives, who are also former high level NASA managers, proposed a series of information exchanges between NASA and the NSWMA, to discuss relevant technologies which could be applied to waste disposal systems and solid waste sites in the United States and abroad. Discussions were facilitated by the Washington group J.M. Beggs Associates, funded independently by the NASA Office of Commercialization at NASA Headquarters. A series of workshops were held to identify several potential joint projects that would transfer technology in both directions between NASA and the solid wastes management industry (see

Appendix F). The Environmental Protection Agency is also a participant in the dialog, enabling potential Intra-Federal transfer as well. Current discussions are focused on the first phase of a three phase project to develop an a chemical sensor using advanced life support technology that could be installed in a ground water monitoring well adjacent to a municipal solid waste landfill. If successful, the monitor could greatly reduce the expense of the required thirty year post-closure landfill monitoring period by minimizing the need to draw water samples out of each of several wells and take them to an analytical chemistry laboratory for expensive, specialized analysis of the 47 different constituents required.

3.5.2 Issues

Currently, technology transfer from NASA to the commercial sector is managed out of a separate organization (the Commercialization or Technology Utilization Office) from the research and technology directorates at each Center. This can at times compromise clear accountability and authority over individual commercial technology transfer projects. Responsibility to manage such projects should be integrated into the technology provider's organization.

3.5.3 Recommendations

1. The management of most commercial technology transfer projects should be integrated into the NASA field center organization which is providing the technology. Criteria should be developed, in conjunction with the R&TD organizations, to allow identification of those projects which should be managed out of the Technology Utilization offices.

2. Dialog with appropriate commercial trade associations should be expanded. The trade association can be a valuable organization to engage in technology transfer discussions and activities, as its leadership has a global view of both it's industry's needs and the individual capabilities of it's member firms. Trade associations also allow for access to top management decision makers.

4.0 LESSONS LEARNED

In addition to the above cited recommendations, the following lessons learned are offered. Note that most of the experience the ARC/ALSD has gained since its creation in 1990 has been in external transfer projects. Thus, the following issues largely relate to transfer external to the agency.

4.1 Generic Issues

A few generic lessons have been identified which span all technology transfer arenas. These include:

1. Incentive Structure.

   The primary incentive structure within the research groups at the project level is rewards for producing research results and research papers. The incentives are not aimed at encouraging and rewarding technology transfer. Rather, the assumption is made that technology transfer occurs "naturally," through personal relationships and the organization. Likewise managers, while generally aware that a "track record" of technology transfer will benefit the perception of the program, are not provided with formal incentives or specialized training in order to effect the transfer of technology.

2. Institutional Support.

   Technology transfer activities are not considered an integral part of the program/project, but rather are managed as a separate institutional activity in the NASA technology utilization/commercialization office. Dedicated personnel and ongoing programmatic support for technology transfer are not a part of the project life cycle, nor are the costs associated with technology transfer planned for. Travel budgets, for example, are oriented towards completing projects, rather than permitting the face-to-face exchanges necessary for effective transfer technology.

3. Application-Specific Research

   R&TD projects are rarely allowed to allocate even a small fraction of programmatic funds to modifications in the research which permit or support transfer applications. Generally, technology which is originally developed for a specific mission, especially civil space flight programs, usually must be modified for transfer to other applications.

Transfer of the knowledge to other users requires modification of the application at some point in the process, either by the original developer or by the "transferee."

4. Contractor's role and entitlement.

Under current NASA policy, if a contractor requests "right of first refusal" to title or exclusive licenses on NASA funded technology, their request generally will be granted. Any further "transfer" is then dependent on the company, as NASA retains only a research license. This broad entitlement practice should be re-examined in light of the unduly restrictive effect it has on technology transfer.

4.2 Intra-NASA Transfer

1. Organizational Support

There is an absence of formal institutional mechanisms to facilitate intra-agency transfer, over and above the person-to-person contact that is the fundamental basis of transfer. The supporting mechanisms should include incentives, personnel exchange programs, and targeted funding to permit transfer.

2. Incentives Conflicts

The NASA space flight programs are operating against development deadlines that require them to have technology ready at the start of Phase C/D in the project cycle. The research programs, by culture and structure, are not incentivized to produce technology to deadlines. Also, the drive to build up the institution and maintain the workforce complement has led flight centers to become extensively involved in R&TD programs. This trend has led to direct competition between research and flight centers for the same R&TD funds, which has resulted in a major impediment to technology transfer. The recent Roles and Missions directive from the NASA Administrator is a response to this perceived problem of activity overlap.

4.3 Intra-Federal Transfer

1. Federal Contacts and Incentives

Incentives need to be established to promote the transfer of knowledge and technology between federal agencies. Once again, no formal mechanisms currently exist to facilitate this, as the NASA-NSWMA case cited above illustrates. In this case, contact between

NASA and the EPA, in the specific area of solid waste, was facilitated by the NSWMA, a trade industry association. It should be noted that there had been previous contacts between ARC/ALSD personnel and EPA personnel, but it was on an informal researcher-to-researcher basis.

4.4 NASA-Private Sector Transfers

1. Legal Support

Transfers to the private sector often require legal support. General Counsel support is very limited, and patent counsel support is almost exclusively dedicated to the filing of new patents and assurance of NASA research licensing on privately titled intellectual property. Increased availability of legal counsel resources for working technology transfer issues would serve to remove some of the impediments in the NASA-broader economy arena of transfer.

2. Business Support

Business and commercial support is not available to researchers. Researchers are generally ill-equipped to influence licensing negotiations to protect their financial interests or understand the consequences of commercial "deals." Little or no resources exist to educate the research population about commercial licensing. The development of formal training courses on commercial licensing and technology transfer issues and mechanisms is highly recommended. Training courses on several aspects of technology transfer could prove very helpful and should be developed.

3. Parallel Private Sector Needs

In many cases, there is not an obvious parallel private sector need for NASA civil space technology, in the same way there is for NASA aeronautics technology and research. The most obvious parallel needs for space technology are in power/propulsion, life support, and information systems applications. It is easier to find an interested user for an improved blood pressure monitor than it is to find one for an improved robotics software code for work in a microgravity environment.

4. Cost of Transfer

In addition to face-to-face communication of experts within whom knowledge resides, technology exchanges often require moving equipment, documents, software, etc. Thus,

it can be expensive, under the current system, to arrange for transfer to the private sector. Transfers occur, therefore, when there is a perceptible benefit to the transferee. Finding these returns to be justification enough to make the effort is a judgment call which a manager must make, relative to other demands.

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NASA AMES RESEARCH CENTER
Advanced Life Support Division

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TECHNOLOGY TRANSFER IN THE NASA AMES ADVANCED LIFE SUPPORT DIVISION

A Summary of Representative Activities

APPENDIX

March 17-19, 1992
Tysons Corner, Virginia

Systems Evaluation and Integration Branch
CC-21

APPENDIX A

POTENTIAL TERRESTRIAL APPLICATIONS FROM NASA ADVANCED LIFE SUPPORT RESEARCH

POTENTIAL TERRESTRIAL APPLICATIONS FROM NASA ADVANCED LIFE SUPPORT RESEARCH

Advanced Life Support Division
NASA/Ames Research Center

July 1990

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I. INTRODUCTION

The history of spin-offs and technology applications from NASA life support research may be an indicator of significant social benefits which can result from contemporary advanced life support research.

In June of 1989, the Chapman Research Group, (CRG) Inc. conducted the study "An Exploration of Benefits from NASA 'Spin-off'". Acknowledging the wide diversity of ways that NASA technology reaches into society, the study points outs that documentation of spin-offs is imprecise and probably underestimates the value added to society and the market place from NASA research and development.

With this caveat in mind, the CRG Study identifies some 14 categories of past NASA benefits and technology transfer categories which relate directly to research and development currently being conducted in the Advanced Life Support Division at NASA/Ames Research Center.

The examples cited in the study include such categories as chemicals and allied products, bacterial detection, crop growth, medical instruments, particle detection and water filtration. The estimated value of sales and savings in dollar figures alone equals over $4.5 billion in benefits realized and direct creation of business.

The positive impact upon people and society (the improvement in quality of life, jobs created, and the proliferation of knowledge and opportunities) is not easily quantified, but also of economic value and intrinsic worth. The return on investment in life support technologies of past missions argues compellingly that the present advanced life support research will drive out equal, if not greater, tangible and intangible returns to society and the economy. It is not only past performance, such as the examples cited above, that suggests this. Other reasons are intuitively obvious: Advanced Life Support is technology for human survivability in the harshest environment yet explored by man. It seems logical that spin-offs of significant utility for humankind will derive from an Advanced Life Support program. This document presents some early concepts for potential spin-offs in this area.

II. MANAGEMENT OF POTENTIAL APPLICATIONS IN THE ERA OF THE SPACE EXPLORATION INITIATIVE

Examination of how benefits are transferred to society indicate that a principal factor is the pro-active management of the technology development such that spin-offs are unearthed as early as possible in the life cycle, and brought to the market, through all available means.

In a long life cycle program such as the proposed Space Exploration Initiative, it is imperative that terrestrial benefits become a significant part of the 'front-end' thinking and planning of advanced technology managers. Consistent with this philosophy, and immediately after its creation, the Advanced Life Support Division at NASA/Ames Research Center invited Division personnel to submit spin-off concepts. The response was enthusiastic, and the concepts substantial. These early concepts are included in this document.

III. VALIDATION OF POTENTIAL TERRESTRIAL APPLICATIONS

The following concepts must, however, be regarded as preliminary. Unless noted, they represent potential applications only, and are derived from technology in a very early stage of development. In some important cases, the spin-off potential is being realized apace with the development of the technology itself. The ultimate utility to the public, and to the commercial sector, will be determined as the technologies mature.

IV. POTENTIAL TERRESTRIAL APPLICATIONS

1. REDUCTION OF PLASTICS SOLID WASTE

2. SUPERIOR YIELDS IN GLOBAL AGRICULTURE

3. SOFTWARE TO MANAGE TERRESTRIAL HAZARDOUS MATERIALS AND WASTE PROBLEMS

4. CONTAMINANT MONITORING AND RELIEF STRATEGIES FOR THE IMMUNO-SUPPRESSED AND ENVIRONMENTALLY ILL

5. PROTECTIVE CLOTHING AND LIFE SUPPORT UNITS FOR FIRE FIGHTING AND TOXIC WASTE MANAGEMENT

6. RESIDENTIAL AND COMMERCIAL WATER CLEAN-UP AND RECYCLING

7. REVOLUTIONARY TECHNOLOGY FOR AQUATIC EXPLORATION AND COMMERCIAL UNDERSEA OPERATIONS

8. TECHNOLOGY CLOTHING

1. RECYCLABLE AND DEGRADABLE PLASTICS FOR SPACE USE

SPIN-OFF: REDUCTION OF PLASTICS SOLID WASTE

To minimize the trash load in long-duration space missions, it could be beneficial to process the waste plastics (containers/packaging) into reusable materials. This can be accomplished by judicious recycling, or degradation of the plastic substances into useful, simpler substances. Plastics are chemicals--long chain polymers--and, as such, their molecules can be broken down by absorption of energy which can break down chemical bonds.

Plastics reclamation technologies are under consideration within NASA. The concept is to tailor-make plastic compounds that are especially amenable to photodegradation (capitalizing on the deep ultraviolet radiation available in outer space) or are susceptible to photosensitized degradation. This is being considered to reduce the "trash load" on other planets, and to leave pristine environments as unaltered as possible during human activity. A secondary approach is to try to develop special plastic compounds that yield benign or useful by-products, such as water. This approach facilitates closed loop life support and provides the opportunity to minimize resupply, or to generate a net gain of water during missions. The feasibility of these advanced concepts is substantiated by numerous articles in the polymer and trade literature.

Globally, plastics represent an estimated 10% of municipal solid wastes. In the United States, this is equivalent to 10.3 million tons. Plastics are a widely acknowledged area of concern in waste management and have become a symbol of the enormously complex problems facing the country in this arena.

NASA research on recyclable and degradable plastics offers the possibility of generating novel ideas for significant spin-off applications on earth. A particularly important example of such an application would be to reduce the burden on land fills from plastic trash.

2. CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS RESEARCH

SPIN-OFF: SUPERIOR YIELDS IN GLOBAL AGRICULTURE

NASA's Controlled Ecological Life Support Systems (CELSS) program is developing the technology to recycle life support wastes into useable products for humans. The central features of the CELSS program are controlled environment agriculture, encompassing green plant photosynthesis (whereby oxygen and food are produced, while carbon dioxide is removed from the atmosphere), and transpiration, which produces potable water from the leaves. The CELSS goal is to functionally duplicate the Earth's life support process on a space habitat scale, by integration of biological, physical and chemical processes. Accomplishments of the CELSS program over the past several years include exceeding world record field yields and reducing seeding to harvest cycles by more than 50%.

The goal of CELSS plant research is to characterize the ability of a plant-based system to provide food, oxygen, and purified water, while removing carbon dioxide and recycling contaminated water within the closed environment of a spacecraft. Attention has particularly focused on reducing the crop area required to sustain a human, compared with the area presently required in terrestrial agriculture.

Approximately one acre of crop is required to produce the food energy to supply one person, in the agricultural system practiced in the U.S. Using wheat as an example, CELSS productivity in controlled environments reduces that requirement to 0.002 acre/person.

This dramatic increase in productivity results from studies of environmental influences on plant development and yield with crop plant varieties commonly used in field agriculture. No new "space plant" was needed. These results indicate that there is much greater productivity potential in the crops currently used in agriculture than is presently realized. The CELSS program is designed so that a greater expression of the genetic potential of the plants can be expressed.

Many of the spin-offs from CELSS will have application to the US system of agriculture. However, the fledgling controlled environment agriculture industry is reaping immediate benefit because of easier implementation. Through control of the plant process, productivity per unit input to the system increases drastically, products are consistently of high quality, and production is predictable. Inconsistent production, a low percentage of high quality product, and high input requirements per unit of product are all major problem areas in the U.S. agricultural system.

A joint development program with industry and NASA has been initiated in the area of controlled crop production. The Crop Growth Research Chamber (CGRC) project is involved with the Environmental Growth Chamber Co. of Chagrin Falls, Ohio. The feasibility of co-development of the next generation of controlled agricultural environments is now being explored. If this venture is successful, the level of control of the plant environment will surpass that available today and allow us to identify further the potential for increased exploitation of crop potentials. In addition, technology will be transferred as it is developed to an industry anxious to utilize advances as soon as is possible.

3. ARTIFICIAL INTELLIGENCE FOR ADVANCED LIFE SUPPORT SYSTEMS

SPIN-OFF: SOFTWARE TO MANAGE TERRESTRIAL HAZARDOUS MATERIALS AND WASTE PROBLEMS

The Design Assistant Workstation (DAWN) project entails the development of a simulation and design workstation for advanced space life support systems which utilizes a combination of conventional chemical engineering and artificial intelligence (AI) techniques. In addition to supporting system design and evaluation, this work entails the development of autonomous model-based monitoring and control systems for life support.

On Earth, the production of hazardous materials and the handling of hazardous waste are increasingly problematic, both technologically and in terms of cost. Trade literature indicates that the national cost for hazardous waste clean up may reach $300 billion by the year 2030. A National Academy of Engineering report identifies a key technological idea which will help mitigate these costs. The notion is to stress in-plant processes and design to reduce or eliminate hazardous wastes. In addition, the EPA has stressed the development of prediction capability as a key means of future prioritization for environmental risks. Both of these strategies will require appropriate expert systems and artificial intelligence-derived programs. DAWN technology could significantly aid the effort, using a suite of chemical engineering and AI tools.

AI-based modeling will allow fairly rapid evaluation of hazard release into the environment, where, even in the face of incomplete knowledge, predictions can be made. An AI-based workstation can provide the opportunity to evaluate any number of hazards over a variety of parameters and select the best choice for avoidance or intervention with great rapidity.

Finally, AI-based monitoring (with significant autonomy from humans), can allow the routine evaluation of both industrial plants and hazardous waste sites without necessitating human exposure.

4. CLOSED-LOOP AIR REVITALIZATION

SPIN-OFF: CONTAMINANT MONITORING AND RELIEF STRATEGIES FOR THE IMMUNO-SUPPRESSED AND ENVIRONMENTALLY ILL

Air revitalization is a critical, enabling technology for all aspects of lunar and Mars missions. Closed-loop air recycling will enable long term occupation of extraterrestrial environments In addition to cleansing the air itself, enhanced sensors and breakthrough technologies in air quality sensors, as well as particulate capture and disposal are under consideration in the Advanced Life Support community. Such systems must be small, light weight and have the highest reliability in order to be flight-worthy for long duration missions, and functional in extraterrestrial habitats.

An increasing number of allergic-reactive individuals have been seeking relief in the past decade. Some of these allergic intolerances may be linked to increased use of chemicals in food preparation, and general contamination of air and water quality. The severity of these allergies can lead to increasing intolerance of foreign substances and air born particulates. For a growing population, this condition can become life threatening, resulting in the gradual dehabilitation and isolation of the individual. Many citizens have contacted NASA seeking high technology solutions to their illness, or mitigating systems which would allow them to rehabilitate and seek further biomedical treatment. Research by the NASA Technology Utilization Office has found that existing off-the-shelf technologies are inadequate, and the biomedical community has not engaged in independent technology development to provide 'clean room' type environs for the afflicted.

Advancing the state of the art in closed-loop systems holds the possibility of spinning off environmental technologies, filtration devices and contaminant sensors for the environmentally ill. In addition, applications exist for improved environmental controls in large commercial complexes (the "tight building" syndrome) in areas where fresh air quality is low--such as Los Angeles or other smog burdened areas.

5. EVA MATERIALS AND PORTABLE LIFE SUPPORT SYSTEMS RESEARCH

SPIN-OFF: PROTECTIVE CLOTHING AND LIFE SUPPORT UNITS FOR FIRE FIGHTING AND TOXIC WASTE MANAGEMENT

Materials research and Portable Life Support Systems (PLSS) research promises to improve the safety and functional capabilities of fire fighters working close to a disaster. Examples of disasters abound, where the death tolls mounts because rescuers and fire fighters can not get close enough to the source of the explosion or fire to effectively extinguish it. Each year many fire fighters and other public safety workers lose their lives or are severely injured attempting to save others.

Combining advanced thermal materials research with advanced portable life support units can assist relief workers, particularly in extremely hazardous situations, such as oil and gas well fires, on-board marine fire fighting, and the rescue of air crash victims. In these environments, high temperatures and noxious fumes combine to endanger not only nearby victims but their rescuers as well.

Reduction in weight, power and volume of Portable Life Support Systems, and increase in reliability of such systems for Lunar and Mars missions, offers technology to be transferred to disaster management.

Apollo and Shuttle-era life support research has already transferred technology to this sector. One such example is fire fighting breathing apparatus, developed using extravehicular life support system technology. The resulting unit includes reduced weight, extended duration, simplified harness, and improvements in the helmet, mask and air depletion warning devices. Thousands of these units are used in virtually every metropolitan area. Substantial improvements in these applications can be anticipated, considering the advances already made in space suit technology.

6. 'GREY WATER' RECYCLING DURING LONG DURATION SPACE MISSIONS

SPIN-OFF: RESIDENTIAL AND COMMERCIAL WATER CLEAN-UP AND RECYCLING

In a lunar habitat or during a lengthy Mars mission, the supply of fresh water is critical to the functioning of the crew. Weight and volume constraints make re-supply extremely costly. A closed, or partially closed, regenerative life support system must be capable of recycling water, in addition to air and a certain percentage of food for the crew. Research into biological and physical/chemical processes to meet these life-sustaining requirements must eventually develop small, lightweight recycling units, with high degrees of reliability and efficiency.

On Earth, current water philosophy assumes an endless, cheap supply of fresh water. At present, 96% of of all available fresh water in the United States is groundwater. Underground aquifers are tapped by many communities, as are rivers and lakes, for fresh water supplies. Thus, our water supplies are primarily "open loop." The relative cost of returning the contaminated, or "grey water," back into the hydrologic cycle, (compared to the 'cheap' cost of pumping 'new' water into the system), results in monitoring and centralized elimination of only the most hazardous pollutants.

Residential and commercially derived pollutants are finding their way back into fresh water resources. In 1984, the Office of Technology Assessment compiled a list of over 200 contaminants known to occur in groundwater. Subsequent monitoring indicates that the list of trace contaminants may well be three times larger. Negative health effects from water contamination have been established in many communities in the United States. Water quality is universally recognized as a national concern.

A potential spin-off from space oriented waste water decontamination are systems that could be attached to home septic systems, commercial locations, and underground storage tanks.

Such systems could monitor and purify 'grey water' before it is returned to the water cycle. Conceivably, some water could be immediately recycled at levels of purity suitable for personal sanitation, irrigation and the like. The economic recycling of semi-potable, or potable, water could result in billions of dollars of savings and new business created, in addition to secondary savings in related medical and health costs.

7. HARD SPACE SUIT AND PORTABLE LIFE SUPPORT TECHNOLOGY

SPIN-OFF: REVOLUTIONARY TECHNOLOGY FOR AQUATIC EXPLORATION AND COMMERCIAL UNDERSEA OPERATIONS

A. Improved Life Support Systems

The vacuity of space provides an inhospitable environment for life as we know it. The lack of appropriate gases that allow normal metabolic activity creates a need for a supply of breathable gas and a thermal control system that supplies the specific needs of life. During EVA, the space suit mobility required dictates that no umbilicals be used to supply life support. Therefore, all life support must be carried by the individual. A compact self-contained portable life support system is a necessity for all space exploration missions.

The human body must have oxygen at adequate pressure to survive. The body produces carbon dioxide which must be removed. The thermal balance of the human body is also very delicate. There is a narrow range of temperatures that allows proper metabolic activity. On Earth, the excess heat generated by the body is normally removed be convection to the ambient air stream. However, in space, it is difficult to remove this heat. Each of these factors must be, and is, controlled by portable life support systems during EVA.

There are a variety of applications that could benefit from advances in thermal control, carbon dioxide scrubbing, or oxygen supply. Scuba and commercial diving each present an environment that requires special means of life support. While scuba/commercial divers must be supplied adequate oxygen, and a means of removing carbon dioxide from their breathing gas, they also require protection from the generally cold environment in which they work.

Spin-off technology is under development which could provide highly efficient carbon dioxide scrubbing systems that purify the breathing gas of deep sea divers, and provide a long term oxygen supply to scuba/commercial divers.

B. Advanced Underwater Hardsuits

At high altitudes, artificial means to create pressure on the body must be employed to prevent Decompression Sickness (DCS). It is believed that DCS is caused by previously absorbed gases being released from solutions in the body and forming bubbles. Depending on location, these bubbles are believed to be the cause of pain, paralysis or even death. DCS may be avoided by maintaining appropriate pressure on the body.

In preparation for an extravehicular sortie from the Shuttle, astronauts must breath pure oxygen for several hours. This is done to remove dissolved nitrogen from the blood and tissues before working in the reduced pressure atmosphere of the Shuttle space suit. Failure to perform this "pre-breath" would likely result in DCS. Advanced space suits have been developed that operate at higher pressures and, thus, eliminate the need to "pre-breath".

Scuba/commercial divers face the same physiological problem. However, it is caused in reversed order. A diver descends to higher pressures in the water column, where he absorbs extra gases into the blood and tissues. Upon ascending, these gases come out of solution. If the rate of degasing is too great, DCS may occur. If too much gas has been absorbed, the diver must conduct staged decompression in order to return to the surface safely. Commercial divers, that dive at much greater depths than sport divers, sometimes spend weeks "decompressing." Even short excursions to depth may require extended decompression time. This is hazardous and expensive. Any reduction in decompression time would increase the safety and efficiency of the commercial and research diving community.

A one atmosphere diving suit that has the mobility of a hard suit, such as the AX-5, would allow both research and commercial divers to dive safely and inexpensively.

The size and complexity of commercial diving operations would be greatly reduced, as would the cost of such services. Only cost would prevent the use of such a suit by sport divers, and the added safety would be a boom to the industry.

8. SPACE SUIT HEAT TRANSFER RESEARCH

SPIN-OFF: TECHNOLOGY CLOTHING

A NASA researcher has been issued five patents in the field of protective clothing. All of the patents are based upon Apollo and Shuttle space suits as well as liquid cooled garment technology developed at NASA. The patents cover research on such things as a solar and infrared reflecting uniform that shields the wearer from radiant heating in the same way as a space suit, and a liquid, circulating, medical bandage that can be placed under a cast to promote rapid healing from injury by controlling local blood circulation.

Other spin-offs already on the market include a computer program to predict the response and safety limits of the human body to severe environments. From this, program designs and prototypes of "technology clothing" have been developed, including gloves, socks, hats and ski jackets that utilize a chemical heating element that heats up when exposed to air; lightweight ski jackets using space suit radiation reflective fabrics to reflect lost body heat and provide warmth without bulk; athletic shoes that use a derivative of the Space Shuttle-based ceramic silicon tile fibers to prevent foot heating and chafing during competition; and bedding material that uses active or passive body temperature control systems.

All of the technology-designed clothing uses the principal of controlling the microenvironment next to the body rather than depending upon heating and cooling of large volumes of air. This "microenvironment concept" promises a potential energy saving, since it costs less to heat or cool a human being than the air he or she lives in or passes through.

Interest in technology clothing has been encouraging. The U.S. Track and Field team used some of the designs during the 1984 Olympics. The Navy is investigating the use of such designs to protect divers doing defense-related underwater reconnaissance activities.

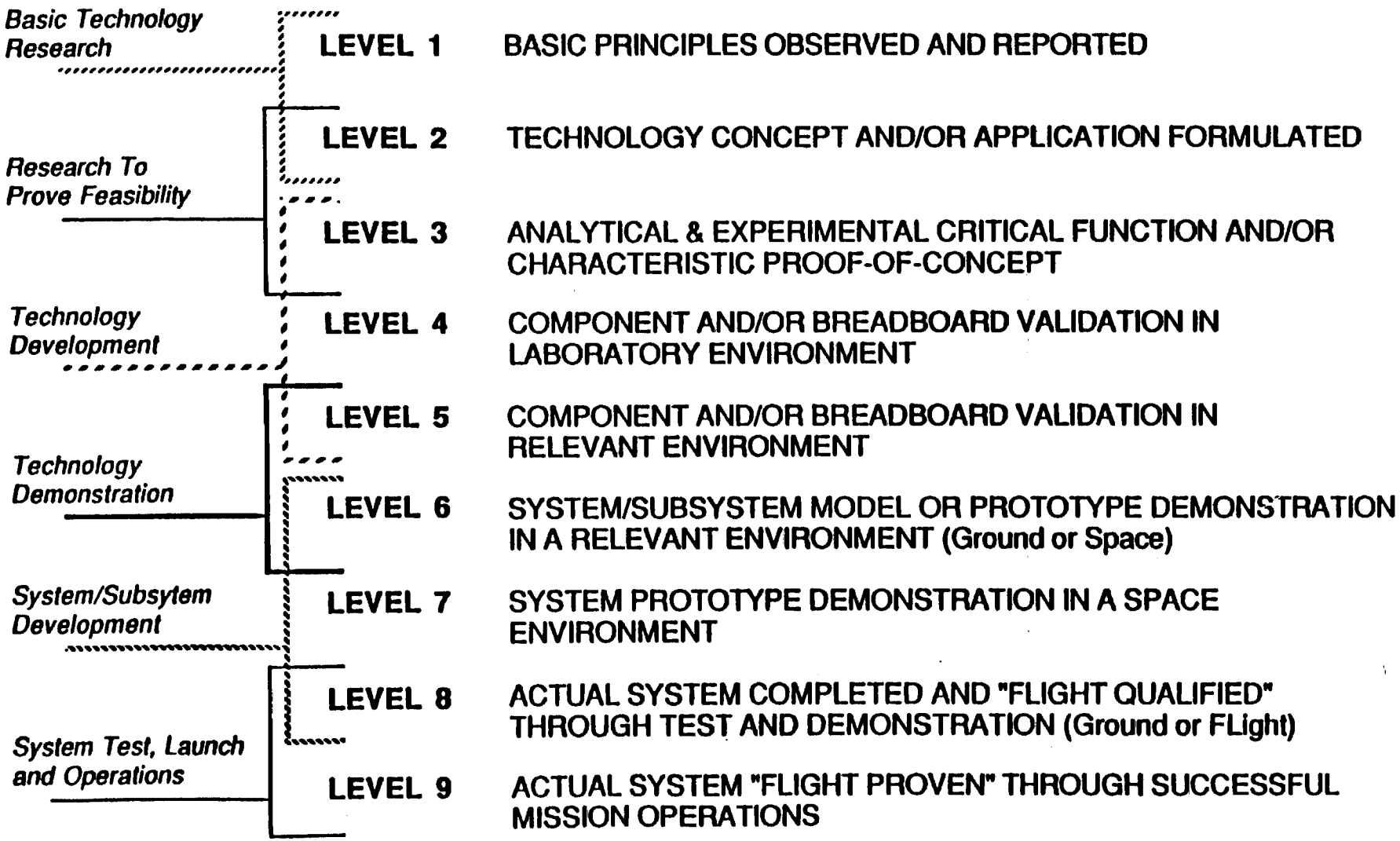
APPENDIX B

THE TECHNOLOGY TRANSFER PROCESS IMPROVEMENT TASK (TTPIT)

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

TECHNOLOGY READINESS LEVELS

OAET



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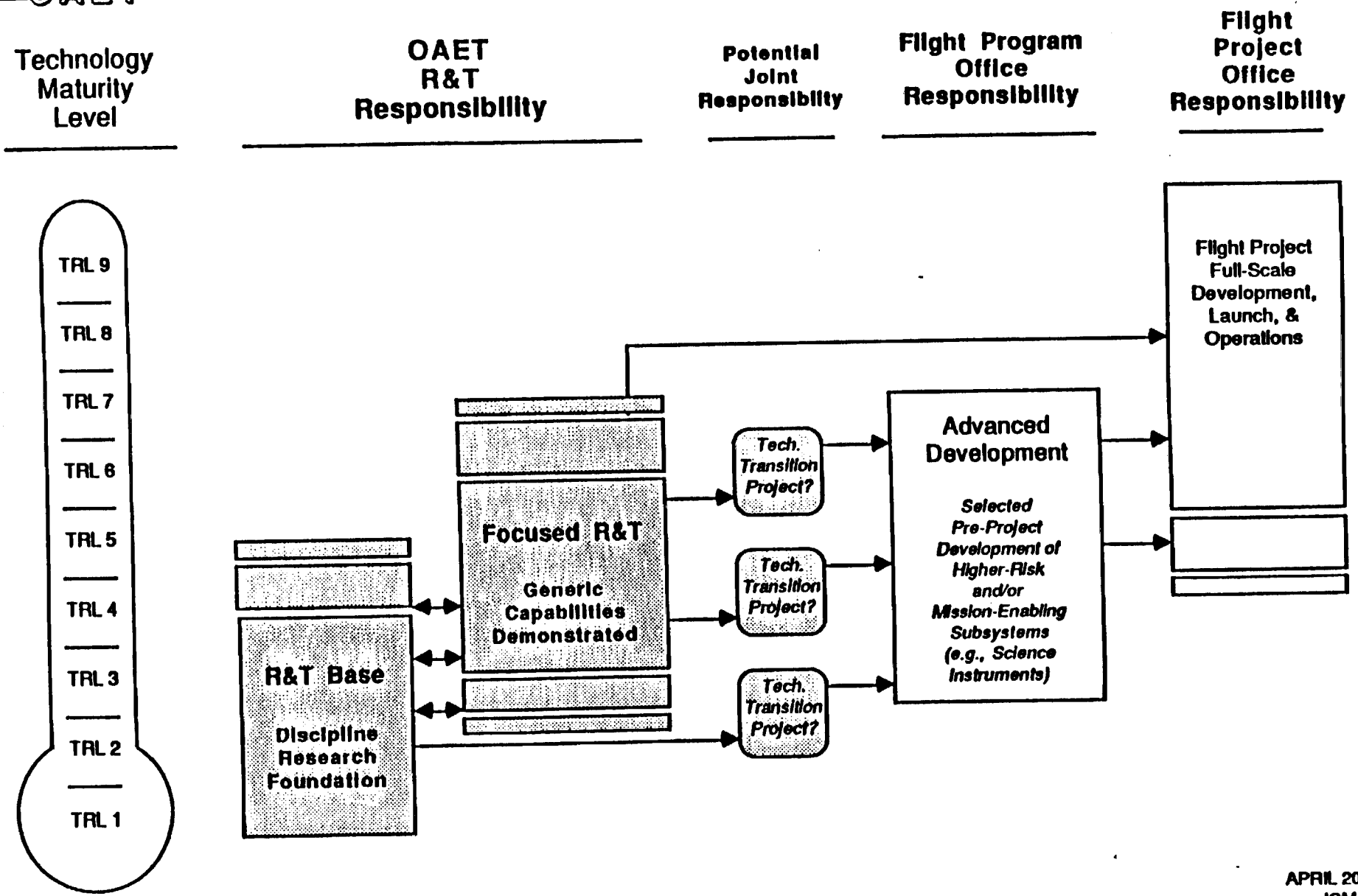
MARCH 17, 1991
JCM-7410

TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

NASA TECHNOLOGY MATURATION STRATEGY

OAET



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The Technology Transfer Process Improvement Task (TTPIT)

Introduction: The Rationale for Technology Transfer Improvement

In April of 1989, President Bush presented his long term plan for the future of the U.S. manned space program: the Space Exploration Initiative or SEI. The SEI would be America's first *strategic* manned space exploration plan calling for a return to the Moon and the exploration of Mars. The SEI poses new challenges to the way NASA previously has done business: a cost/safety driven development environment (versus the Apollo schedule/performance driven environment), simultaneous infrastructure and mission-specific development, event time horizons two to five times greater than any previous U. S. manned space program effort, and the need for multiple, enabling, long lead time technology developments The Apollo effort developed the bare bones minimum technology with a single objective in mind: to send a man to the moon and bring him back safely. The SEI effort must develop many differing types of technologies in order to build up a broad infrastructure in support of what will eventually become a multi-planetary society. The SEI will present an unparalleled demand on both the U.S. and private sector research and development communities;. one of the criterion for success of the SEI will depend on how efficiently NASA brings these enabling technologies from the *supplier* R&D labs into the *customer* infrastructure and/or mission flight programs

In addition to the challenges mentioned, NASA (and the U.S. as a whole) must acknowledge its inefficiencies in bringing innovations from the lab *to the market* (or into the hands of the customer). Any plan for improvement must understand the current shortcomings and identify solutions to the technology development and transfer process. The Technology Transfer Process Improvement Task (TTPIT) addresses the.transfer of technology from the NASA research labs to the NASA flight programs (hereafter described as NASA in-house technology transfer)

The rest of this discussion covers the following: a list of the civil space technology transfer categories, how NASA in-house technology development and transfer currently occurs, impediments to NASA in-house technology development and transfer, and the TTPIT approach for improving NASA in-house technology transfer.

Civil Space Technology Transfer Categories [1]

Four categories of civil space technology transfer are defined :

- From NASA research labs to NASA flight programs
- From federal agencies to NASA (and vice versa)
- From federal agencies to the aerospace industry
- From the aerospace sector to the U. S. economy

As mentioned, the TTPIT activity addresses the first category of technology transfer: From NASA research labs to NASA flight programs.

NASA In-house Technology Transfer

Before describing how technology transfer occurs at NASA, the concept of the Technology Readiness Level (TRL) is introduced Following this the process of NASA In-house Technology Transfer is described.

Technology development at NASA is described in terms of a single criterion defining technology maturity: The Technology Readiness Level or TRL (see Figure 1). The TRL scaling system consists of nine discrete levels with each level specify a set of conditions that once achieved set the technology's TRL. As described in the next paragraph, the TRL specifies which NASA participants would be currently responsible during a technology development project.

Figure 2 summarizes the technology development life cycle from inception to flight article, the participants involved, and the TRL where responsibility is transferred. The technology development and transfer process is as follows: Base and focused R & T brings technology up to TRL 5, at TRL 5 the responsibility is transitioned from focused R & T to the Advanced Development office out of the flight program office, at TRL 8 or 9 the technology article is transitioned to the flight project for integration. The concept of a joint responsibility technology transition project is introduced to help ensure efficient handoff between participants. Figure 2 is a good top level description of how technology development and transfer occurs. The next level of formal detail as to what the

[1] in the draft white paper by Mankins, "Civil Space Technology Development: A Series of Planning Workshops on Technology Transfer and Effectiveness."

process is or how to implement this description does not exist.. Although seemingly elegant in its simplicity, the single criterion of TRL is not enough to describe how to implement technology development and transfer. The need for a formal process cannot be underemphasized: the road to improvement lies in identifying how things are currently done and determining metrics that are the basis for process evaluation and improvement. An ad-hoc process by definition is not quantifiable and therefore not improvable.

Impediments to Technology Development and Transfer

Only an overview of the types of impediments will be discussed; each type could be the topic of a white paper or the subject of a new management initiative. Also, each of these types, especially NASA funding and organization are highly coupled. The point to be made here is to identify the key impediments to efficient and effective technology transfer.

There appear to be three basic types of technology transfer impediments:

- NASA Funding
- NASA Organization
- The Transfer Mechanism

At the center level, individual centers vie for funding against one another leading to an environment that is not conducive to open communication or cooperation. At the program/project level, technology development projects at >TRL=5 are in direct competition for funding with their flight project(s) beneficiary.

NASA's organization does not provide for a concurrent engineering relationship between the *supplying* researchers and *customer to be* flight project. Neither party views research as an integral part of the flight project development process: neither party views research as an integral part of the concept definition phase, and the researchers don't view the flight program as the true source of technology requirements in the specification sense. This type of organization results in development of technology capability that is not responsive to the customer needs.

As mentioned, there does not exist a rigorously defined technology transfer development and transfer process. The exchange of

information between the R & T supplier and flight project customer is crucial to the success of any complex development The customer must continually update his risk assessment plan specifically when enabling technology is concerned; the supplier must continually be informed as to the requirements and schedule on the technology being developed in order to remain responsive to the customer's need.

Technology Transfer Process Improvement Task (TTPIT) Proposal

The Technology Transfer Process Improvement Task proposal will perform the following:

- An in-depth analysis of the existing technology transfer process.

- Recommendations on a more rigorous definition of TRL

- Formalize the concept of a technology development and transfer life cycle; TRL acts like a major control gate between the nine phases of development - additional minor control gates need to be defined (from both the research and flight project perspective). for what occurs between TRLs.

- Formalize the information flow (types and content) between technology suppliers and flight project customers.

- Enhance the scope of the technology transfer problem to include:

  Strategic Planning: Inputs from the researchers that could define entirely new mission opportunities or save viable conceptual designs from killer trades

  Progress Monitoring and Resource Allocation: How often the exchange of information between R & T supplier and flight project customer should occur - given the funding environment, how the flight project can allocate resources, especially funding,

in order to minimize risk based on the internal rate of return and the time value of capability.
Product Development and Transfer: The concepts of technology development and technology transfer cannot be separated

Clearly identify the perspectives of both the R & T supplier and flight project customer with regard to Strategic Planning, Progress Monitoring and Resource Allocation, and Product Development and Transfer.

- Identify a joint development transition project between all representatives of the technology development and transfer life cycle; form a concurrent engineering team and begin validating the TTPIT approach.

Omit

APPENDIX C

MEMORANDUM OF AGREEMENT
BETWEEN
THE NATIONAL SCIENCE FOUNDATION
AND
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ON
ANTARCTIC ACTIVITIES

NASA

MEMORANDUM OF AGREEMENT

BETWEEN

THE NATIONAL SCIENCE FOUNDATION

AND

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ON

ANTARCTIC ACTIVITIES

JANUARY, 1991

MEMORANDUM OF AGREEMENT
BETWEEN
THE NATIONAL SCIENCE FOUNDATION
AND
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ON ANTARCTIC ACTIVITIES

INTRODUCTION

This Memorandum of Agreement provides the framework for collaboration between the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) on antarctic activities applicable to space research and exploration.

Typical joint activities may include:

1. Review of current and planned program efforts that relate to mutually beneficial areas.
2. Establishment of joint scientific research projects in the Antarctic, providing for joint solicitation and selection of researchers.
3. Preparation of strategic plans to identify, prioritize, and develop technology and applications common to terrestrial antarctic and space needs.
4. Preparation and execution of appropriate demonstration projects.

AUTHORITY

This agreement is authorized by Section 203(c) of the National Aeronautics and Space Act of 1958, as amended, and Section 3(a) and (b) of the National Science Foundation Act of 1950, as amended.

BACKGROUND

NSF and NASA have a long history of cooperative projects in Antarctica. These projects include: the recovery of meteorites from the ice sheet; glaciological studies and the potential for climate change-induced collapse of the ice sheet (SEARISE); large scale long-duration ballooning, including a planned project for cross calibration of Mars Observer and Phobos instruments by US and Soviet scientists; the development of improved satellite communications systems, such as the South Pole Satellite Data Link (SPSDL); and cosmic microwave background measurements, made simultaneously from South Pole and the NASA satellite COBE.

Previous work that is related to the exploration of planets includes: a series of jointly sponsored studies and workshops on the similarities of working in Antarctica and in space and on other planets; studies of cryptoendolithic plants in Antarctica that live beneath the surface of rocks, as they may have on Mars; and studies of the flora in the lakes of the Dry Valleys as might be related to life on Mars; these studies include plans to develop telerobotic techniques so that diving vehicles can be remotely operated by scientists physically located at Ames Research Center in California, and elsewhere. The Soviets have used Antarctica for studies of the effects of isolation on Cosmonauts, and some of the Apollo Astronauts visited the Dry Valleys before going to the moon.

Now there are many new opportunities that will prove to be mutually beneficial. Science activities related to NASA's ongoing program in space science and applications will extend their focus on Antarctica as a unique environment on planet Earth. These activities will continue as NASA prepares to undertake the additional challenges associated with future human missions to the moon and to Mars. For example, NASA will make use of Antarctica to test prototype hardware in a realistic setting, while NSF will benefit from the transfer of space technology in many areas. Of special interest are power systems, energy storage and conservation systems, telerobotics and automated systems, environmental protection and conservation of resources through advanced

waste management systems. NASA is interested in studying the psychology and physiology of the crews of small isolated stations, such as South Pole or the proposed high altitude station, while NSF will benefit from the insight that will enable better crew selection and training in the future.

SCOPE

1. NSF interests under this agreement are to:

- Identify advanced technologies that offer potential short and long-term benefits to planned antarctic base improvements/initiatives.
- Apply and test promising technologies at the earliest practical time to determine useful applications/benefits.
- Optimize living/working conditions at antarctic and other polar facilities.
- Reduce operations/logistics costs through improved power and waste management systems.
- Reduce environmental impacts of antarctic bases.
- Advance antarctic research by various means including joint projects in areas of mutual interest such as:
  - Antarctic Terrestrial Ecology,
  - Human Behavior and Performance,
  - Geological Exploration Techniques,
  - Atmospheric Chemistry,
  - Upper Atmospheric Physics,
  - Astrophysics.
- Foster interagency cooperation to support current and new initiatives.
- Promote networking with a broad range of technology and design resources.

2. NASA interests under this agreement are to:

- Provide for scientific research in areas of interest to NASA's program in space science and applications.
- Realize early demonstrations of crew operations under realistic environmental and working/living conditions.
- Demonstrate vital planetary surface and terrestrial technologies, including construction, power, waste control/recycling, and automation/telepresence.
- Demonstrate environmental and other benefits of space technology.
- Provide maximum leverage on NASA's investment in technology to assist other agencies that have common needs and interests.
- Foster interagency cooperation to provide long-term space program benefits.

AGREEMENT

NASA and NSF will, to the extent practicable and appropriate and within legal limits, jointly support beneficial activities concerned with antarctic analogs to space research and exploration, including preparation and planning activities, joint science projects, and demonstration projects involving both research and technology.

1. Major NSF contributions will be in the form of logistics support and procurement of hardware required by the U.S. Antarctic Program. In addition, and as appropriate, it will contribute to joint support of research projects. It will support planning and development related to new program hardware and facilities.

2. NASA will support mutually agreed tasks within the scope of its approved programs.

This agreement is effective as of the date of the signature of the last executing authority.

AMENDMENTS, FUNDING, AND TERMINATION

1. This Memorandum of Agreement may be modified, amended, or terminated by written mutual agreement. Statements of tasks to be conducted under this agreement will be appended to this document. Approval authority for subordinate task statements may be delegated to officials with resource authority to execute their terms.

2. Mutually agreed upon tasks will include a statement of:

A. Overall goal/objectives
B. Work requirements by each party
C. Time constraints/completion dates
D. Cost/funding detailed by agency
E. Approval points/milestones
F. Logistics requirements
G. Other pertinent information

Once agreement is reached by NSF and NASA on a statement of task, any reimbursable funding arrangements will be accompanied with or followed by a written order with funding which will be signed by a Contracting Officer from each agency.

3. In the event circumstances are such that either organization deems it necessary or desirable to terminate this agreement before completion of any services initiated hereunder, the parties will consult in advance of such termination and will, insofar as possible, fix a termination date sufficiently in advance so that they may determine how on-going grants or contracts shall be completed; and to make personnel and other adjustments in their operations in light of such termination.

NSF
Directorate for Geosciences

Robert W. Corell
Assistant Director

Date 1/25/91

NASA
Office of Aeronautics,
Exploration, and Technology

Arnold D. Aldrich
Associate Administrator

Date 1-23-91

NASA
Office of Space Science and
Applications

L. A. Fisk
Associate Administrator

Date 1/16/91

omit

APPENDIX D

Part 1:
MEMORANDUM OF AGREEMENT (MOA)
FOR
THE AMES-McDONNELL DOUGLAS
RESEARCH ASSOCIATE EXCHANGE PROGRAM

Part 2:
NON-DISCLOSURE AGREEMENT
BETWEEN
AMES RESEARCH CENTER AND McDONNELL DOUGLAS
regarding the
COMPUTER-AIDED SYSTEM ENGINEERING/ANALYSIS (CASE/A) CODE

MEMORANDUM OF AGREEMENT (MOA)
FOR
THE AMES-McDONNELL DOUGLAS
RESEARCH ASSOCIATE EXCHANGE PROGRAM
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
AND
McDONNELL DOUGLAS CORPORATION
THROUGH ITS
McDONNELL DOUGLAS SPACE SYSTEMS COMPANY

The National Aeronautics and Space Administration (hereinafter NASA), under the provisions of the National Aeronautics and Space Act of 1958, as amended, 42 USC § 2473(a)(3), is responsible for providing the widest practicable and appropriate dissemination of information generated through its activities, as well as for fostering the advancement of the state of the art in aeronautics and space research and technology. NASA recognizes that technical exchanges, through all appropriate means, between NASA and industrial organizations will accelerate the development and application of advanced regenerative life support technologies and systems to enable the future human exploration of space through a two-way exchange of specialized expertise and information.

McDonnell Douglas Corporation through its McDonnell Douglas Space Systems Company (hereinafter MDSSC) recognizes the value of these technical exchanges in the opportunity to assign employees to ARC in order to acquire specialized knowledge and experience related to advanced regenerative life support research and technology development, as well as to enhance the ability of MDSSC to meet marketplace needs. Both ARC and MDSSC desire to participate in the ARC-MDSSC Research Associate Exchange Program under the terms and conditions set forth below.

NOW, THEREFORE, IT IS AGREED:

Part 1. Assignment of MDSSC Employees to ARC

1.1 MDSSC, after consultation with ARC, may assign employees to ARC to perform space research and technology in specific technical areas. The technical areas may include modeling, experiment design and component testing of life support systems, systems analysis, and planetary surface and spacecraft life support systems performance studies. Each of the assignments will be in accordance with this Agreement with the specific technical areas and assignments delineated by an Annex to this Agreement.

1.2 The period of assignments under this Agreement shall be mutually agreed upon by ARC and MDSSC, but shall not exceed the expiration of this Agreement.

1.3 The research task of an assigned employee including objective, scope and schedule, shall be mutually established between ARC and MDSSC and set forth in an Annex to this Agreement executed by Authorized Representatives, who are named below. ARC shall select a mentor for each assigned MDSSC employee who will provide direction and general guidance to the assigned employee. Details of the research to be performed shall be agreed upon by the ARC mentor and the MDSSC assigned employee deriving from

the tasks delineated in the Annex to this Agreement. The MDSSC assigned employee shall be responsible for performing the assigned task.

1.4 At all times during their assignment under this Agreement, employees assigned by MDSSC shall retain their status as employees of MDSSC for purposes of salaries, fringe benefits, leave, insurance, workmen's compensation, seniority, and all other applicable employee rights and benefits. No employer-employee relationship shall be created by this Agreement between ARC and any MDSSC employee.

1.5 MDSSC shall provide all salary, fringe benefits, relocation expenses, per diem and travel expenses of its employees assigned under this Agreement.

1.6 Employees assigned by MDSSC shall comply with all security and safety regulations in the areas to which they are assigned.

1.7 MDSSC will report in writing to the Patent Counsel at ARC any invention, discovery, improvement, or innovation made by an employee while assigned to ARC arising from the performance of the assigned tasks hereunder, whether or not the same is susceptible of protection under the patent laws of the United States. Rights to such invention, discovery, improvement, or innovation will be determined in accordance with the provisions of Section 305 of the National Aeronautics and Space Act of 1958 (42 USC 2457).

1.8 The principal elements of the tasks of MDSSC employees will be performed at ARC. However, participants may be required to travel to other locations on occasion to participate in technical discussions and reviews. MDSSC will pay all travel expenses and per diem costs of its employees to attend such discussions or reviews.

1.9 Reports describing the results of the research performed may be either jointly or individually authored at the discretion of the ARC mentor. These reports may be published under NASA sponsorship and will be classified according to applicable DOD and NASA security guidelines. Within the security guidelines limitations, papers describing the results of the research may also be presented by the author or authors at one or more technical conferences. In the event ARC decides not to publish the results of the research under NASA sponsorship, then the assigned employee may seek other publication sources, provided that ARC may require that any such publication contain a statement that the results obtained as a consequence of the research and the conclusions drawn therefrom, are those of the employee and do not represent the conclusions of NASA.

1.10 ARC will provide, for MDSSC employees assigned to ARC under this Agreement, necessary facilities, equipment, software, analysis, and synthesis methods and techniques, provided that nothing herein shall preclude the assigned employee of MDSSC from providing facilities, software, data equipment, or methods to perform tasks if agreed to by the ARC mentor.

Part 2. Assignment of ARC Employees to MDSSC

2.1 ARC, after consultation with MDSSC, may assign employees to MDSSC to perform space research and technology in specific technical areas. The technical areas may include modeling, experiment design and component testing of life support systems, systems analysis, and planetary surface and spacecraft life support systems performance studies. Each of the assignments will be in accordance with this Agreement with the specific technical areas and assignments delineated by an Annex to this Agreement.

2.2 The period of assignments under this Agreement shall be mutually agreed upon by MDSSC and ARC, but shall not exceed the expiration of this Agreement.

2.3 The research task of an assigned employee including objective, scope and schedule, shall be mutually established between MDSSC and ARC and set forth in an Annex to this Agreement executed by Authorized Representatives.. MDSSC shall select a mentor for each assigned ARC employee who will provide direction and general guidance to the assigned employee. Details of the research to be performed shall be agreed upon and the MDSSC mentor and the ARC assigned employee deriving from the tasks delineated in the Annex to this Agreement. The ARC assigned employee shall be responsible for performing the assigned task.

2.4 At all times during their assignment under this Agreement, employees assigned by ARC shall retain their status as employees of ARC for purposes of salaries, fringe benefits, leave, insurance, workmen's compensation, seniority, and all other applicable employee rights and benefits. No employer-employee relationship shall be created by this Agreement between MDSSC and any ARC employee.

2.5 ARC shall provide all salary, fringe benefits, relocation expenses, per diem and travel expenses of its employees assigned under this Agreement.

2.6 Employees assigned by ARC shall comply with all security and safety regulations in the areas to which they are assigned.

2.7 The principal elements of the tasks of ARC employees will be performed at MDSSC. However, participants may be required to travel to other locations on occasion to participate in technical discussions and reviews. ARC will pay all travel expenses and per diem costs of its employees, to the extent provided by law, to attend such discussions or reviews.

2.8 Reports describing the results of the research performed may be either jointly or individually authored by the parties pursuant to this Agreement. These reports may be published under NASA sponsorship and will be classified according to applicable DOD and NASA security guidelines. Within the security guideline limitations, papers describing the results of the research may also be presented by the author or authors at one or more technical conferences.

2.9 MDSSC will provide for ARC employees assigned to MDSSC under this Agreement, necessary facilities, equipment, software, analysis, and synthesis methods and techniques, provided that nothing herein shall preclude the assigned employee of ARC from providing facilities, software, data equipment, or methods to perform tasks if agreed to by the MDSSC mentor.

Part 3. Additional Provisions

3.1 Inventions

(a) With respect to any invention first conceived or reduced to practice (made) by either party in the performance of this Agreement, each party agrees to promptly notify the other party and furnish the other party a disclosure of the invention. Such invention disclosure shall be held in confidence by the parties until all patent applications have been filed or other final disposition has been made. Under no circumstances will the period of confidentiality exceed one year from the time of receipt of a disclosure.

(b) With respect to any invention solely made by a party in performance of this Agreement, the invention shall be the property of the inventing party. In the event an invention is made jointly by the parties in performance of this Agreement, such invention shall be jointly owned. Any patent application which may be filed thereon shall be prepared and prosecuted as mutually agreed; however, every such patent application shall contain a section entitled "Origin of the Invention," and that section shall contain the following text:

> "The invention described herein was jointly made by (an) employee(s) of the U.S. Government and by (an) employee(s) of MDSSC, and it may be manufactured and used by either party without payment of any royalties thereon or therefor to the other party."

3.2 Data

(a) Under this Agreement, data is defined specifically to include technical information and know-how. Except for limitations expressly stated in this Agreement, all data exchanged pursuant to this Agreement will be subject to no restrictions and the receiving party shall have unlimited rights therein. Specifically, except for data limitations expressly stated elsewhere in this Agreement, the parties shall each have the right to use, duplicate, and disclose, in whole or in part, in any manner and for any purpose whatever, and have others so, all data exchanged pursuant to this Agreement.

(b) Nothing contained in this Agreement alters the earlier Agreement executed between the parties, entitled Non-Disclosure Agreement, and particularly it does not modify the terms and conditions for the exchange of technical data contained in that Agreement.

(c) In accordance with the assignment described in Annex 1, a MDSSC employee will bring to NASA derivative computer programs (developed under MDSSC's IR&D Program) of NASA's CASE/A and will write derivative programs while in residence at NASA. Collectively, these derivative programs, and any others made by MDSSC pursuant to other Annexes, are hereinafter called CASE/A Derivative Programs. NASA shall have a nonexclusive, non-transferable, paid-up license in perpetuity to use, reproduce, modify, adapt, and combine CASE/A Derivative Programs with other programs; however, NASA may not disclose CASE/A Derivative Programs to other parties, except support service contractors, without the written permission of MDSSC. Disclosure of CASE/A Derivative Programs may only be made to support service contractors who aid NASA in the use or modification of CASE/A and subject to the same restrictions imposed on NASA.

(d) Although reasonable efforts will be made by the parties to minimize such occurrence, it may be necessary for MDSSC, within its sole discretion, to furnish or otherwise disclose to NASA certain data, other than CASE/A Derivative Programs, which constitutes trade secrets of MDSSC. In order to enable MDSSC to maintain its trade secret rights in such data (other than CASE/A Derivative Programs), hereinafter called Trade Secret Data, the following notice shall be affixed to the Trade Secret Data and NASA will thereafter treat the Trade Secret Data in accordance with the conditions of the notice:

> NOTICE
>
> This data is proprietary and/or a trade secret of MDSSC and is submitted in confidence to NASA under an Agreement. The data may be used and reproduced by NASA only for the purpose of carrying out the Agreement and may not be disclosed to a third party without the written permission of MDSSC except that NASA has the right to disclose the data to support service contractors for purposes consistent with the Agreement providing such contractors agree to the same restriction imposed on NASA.

(e) The requirement for protection of Trade Secret Data shall survive any termination or expiration of this Agreement and shall remain in force until midnight December 31, 1995.

3.3 As to the CASE/A computer program disclosed to MDSSC by NASA in the performance in the Agreement, MDSSC is granted, in accordance with NASA NMI 2210.2B, a nonexclusive, non-transferable, paid-up license in perpetuity to use, reproduce, modify, adapt, and combine CASE/A with other software, but MDSSC may not export CASE/A, or a derivative thereof, or disclose CASE/A, or a derivative thereof, to other parties without the written permission of NASA. Should it become necessary in the course of the Agreement for NASA to disclose computer programs other than CASE/A to MDSSC, the disclosures shall be made pursuant to NMI 2210.2B.

3.4 (a) ARC (subject to the limitations set forth in Paragraph (c) below) and MDSSC shall each bear its own costs of participating in this Agreement. There will be no exchange of funds between ARC and MDSSC under this Agreement.

(b) ARC will use reasonable efforts, on a noninterference basis with other ARC activities, to provide its personnel and other resources in support of this Agreement.

(c) ARC's ability to perform its obligations under this Agreement is subject to the availability of appropriated funds. ARC will use reasonable efforts to obtain needed funding. If adequate funds are not appropriated, this Agreement may be terminated by ARC as provided in Paragraph 3.14 below. Nothing in the Agreement commits the United States Congress to appropriate funds for the purposes stated herein.

3.5 This Agreement is not intended to constitute, create, give effect, or otherwise recognize a joint venture, partnership, formal business organization, or agency agreement of any kind, and the rights and obligations of the parties shall be only those expressly set forth herein. Both parties shall remain independent organizations, each responsible for its own employees, costs, risks, liabilities and expenses incurred in the performance of this Agreement.

3.6 Each party will bear the cost of discharging its own responsibilities, including travel and subsistence of its own personnel and transportation charges on all of its own equipment. It is understood that the ability of ARC and MDSSC to carry out their responsibilities is subject to their respective funding procedures.

3.7 This Agreement is entered into by NASA under the authority of the National Aeronautics and Space Act of 1958, as amended, 42 USC § 2473(c)(5).

3.8 MDSSC shall not make any claim against the United States Government or its contractors or subcontractors for damages or other relief for any delay (including a deferral, suspension, or postponement) or termination of performance of this Agreement.

3.9 Neither ARC nor MDSSC shall make any claim with respect to injury or deaths of its own or its contractors' or its subcontractors' employees, or damage to its own or its contractors' or subcontractors' property caused by activities arising out of or connected with the performance of the Agreement, whether such injury, death, or damage arises through negligence or otherwise.

3.10 No member or delegate to the United States Congress, or resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

3.11 This Agreement may be modified at any time by a written document signed by officials authorized to bind the parties.

3.12 This Agreement shall not prevent either party from entering into a similar agreement with others.

3.13 Neither this Agreement nor any interest arising under it shall be assigned by either party without the consent of the official executing this Agreement on behalf of ARC and MDSSC, or another official delegated such authority by the executing official.

3.14 The term of this Agreement shall be thirty-six (36) months from the date of execution hereof. Either party may at any time during the term of this Agreement terminate this Agreement, without liability to the other party, by written notice to the other party, the effective date of termination will be thirty (30) days after receipt of such notice by the other party.

3.15 NASA will not be liable for any results or data produced, or conclusions drawn, by MDSSC as a result of MDSSC's, its employees', contractors', or subcontractors' use of ARC methods or software which are obtained by MDSSC or its employees as a result of this Agreement.

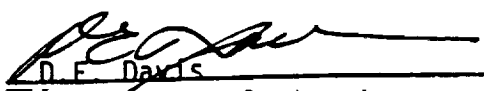
3.16 MDSSC will not be liable for any results or data produced, or conclusions drawn, by ARC as a result of ARC's, its employees', contractors', or subcontractors' use of MDSSC's methods or software which are obtained by ARC or its employees as a result of this Agreement.

3.17 For purpose of characterizing and choosing assignments under Parts 1 and 2 and preparing and executing Annexes, as necessary, to this Agreement, the parties select these Authorized Representatives:

NASA Authorized Representative:

Vincent J. Bilardo, Jr.
Chief, Systems Evaluation & Integration Branch
Advanced Life Support Division

McDonnell Douglas Authorized Representative:



D. F. Davis
Title: Manager- Contracts
McDonnell Douglas Corporation
McDonnell Douglas Space System Company

Executed in duplicate originals by the undersigned who are authorized to bind their respective organization to the terms hereof.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
MOUNTAIN VIEW, CALIFORNIA

By _____
DALE L. COMPTON
Director

Date: 5/28, 1991

McDONNELL DOUGLAS CORPORATION
McDONNELL DOUGLAS SPACE SYSTEMS COMPANY
HUNTINGTON BEACH, CALIFORNIA

By _____
D.C. WENSLEY
Vice President, Deputy General Manager
Space Station Division

Date: 5-7, 1991

Jm f

ANNEX 1
MEMORANDUM OF AGREEMENT
FOR
THE AMES-McDONNELL DOUGLAS
RESEARCH ASSOCIATE EXCHANGE PROGRAM
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND
McDONNELL DOUGLAS CORPORATION
THROUGH ITS
McDONNELL DOUGLAS SPACE SYSTEMS COMPANY

A. Technical Area: Advanced Life Support Systems Analysis

B. Assignment: McDonnell Douglas Space Systems Company (MDSSC) will assign an employee to NASA-Ames Research Center (ARC) in the technical area of Advanced Life Support Systems Analysis. The assignment will be associated with the Analytical Tool Validation Task for Bioregenerative Life Support Systems Analysis within the Systems Evaluation and Integration Branch (Code SAS) of the Advanced Life Support Division. The objective is to utilize the CASE/A life support systems modeling program, together with the bioregenerative and waste processing component extensions developed under the MDSSC Internal Research and Development (IRAD) Program, to model and simulate one or more ground-based bioprocessor chambers located at NASA ARC. The model predictions will be compared to actual test data produced with the chamber(s) to allow refinement of the model and CASE/A extensions.

C. Assignment Period: A six month period on site at NASA ARC to commence not earlier than March 15, 1991.

D. Assignee: Stephen R. Gustavino

Approved:

Vincent J. Bilardo, Jr., Chief
Systems Evaluation and
Integration Branch
NASA Ames Research Center
Mountain View, CA

D.E. Davis
Manager-Contracts
McDonnell Douglas Space
Systems Company
Huntington Beach, CA

MCDONNELL DOUGLAS

McDonnell Douglas Space Systems Company

January 20, 1991

Subject: Memorandum of Agreement, Annex 2

To: National Aeronautics and Space Administration
Vincent J. Bilardo, Jr.
Mail Stop 239-8
Ames Research Center
Moffett Field, CA 94035-1000

Reference: SAS:239-8

Dear Mr. ~~Bilardo~~ Vince:

It is a pleasure to return to you the signed Annex 2 of the Memorandum of Agreement between NASA Ames Research Center and McDonnell Douglas Space Systems Company.

We are quite pleased with the outstanding support that Steve Gustavino, our MDSSC Guest Investigator for Annex 1, has received during his tenure at Ames in your organization. We appreciate your energy, enthusiasm, and leadership in providing for Steve a stimulating environment addressing important topics in advanced life support research and analysis.

Now, with the signing of Annex 2 it is our turn to host the NASA-ARC Guest Investigator. We are now making detailed arrangements to facilitate a smooth transfer of Ann McCormack, the NASA Guest Investigator, to Huntington Beach.

Both our advanced technology division (APD&T) and the Space Station Division are looking forward to the continuing partnership with your organization. Please call me at 714-896-3817 at any time if I can be of help.

Sincerely,

Bob Sirko

Dr. Robert J. Sirko
Advanced Space Science and Technology
Advanced Product Development & Technology Division

Enclosure

1189/Sirko/5/de

5301 Bolsa Avenue, Huntington Beach, CA 92647-2048 (714) 896-3311 TELEX 67-8426 FAX 896-1313

ANNEX 2
MEMORANDUM OF AGREEMENT
FOR
THE AMES-McDONNELL DOUGLAS
RESEARCH ASSOCIATE EXCHANGE PROGRAM
BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND
McDONNELL DOUGLAS CORPORATION
THROUGH ITS
McDONNELL DOUGLAS SPACE SYSTEMS COMPANY

A. Technical Area: Advanced Life Support Systems Analysis

B. Assignment: NASA-Ames Research Center (ARC) will assign an employee to McDonnell Douglas Space Systems Company (MDSSC) in the technical area of Advanced Life Support Systems Analysis. The assignment will be continuing the work in Biroregenerative Life Support Systems Analysis started on previous associate exchange. The primary emphasis will be focused on the following areas: refining and documenting the Salad Machine model, performing studies on mathematical models describing the plant parameters which become important when plants are integrated into a life support system, and developing a bioprocessor, its hardware and control algorithms.

C. Assignment Period: A six to nine month period on site at MDSSC, Huntington Beach, California, to commence not earlier than February 1, 1992.

D. Assignee: Ann C. McCormack

Approved:

Vincent J. Bilardo, Jr., Chief
Systems Evaluation and
Integration Branch
NASA Ames Research Center
Mountain View, CA

D.E. Davis 1/20/92
Manager-Contracts
McDonnell Douglas Space
Systems Company
Huntington Beach, CA

NONDISCLOSURE AGREEMENT

This agreement, which begins on the date of the signing of the last signatory, is between McDonnell Douglas Space Systems Company, hereinafter called DISCLOSER, located at Huntington Beach, California and NASA Ames Research Center, hereinafter called EVALUATOR, located at Moffett Field, CA 94035-1000. DISCLOSER, in order to generate sales interest in the EVALUATOR and/or establish a beta test, wishes to disclose information to EVALUATOR about the following products: Plant Growth routine, Harvestor routine, and Food Processor routine for the Computer-Aided System Engineering/Analysis (CASE/A) computer code. DISCLOSER may additionally wish to loan EVALUATOR a prototype or sample product. DISCLOSER believes the information to be disclosed is not generally known in the relevant trade or industry and desires it to remain confidential.

EVALUATOR agrees to use reasonable care not to disclose to third parties delivered information which is in recorded form (written, typed, printed, graphic, or machine readable) and which bears an appropriate restrictive marking. In order to be protected hereunder by EVALUATOR, recorded delivered information which DISCLOSER wishes to remain confidential must be clearly and conspicuously marked with a suitable "confidentiality" notice or legend. Such information shall hereinafter simply be referred to as "delivered data". EVALUATOR may disregard, remove or obliterate any notice or legend that is not in keeping with this agreement. Any information disclosed to EVALUATOR which is not in recorded form and lacks the aforementioned notice or legend shall be considered unrestricted as to its use and dissemination, and not protected by this agreement, unless such disclosed information is identified orally as confidential at the time of disclosure and is subsequently furnished to EVALUATOR in an appropriately marked recording within twenty (20) days of the initial disclosure. EVALUATOR shall not be liable for inadvertent or accidental disclosure of delivered data provided reasonable care was used to protect it.

EVALUATOR shall not be barred from disclosing to others delivered data if it:

1. Is in the public domain;
2. Is known to EVALUATOR at the time of receipt;
3. Becomes known to EVALUATOR without a similar restriction from a third party; or
4. Is released by DISCLOSER to a third party without restriction.

EVALUATOR shall not be liable for disclosure of delivered data if the disclosure is made in response to an order of a court of competent jurisdiction, provided however that EVALUATOR will first give notice to DISCLOSER before such disclosure so a protective order, if appropriate, may be sought by DISCLOSER.

EVALUATOR has the right to use delivered data and any accompanying prototype or product, only for purposes of evaluation and EVALUATOR may be assisted in the evaluation by government contractors as long as the contractors agree to protect the delivered data from unauthorized use or disclosure as set forth herein, and DISCLOSER is given written notice as to the identity of such contractors. EVALUATOR may reproduce the delivered data as is necessary to perform an evaluation. The evaluation period shall be in effect 730 days. When that period expires, DISCLOSER may take possession of all delivered data along with any copies thereof, or direct EVALUATOR to discard or destroy the delivered data and copies. Further, at the end of the period, EVALUATOR will turn over to DISCLOSER any prototype or product that EVALUATOR has received from DISCLOSER in addition to the delivered data; and DISCLOSER agrees to hold EVALUATOR harmless, not bring any claim against or sue EVALUATOR and to absorb the financial and other consequences for any wear, damage, loss, mysterious disappearance or theft of a prototype or product while it is in the possession of EVALUATOR. As used herein, "prototype" or "product" means an item other than delivered data such as a device, machine, or apparatus. During the course of the agreement EVALUATOR may not turn

over possession of a prototype or product to a third party, other than aforementioned government contractors, but EVALUATOR does not have the duty of shielding a prototype or product from the view of third parties. All of DISCLOSER'S use and disclosure restrictions on the delivered data shall expire December 1, 1992, if not sooner.

DISCLOSER:

Robert J Sirko

Dr. Robert J. Sirko
Senior Manager, Advanced Space
Science and Technology
APD&T Division
McDonnell Douglas Space Systems Co.

Date: 3/6/91

EVALUATOR:

Vincent J. Bilardo, Jr.
Chief, Systems Evaluation and
Integration Branch
Advanced Life Support Division
NASA Ames Research Center

Date: 3/6/91

omit

APPENDIX E

FOSTER GRANT PATENT LICENSE

EXCLUSIVE LICENSE AGREEMENT

U.S. Patent No.	:	4,137,365
Issue Date	:	January 30, 1979
Canadian Patent No	:	1,077,787
Issue Date	:	May 20,1980
Title	:	Oxygen Post-Treatment of Plastic Surfaces Coated with Plasma Polymerized Silicon-Containing Monomers
Licensor	:	The United States of America, as Represented by the National Aeronautics and Space Administration (NASA)
LICENSEE	:	Foster Grant Corporation
Date of License	:	DEC 16 1982

INDEX

EXCLUSIVE LICENSE AGREEMENT

U.S. Patent No.	:	4,137,365
Issue Date	:	January 30, 1979
Canadian Patent No.	:	1,077,787
Issue Date	:	May 20, 1980
Title	:	Oxygen Post-Treatment of Plastic Surfaces Coated with Plasma Polymerized Silicon-Containing Monomers

This Agreement made and entered into at Washington, D.C., by and between the United States of America, as represented by the National Aeronautics and Space Administration (NASA) hereinafter referred to as LICENSOR, and Foster Grant Corporation, a Delaware Corporation, with its principal place of business at 289 North Main Street, Leominster, Massachusetts, 01453, hereafter referred to as LICENSEE.

WITNESSETH:

WHEREAS, under the authority of Public Law 96-517, LICENSOR has issued Patent Licensing Regulations, 14 CFR § 1245.2 et seq., specifying the terms and conditions upon which licenses will be granted for NASA-owned inventions, and

WHEREAS, such regulations provide that NASA-owned inventions will best serve the interest of the United States when they are brought to practical application in the shortest time possible, and

WHEREAS, it is the policy of NASA to grant exclusive licenses when such licenses will provide the necessary incentive

to the LICENSEE to achieve early practical application of the invention, and

WHEREAS, LICENSOR is the owner of U.S. Patent No. 4,137,365 and Canadian Patent No. 1,077,787 for the "Oxygen Post-Treatment of Plastic Surfaces Coated with Plasma Polymerized Silicon-Containing Monomers," and has announced the availability of the invention for licensing in written media in an effort to encourage the practical application of the invention, and

WHEREAS, LICENSOR desires in the public interest that the invention be perfected, marketed, and practiced so that the benefits thereof are readily available for the widest possible utilization in the shortest time possible, and

WHEREAS, LICENSEE, in consideration of the grant of an exclusive license, is willing to pay a royalty, make a substantial capital investment and use its best efforts to achieve early practical application of the invention, and

WHEREAS, LICENSOR has determined that the invention has not been brought to the desired practical application by a nonexclusive licensee and such practical application is not likely to be achieved expeditiously by further funding by the Government or under a nonexclusive license requested pursuant to the NASA Patent Licensing Regulations, and

WHEREAS, LICENSOR has determined that the granting of an exclusive license to LICENSEE to practice the invention will provide the necessary incentive for LICENSEE to achieve the desired early practical application and that the granting of an exclusive license to the LICENSEE will be in the public interest,

NOW THEREFORE, in accordance with the NASA Patent Licensing Regulations, and in consideration of the foregoing and of the terms hereinafter contained in this Agreement, the parties agree as set forth below:

ARTICLE I

Definitions

1.1 For the purposes of this Agreement, the following definitions shall be applicable:

(a) "LICENSED INVENTION" means the invention described and claimed in U.S. Patent No. 4,137,365 and Canadian Patent No. 1,077,787 and any reissue thereof;

(b) "PRACTICE" means to make or have made, use or have used, or sell or have sold;

(c) "PRACTICAL APPLICATION" means the practice of an invention under such conditions as to establish that its benefits are reasonably accessible to the public;

(d) "ROYALTY-BASE PRODUCTS" - any and all lenses treated by the process covered by any subsisting and unexpired claim in U.S. Patent No. 4,137,365 or Canadian Patent No. 1,077,787 and any reissue thereof

ARTICLE II

License Grant

2.1 LICENSOR hereby grants to LICENSEE a royalty-bearing, limited, exclusive license to make, use, or sell the LICENSED

INVENTION in the United States and in Canada and a nonexclusive right to sell anywhere in the world products utilizing the LICENSED INVENTION which were manufactured in the United States or Canada.

ARTICLE III

Term

3.1 The license shall commence as of January 1, 1983, and shall continue until January 30, 1996 unless revoked or terminated at an earlier date in accordance with other provisions of this Agreement.

ARTICLE IV

Best Efforts

4.1 LICENSEE shall use his best efforts to achieve PRACTICAL APPLICATION of the LICENSED INVENTION within two (2) years after the effective date of this Agreement and thereafter to continue to make the benefits of the LICENSED INVENTION accessible to the public.

ARTICLE V

Royalty

5.1 In consideration of the license granted under this Agreement, LICENSEE agrees to pay, and will pay, to LICENSOR within 30 days after the commencement date of this Agreement, a sum of five-thousand dollars ($5,000.00). Two-thousand five-hundred dollars ($2,500.00) of this sum shall be creditable

against royalties accruing under paragraph 5.2. This check shall be made payable to the Treasurer of the United States.

5.2 In addition to the payment recited in paragraph 5.1 of this Agreement, LICENSEE agrees to pay and will pay to LICENSOR a running royalty of one cent ($.01) for each pair of lenses treated by the process covered by any subsisting and unexpired claim in U.S. Patent No. 4,137,365 or Canadian Patent No. 1,077,787 and any reissue thereof, and sold. Returns shall be creditable.

5.3 LICENSEE shall assume full responsibility for the reporting and payment of all royalties due LICENSOR for the manufacture, use, or sale of the LICENSED INVENTION by any SUBLICENSEE.

ARTICLE VI

Annual Report and Payment

6.1 LICENSEE agrees to submit to LICENSOR an annual report in writing no later than March 1 of each year during the period of this Agreement which shall include:

(a) A brief statement describing the activities of LICENSEE during the preceding calendar year in achieving PRACTICAL APPLICATION of the LICENSED INVENTION and in making the benefits of the LICENSED INVENTION accessible to the public.

(b) Responses to the following questions from LICENSEE:

(1) Sales in dollars of products incorporating the LICENSED INVENTION by your company for the preceding calendar year.

(2) Total sales in dollars, to date, of products incorporating the LICENSED INVENTION by your company.

(3) Number of pairs of lenses treated by the LICENSED INVENTION and sold by your company in the preceding calendar year.

(4) Total number of pairs of lenses treated by the LICENSED INVENTION and sold, to date, by your company

(5) Amount of royalties, if any, due NASA under the above identified license for the preceding calendar year.

(6) Date your company achieved commercialization of the LICENSED INVENTION.

(7) Percentage of possibility of your company ever achieving commercialization of the LICENSED INVENTION

(8) Date your company expects to achieve commercialization of the LICENSED INVENTION.

(9) Cost, to date, in labor and resources to your company to commercialize the LICENSED INVENTION, broken down into the following categories:

(1) Technical development

(2) Production facilities

(3) Marketing and sales promotion

(10) Estimate of the additional cost in labor and other resources, to your company, that will be necessary to commercialize the LICENSED INVENTION, broken down into the following catgegories:

(1) Technical development

(2) Production facilities

(3) Marketing and sales promotion

6.2 Payment of the royalties due for the preceding calendar year shall accompany said report.

ARTICLE VII

Books, Records and Examination

7.1 LICENSEE shall keep full, true and accurate books of account containing all particulars which may be necesssary for the purpose of showing the amount payable to LICENSOR by way of royalty, as aforesaid. Said books of account and the supporting data shall be open at all reasonable times, for two (2) calendar years following the end of the calendar year to which they pertain, for inspection by an authorized representative of LICENSOR for the purpose of verifying LICENSEE's royalty reports.

ARTICLE VIII

Sublicenses

8.1 LICENSEE may grant written sublicenses under this license upon terms that LICENSEE may arrange provided that:

(a) Each sublicense shall be subject to the terms and conditions of this license including the rights reserved by the LICENSOR under ARTICLE XIV of this license; and

(b) Each sublicense shall include the condition that the sublicense shall automatically terminate upon the termination of this license; and

(c) Before any sublicense is granted by LICENSEE, the written approval of LICENSOR shall first be obtained for each sublicense; and

(d) Within thirty (30) days after a sublicense grant or modification, LICENSEE shall furnish LICENSOR with an executed copy of the sublicense or modification; and

(e) The granting of any sublicenses by LICENSEE shall in no way relieve LICENSEE from any of the requirements of this license.

ARTICLE IX

Patent Marking and Advertisement

9.1 LICENSEE shall mark all units of the LICENSED INVENTION made or sold by it under this Agreement in accordance with the statutes of the United States and Canada relating to the marking of patented articles. Such marking shall include the notation "Licensed from the National Aeronautics and Space Administration under U.S. Patent No. 4,137,365, or Canadian Patent No. 1,077,787," or other appropriate reference to the license.

9.2 Except as required in paragraph 9.1, LICENSEE and all SUBLICENSEES shall not use the names of the inventors or the name of LICENSOR, nor any adaptation thereof, in any advertising,

promotional, or sales literature without prior written consent obtained from LICENSOR.

ARTICLE X

Nontransferability

10.1 This license shall be nontransferable except to a successor to that part of LICENSEE'S business to which the invention pertains.

ARTICLE XI

Revocation by Licensor

11.1 The license granted pursuant to ARTICLE II of this Agreement may be revoked, either in part or its entirety:

(a) if in LICENSOR'S opinion, LICENSEE at any time fails to use its best efforts to achieve PRACTICAL APPLICATION of the LICENSED INVENTION, or

(b) if LICENSEE fails to achieve PRACTICAL APPLICATION of the LICENSED INVENTION within two (2) years after the effective date of this Agreement, or

(c) if LICENSEE, after achieving PRACTICAL APPLICATION of the LICENSED INVENTION, fails to continue such PRACTICAL APPLICATION, or

(d) if LICENSEE fails to pay royalties in accordance with ARTICLES V and VI of this Agreement, or

(e) if LICENSEE, at any time, shall default in making any report required by this Agreement, or shall make any false report, or shall commit any breach of any covenant or agreement herein contained, and shall fail to remedy any such default, false report, or breach within thirty (30) days after written notice from LICENSOR, or

(f) if LICENSEE becomes insolvent, or shall make any assignment for the benefit of creditors of that part of LICENSEE'S business to which this invention pertains, or if LICENSEE is adjudged bankrupt, or if a receiver or trustee of LICENSEE'S property shall be appointed.

11.2 Before revoking the license herein granted for any cause, there will be furnished to LICENSEE and to all SUBLICENSEES a written notice stating LICENSOR's intention to revoke the license and the reason therefore. LICENSEE and all SUBLICENSEES will be allowed thirty (30) days after receipt of such notice to appeal in writing to the Administrator of NASA on the question of whether the license or sublicense should be revoked. The notice of appeal and all supporting documentation should be addressed to the Administrator, National Aeronautics and Space Administration, Washington, DC 20546. LICENSEE shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. The decision on the appeal shall be made by the NASA Administrator or designee. There is no further right of administrative appeal from this decision.

ARTICLE XII

Termination by Licensee

2.1 This license may be terminated at any time at the option of the LICENSEE upon thirty (30) days written notification to LICENSOR of intent to terminate. All outstanding royalties become due with notice of termination, and after payment in full thereof, LICENSEE is released from any further obligation under this Agreement.

ARTICLE XIII

Disputes

13.1 All disputes concerning the interpretation or application of this Agreement shall be discussed mutually between the parties; and those disputes which are not disposed of by mutual agreement shall be decided by the Assistant General Counsel for Patent Matters, NASA Headquarters, Washington, D. C. 20546, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to LICENSEE. His decision shall be final and conclusive, unless within thirty (30) days from the date of receipt of such copy, LICENSEE mails or otherwise furnishes a written appeal addressed to the Administrator, National Aeronautics and Space Administration, Washington, D. C. 20546. LICENSEE shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. The decision on the appeal shall be made by the NASA Administrator or designee. There is no further right of administrative appeal from this decision.

ARTICLE XIV

Reservation of Rights

14.1 LICENSOR reserves an irrevocable royalty-free right to practice and have practiced the LICENSED INVENTION throughout the world by or on behalf of the Government of the United States and on behalf of any foreign government pursuant to any existing or future treaty or agreement with the United States.

ARTICLE XV

Representations and Warranties

15.1 LICENSOR makes no representation or warranty that the practice by LICENSEE of the LICENSED INVENTION will be free from infringement or charges of infringement of other patents, and LICENSOR assumes no liabilities whatsoever that may result from the exercise of the license.

15.2 Nothing contained in this Agreement shall be construed as (1) a warranty or representation by either party as to the validity or scope of the licensed patent, and (2) granting by implication, estoppel, or otherwise, any licenses or rights under patents other than the licensed patent.

15.3 LICENSOR makes no representations, extends no warranties of any kind, either express or implied, and assumes no responsibilities whatever with respect to use, sale, or other disposition by LICENSEE or its vendees or other transferees of products incorporating or made by use of (i) the LICENSED INVENTION or (ii) information, if any, furnished under this Agreement.

ARTICLE XVI

Litigation

16.1 LICENSEE may call to the attention of LICENSOR any infringement of the licensed patent which infringement, if continued, might affect the rights of LICENSEE. If, after receiving such notice of infringement from LICENSEE, LICENSOR does not file suit or cause such alleged infringement to cease within a period of six (6) months from the date of such notice, then LICENSOR agrees that LICENSEE shall have the right to sue in its own name, at its own expense, and for its own benefit, any such infringer of the licensed patent. The LICENSEE may join the LICENSOR, upon consent of the Attorney General of the United States, as a party complainant in any litigation involving the licensed patent, but without expense to the LICENSOR.

ARTICLE XVII

Covenant Against Contingent Fees

17.1 LICENSEE warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by LICENSEE for the purpose of securing business. For breach or violation of this warranty, LICENSOR shall have the right to revoke this Agreement without liability.

ARTICLE XVIII

Officials Not to Benefit

18.1 No member of, or delegate, to Congress, or resident commissioner, shall be admitted to any share or part of this Agreement or to any benefit that may arise therefrom, but this provision shall not be considered to extend to this Agreement if made with a corporation for its general benefit.

ARTICLE XIX

Addresses

19.1 Any communications including reports, payments, and notices to be given hereunder shall be mailed to the following respective addresses:

Director of Patent Licensing
NASA Headquarters
Mail Code GP-4
Washington, DC 20546

Mr. Hugh C. Crall
Division Patent Counsel
Foster Grant Corporation
289 North Main Street
Leominster, MA 01453

LICENSOR: United States of America

by _____
General Counsel
National Aeronautics and Space Administration

DATE: December 16, 1982

LICENSEE: Foster Grant Corporation

by _____

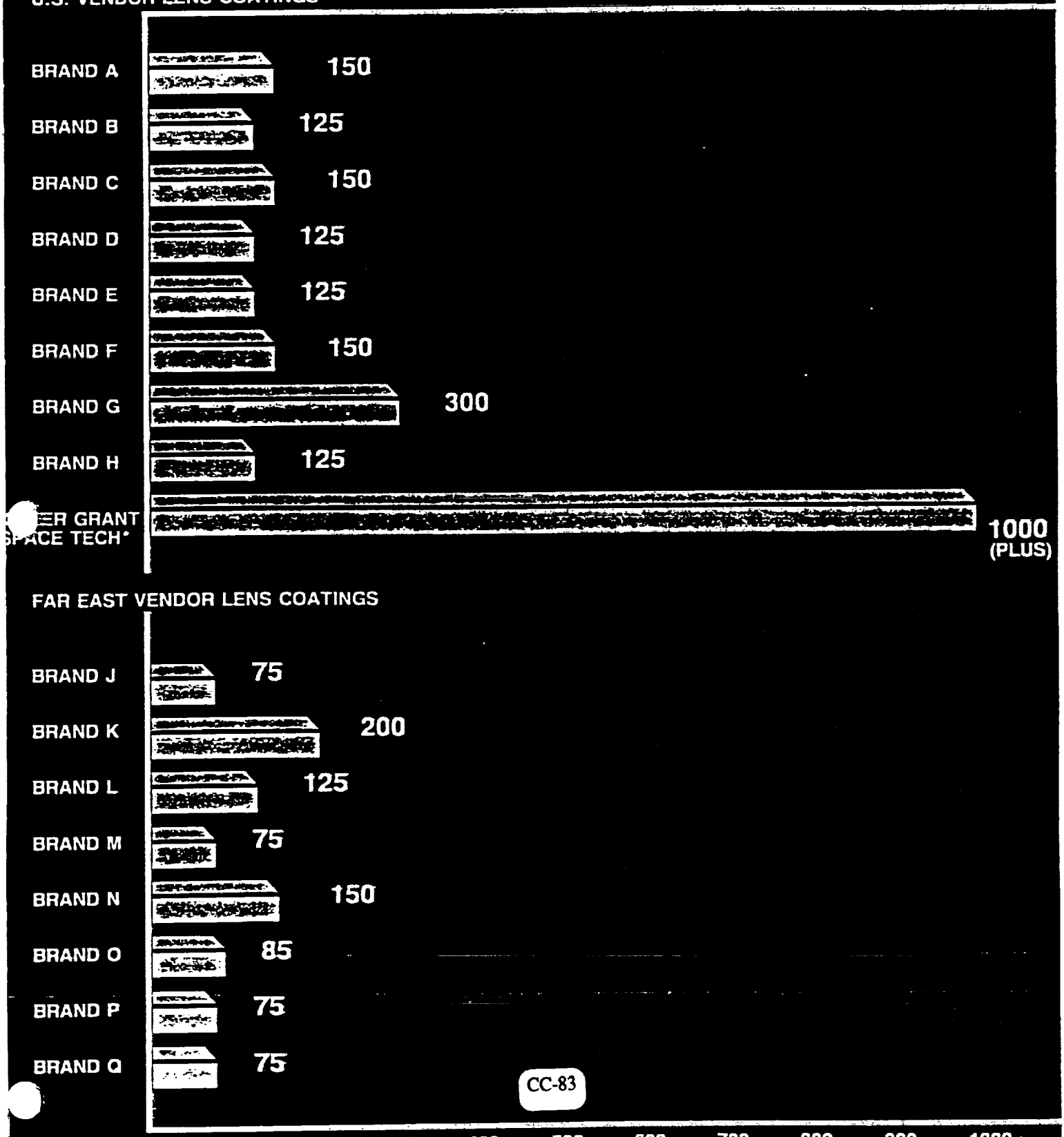
DATE: December 8, 1982

IS THE FOSTER GRANT SPACE TECH* LENS REALLY THAT GOOD?

CHECK NUMBER OF RUB CYCLES REQUIRED TO GENERATE A 3% HAZE ON THE VARIOUS BRANDS OF OPTICAL AND SUNGLASSES LENSES.

WHAT IS THE SIGNIFICANCE OF 3% HAZE ON A LENS? IT IS AT THIS POINT THAT THE NAKED EYE SEES THE SCRATCHES ON THE LENSES. A 2% HAZE IS VERY HARD TO SEE AND LESS THAN 2% CANNOT BE SEEN BY THE NAKED EYE.
TESTING METHOD: GRIT RUB TEST USING #600B SILICONE CARBIDE AT 60 RUBS/MIN. WITH WEIGHTED RUB OF 100 GRAMS.-THIS TESTING METHOD ADOPTED BY THE SUNGLASS ASSOCIATION OF AMERICA.

—LENS AND COATING 3% HAZE CHART—



*MANUFACTURED BY FOSTER GRANT UNDER LICENSE FROM THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION UNDER U.S. PATENT NO. 4,137,365 OR CANADIAN PATENT NO. 1,077,787, AND FOSTER GRANT'S PATENT NOS. 4,492,733 AND 4,435,476.

W7316

APPENDIX F

COLLABORATION
between
NASA AMES RESEARCH CENTER
and
NATIONAL SOLID WASTES MANAGEMENT ASSOCIATION
(NSWMA)

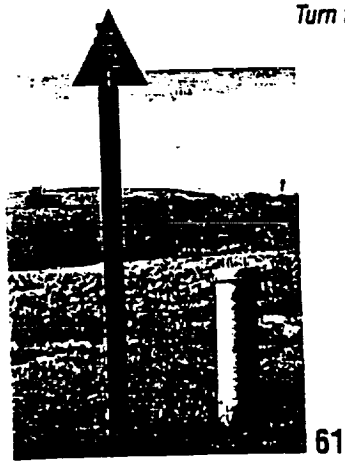
Waste Age

December 1991

Volume 22, Number 12

Waste and rail companies are hoping that MSW will be a frequent passenger on the country's freight trains. *Turn to page 34.*

Features



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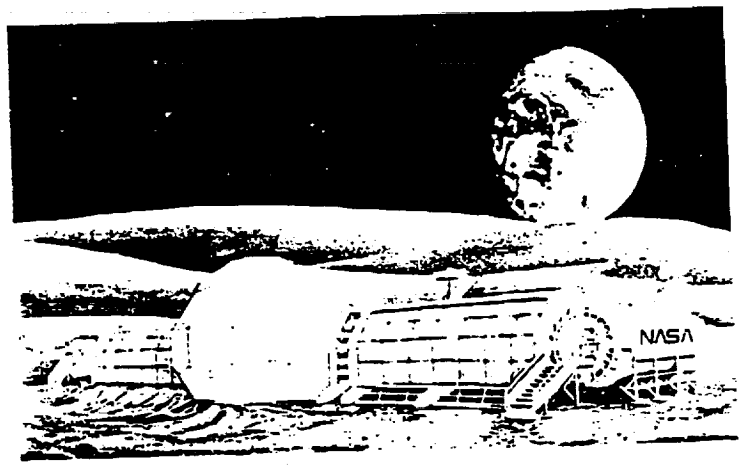
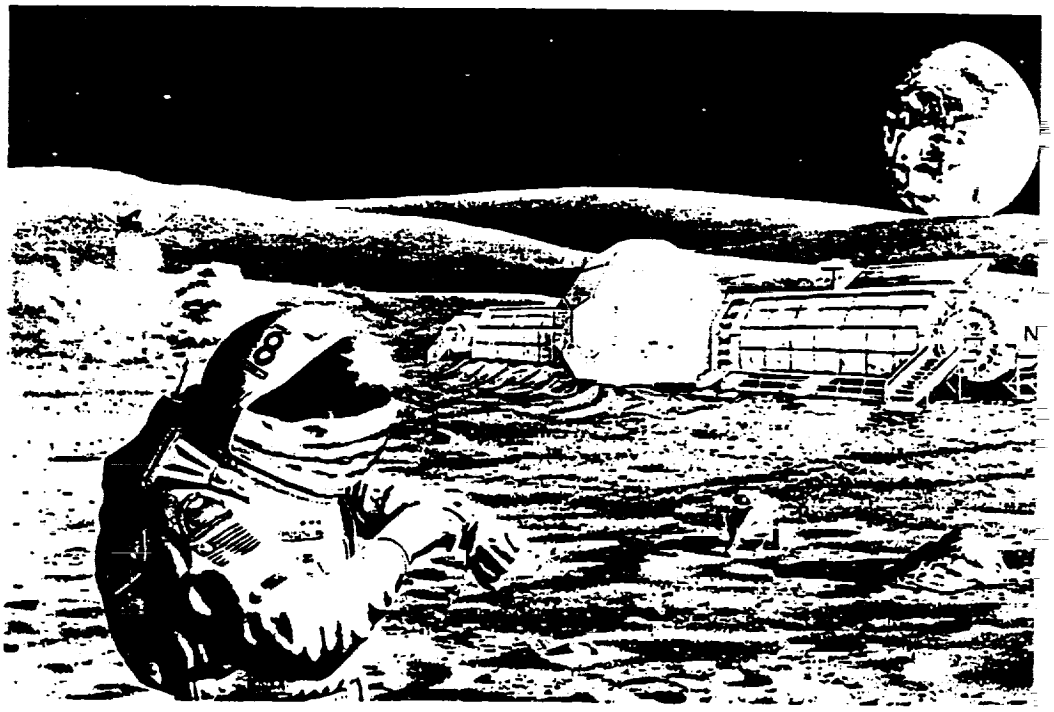


Departments

NASA AND NSWMA:
EXPLORING TOMORROW'S TECHNOLOGY

The waste industry and NASA are investigating a unique relationship that may bring recycling to outer space and space technology to earthly waste problems.



Since space is indeed the last frontier, the National Aeronautics and Space Administration (NASA) is developing, borrowing, and refining a wide range of technology to explore new worlds. To manage and recycle waste during its space voyages and explorations, NASA is investigating the use of technology developed in the waste industry. In return, NASA technology may be of help in the monitoring and processing of waste here on earth.

On October 7-10, in a National Solid Wastes Management Association (NSWMA)/NASA-sponsored workshop that all involved called "unique" and "of incredible importance," NASA and waste industry representatives met to discuss ways government and industry can work together to solve solid waste management problems on earth and in space. As a result of the workshop, demonstration projects will be developed as part of a continuing agreement between NSWMA and NASA.

As space exploration goes out into the solar system, to Mars and beyond, a major concern of NASA is to be environmentally conscious from the start. "No one wants to see rows of Martian landfills," William Berry, chief of NASA's Advanced Life Support Division, told *Waste Age*. "We need to explore ways to use all materials we bring with us in outer space exploration in the most efficient way possible. And you people in the waste industry are doing a lot that's relevant for us. For example, you're working on super critical water oxidation; the catalytic transfer of waste from the water stream. We're also interested in incineration and pyrolysis, especially in the pyrolysis products that can be used for other things. For the waste industry, there was discussion of exploring the application of the space shuttle's ventilation systems to waste industry problems."

BY JOHN T. AQUINO AND
CHERYL L. ROBINSON

Illustration courtesy of NASA

All forms of recycling and reuse were of special interest to Berry. "All of the habitational areas we work in, with space exploration, are very small, as are our waste streams, relatively speaking. And so we want to recycle all water in an enclosed system—everything, perspiration, urine—process it, and return it to the cabin as water. And from what we saw and heard at the workshop, the waste industry is doing more in this than we thought, especially in the areas of leachate tests."

When asked why this had not been a NASA priority until now, Berry explained to *Waste Age*, "There's been no need. We say that being on the space shuttle is like camping out. And like all good backpackers we have been taking our waste home with us. Now, the Soviets in their space shuttle equivalent rendezvous with a supply ship and then put their waste in the empty ship and let it burn up in the atmosphere. In this way, the Soviets incinerate their waste, and we bring ours home.

"But now that we're pursuing President Bush's goal of going to Mars," Berry continued, "we will not have the luxury of frequent visits from supply ships and no easy method of getting our waste back. And so we need to explore ways to use all materials that we bring with us in outer space exploration in the most efficient way possible. We want to recycle things, extract the water, reduce the material to their constituent products. We do not want to accumulate waste on new worlds.

"There's also a cost advantage," Berry adds. "We estimate that to deliver just one pound of material on the lunar surface costs $20,000. You hate to throw that away."

But Berry, for all of the advantages to NASA, also sees the relationship between NASA and the waste industry as "very much a two-way street." NSWMA Chairman Wayne Trewhitt agrees. "I can see the possibility of technology transfer, on-line monitoring, the ability to take certain technology and size it down and make it more readily transportable. NASA is on the leading edge, and we're looking to them for technological advancement expertise. For waste management expertise, they're looking to us."

Workshop Participants

James M. Beggs, J.M. Beggs Associates [former NASA Administrator]
William Berry, Chief, Advanced Life Support Division (ALSD), NASA
Lee Brandsma, Executive Vice President, Groot Industries
Theresa Buckey, EVA Group
Kathleen Connell, ALSD
Peter Daley, Senior Director, Research and Development, Chemical Waste Management, Inc.
Luis Diaz, President, Cal Recovery, Inc.
John Fisher, ALSD
Pamela Harris, Director, Loss Control Services, Browning-Ferris Industries, Inc.
John Hines, ALSD
Richard Lamparter, Chief Regenerative Systems Branch, ALSD
Geoffrey Lee, Technology Utilization Office, ALSD
Curtis Lomax, EVA Group
Chris Miles, ALSD
Larry Milov, Chief, External Relations, NASA
Helene Najduk, Lockheed
Peter Palmer, Ecosystems Science and Technology Group
James Robertson, J.M. Beggs Associates
Cheryl L. Robinson, Managing Editor, *Waste Age*
Jeff Rowe, Scientist, Teknekron Sensor Development Corporation
John Skinner, Deputy Assistant Administrator, Office of Research and Development, U.S. Environmental Protection Agency
Patrick Templeton, J.M. Beggs Associates
Anthony Tomasello, Vice President—Operations, Stericycle
Wayne Trewhitt, Chairman, NSWMA, President, WASTECH, Inc.
George Vander Velde, Vice President, Science & Technology, Chemical Waste Management
Peter Vardy, President, Peter Vardy Associates
Eugene Wingerter, Executive Director and CEO, NSWMA
Bruce Webbon, Chief, EVA Group

The workshop

Workshop participants (see sidebar) spent two days at Chemical Waste Management, Inc. (CWM), in Geneva, Ill., in a focus group on "Processing and Modeling" during which NASA and waste industry representatives discussed past experiences, current practices, and future needs. The session was climaxed by tours of the WMI Environmental Monitoring Laboratories, the Settler's Hill Landfill, and the landfill gas recovery plant.

Richard Lamparter, chief, regenerative systems branch of NASA's Advanced Life Support Division, identified key problem areas that NASA had targeted: getting the maximum amount of resources from waste and not creating dumps where NASA goes; resource recovery—water and energy from waste; and sterilization, primarily for drinking water. From his perspective, U.S. EPA's John Skinner identified waste management needs, including new uses for recycled materials and continuous emissions monitoring capabilities.

Sterilization was identified as a NASA interest, and Anthony Tomasello of Stericycle discussed their radio-wave sterilization technology. NASA representatives were also very interested in the water analysis work of CWM. Peter Daley of CWM explained that, like NASA, CWM is keying on reduced-scale treatment studies and has taken the leachate tests down from 1,000 to 200 gallons; they are looking to be able to test with 10 gallons in the near future. In CWM's PO*WW*ER system, Daley continued, waste water is taken to a solid and steam is catalytically oxidized. There was also discussion of recycling and waste-to-energy.

The workshop then moved to the West coast, to NASA's Ames Research Center in Moffett Field, Calif., for focus groups on "Monitoring and Control Technology," chaired by George Vander Velde of CWM, and "Hazard Identification and Protection Systems," chaired by Pamela Harris of Browning-Ferris Industries, Inc.

The third session of the overall workshop explored early warning systems, monitoring ground and air, and, for later on, remote monitoring. Vander Velde said to *Waste Age* afterwards that there was keen interest in modular miniature monitoring systems. "NASA has technology under development that looks like it might be directly applicable to waste industry uses. There are a number of similarities between our needs and theirs. Both have unique requirements that the monitoring systems operate failsafe for extended periods of time." At the session, Vander Velde made clear the need to bring EPA into the project planning early.

After chairing the fourth session, Harris told *Waste Age* that she thought the possible projects have "a lot of potential for the industry. And one interesting thing that came up was that our experience might be helpful to NASA, not in the science of risk but in the perception of risk. Science, for example, tells us that the actual risk from medical waste can be easily contained. But we know from experience that there is a gap between this scientific knowledge and what workers and the public perceive. NASA will encounter that and can gain from our experience."

At the final sessions, according to Harris, the discussions centered on three areas that would be of special interest to waste industry firms: utilizing fiber optics systems—which are so sensitive they can detect the presence of chemicals in material that is still in containers—to detect hazardous substances before employees are exposed to them; using a Doppler kind of warning device, installed on a garbageman or landfill spotter, to warn them of the dangerous traffic around them; and employing a ventilation system used in the space shuttle that would remove odors, dust, fibers, and chemicals from the breathing zone of employees sorting recycled materials.

The future

At the workshop's end, among the areas identified a probable topics for future demonstration projects were sterilization through radio frequencies, using Stericycle' technology in a smaller environment; vapor oxidization using CWM's PO*WW*ER system; the use of fiber optic sensor systems in waste facilities; microbacterial detec tion; and miniaturization. Geoffrey Lee, technology uti lization officer at Ames, notes that there was immediate inter est in those areas that already have mature technology Harris adds that there was discussion of a longer-term pro ject that would involve looking where things should be i the year 2020.

According to Lee, the projects will operate throug NASA's Technology Utilization Program (TUP) which pro vides for the use of NASA technology in the private secto by implicit transfer—the direct transfer or application c NASA technology to private industry use—and explic transfer—which involves modification of NASA techno ogy for some other application than for which it was orig inally intended. The TUP is part of the Space Act, an each NASA location has a TUP office.

The next step is the development of a three-party rel tionship between NSWMA, NASA, and EPA for thes demonstration projects. NASA currently has a technolog transfer agreement with EPA and a memorandum of unde standing with NSWMA. These demonstration projection could involve the expansion of one of the agreements so th NSWMA, EPA, and NASA could all work together. At press time, NSWMA was to decide which technologi look the most promising and then discuss them with EP

When asked if he thought that the partnership betwe the waste industry and NASA has relevance for day-to-d operations of waste firms, Wayne Trewhitt felt very stron ly that it did. "Things have come up on the regulatory fro that make it harder and harder to be profitable, and the si nals we get are often in conflict. We are drowning ourselv in bureaucracy and are grinding to a halt. If you get a fal start with a false reading when monitoring, it can cost y $200,000 to $300,000. This relationship with NASA cou help demonstrate that we are using state-of-the art tec nology—technology that is developed in coordination wi the most reputable technological innovator in the world- in order to protect the environment. The industry gai great credibility from this relationship. And as a result, t monitoring would be more reliable and provide early war ing on a uniform basis."

Further developments of this story will, of course, reported in *Waste Age*.

A Research Experiment on Facilitation and Formation of Joint R&D Programs between Government, Industry & Universities: Overview, Preliminary Findings and Observations

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- Working Paper -

Panel on:
Building Market Driven Research Programs and Consortia

Conference on Technology Commercialization: Innovative Alliances for Economic Development

Albuquerque, New Mexico
September 12-13, 1991

A Research Experiment on Facilitation and Formation of Joint R&D Programs between Government, Industry & Universities: Overview, Preliminary Findings and Observations

There are numerous ideas being pursued today, both at the national and local levels, to build research programs and consortia to best leverage R&D resources across government, industry and academia. Some of these efforts employ mechanisms that would incorporate and promote a market-driven approach to public-private sector R&D collaboration, while others encourage traditional technology transfer and commercialization approaches. An approach or mechanism for R&D collaboration for the most part will be market-driven depending upon how close the process, pricing and implementation of the transaction or project resembles a free-market, risk-reward investment transaction, as is frequently found in the private sector. In a market-driven transaction for R&D collaboration the parties directly negotiate R&D plans, finances, in-kind resource contributions, intellectual property rights, commercialization commitments, and other terms and conditions.

The work in progress at American Technology Initiative (AmTech), a nonprofit, public benefit research corporation located in California, represents a unique research program aimed at learning from the facilitation and formation of market-driven research projects and consortia. AmTech has specifically chosen to focus on a joint-venture approach to study public-private R&D collaboration. The AmTech effort, which we call a research experiment, has been based on the following fundamental premises:

- U.S. competitiveness can be significantly enhanced by improving the productivity of the U.S. R&D sector.
- Enhancing public-private R&D collaboration is a critical need requiring research and experimentation to develop and implement innovative mechanisms for effective and accelerated transfer and commercialization of technology.
- A long term focus on institutionalizing market-driven mechanisms for public-private R&D collaboration is most appealing in the context of the free-market orientation of the U.S. economy.

Within the framework of these broad premises, one of AmTech's research experiments is dedicated specifically to the exploration of a free-market approach to public-private collaboration through the development and implementation of a joint venture mechanism to enable formation of R&D projects between government, industry and academia. Joint R&D projects are designed to:

- Leverage the mutual and concurrent, but independent goals of participants.

- Trade technology rights in return for R&D resources.

- Ensure mutual sharing of risks and rewards.

The R&D joint ventures are appropriate when public and private sector research goals overlap, but may often lead to distinct end uses of resulting technologies. The government aims to pursue mission objectives, while industry focuses on commercial products. Of the approximately $140 billion annual U.S. R&D expenditure, the area of this overlap, represented by federal civilian R&D with a 3-5 year technology development timeframe, is estimated to be 10% of total federal civilian R&D--well over a billion dollar opportunity. If this segment of public-private R&D can be more effectively coordinated through joint ventures, it would go a long way towards enhancing the productivity of U.S. R&D, while also providing the following specific tangible benefits to participants in the joint venture:

i) for the government:

- Accomplish more mandated mission R&D objectives by leveraging R&D expenditures with industry.

- Ensure critically needed transfer of technology from the government and universities to industry.

- Gain access to manpower and state-of-the-art background technology residing in universities and industry.

- Generate royalties for government agencies and inventors by promoting the transfer and commercialization of technology.

ii) for industry:

- Reduce the cost of product development by leveraging R&D expenditures with the government.

- Obtain non-exclusive or exclusive commercial rights to technology developed in collaboration with the government and the research institution.

- Foster, negotiate, and incorporate, at the outset, specific industry concerns in the joint venture agreement.

- Provide access to R&D undertaken at universities, nonprofit research institutions, and government laboratories, and to specialized government equipment and facilities.

iii) for the university/research institution

- Utilize joint ventures to gain support for research programs at the cutting edge of technologies leading to commercialization.

- Capitalize on the opportunity for researchers, including students, to contribute to important new discoveries leading to commercial products/processes.

- Provide academic researchers, including students, access to state-of-the-art facilities in government and industry.

- Obtain intellectual property rights that will generate royalty income from resulting commercialization.

In order to capitalize on this opportunity, AmTech, under NASA sponsorship of research on legal, financial, business and management issues involving R&D collaboration between government, industry and academia, set out to a) design an innovative market-driven mechanism for entering into public-private joint ventures; b) provide facilitation services to identify, develop, negotiate and draft agreements for each specific joint R&D project; c) monitor, administer and facilitate the on-going relationship between the participants throughout the life of the joint R&D project; and d) create an organization dedicated to learning through research, experimentation and feedback resulting from real world experience with joint R&D projects.

AmTech has already assisted in pioneering a unique mechanism, called the "Joint Sponsored Research (JSR) Agreement" which is designed to involve four key institutional partners: government, industry, a university or nonprofit research institution and AmTech. Under the JSR Agreement, the research is carried out to ensure that:

- Federally funded R&D is undertaken at a university or nonprofit institution.

- The scope of joint R&D and the rights to resulting technology are pre-negotiated consistent with the needs of the parties.

- Technology transfer and commercialization objectives are incorporated into the R&D process and are implemented from the beginning of the R&D project.

- Participants share the co-management of the specific technical and administrative responsibilities of the R&D project.

AmTech, in collaboration with NASA, has successfully implemented two prototype joint ventures and is in the various stages of identification, development, negotiation and drafting of agreements for an additional ten JSR projects. The participants in the two prototype projects have appreciated the benefits of this unique arrangement and the success of these projects has already been demonstrated:

- The time to commercialization can be significantly reduced. In the first prototype JSR project, the technology is currently under license negotiation, less than 12 months after completion of R&D (the norm for commercialization of federal technology in the past has ranged from 6 to 10 years).

- A complex research relationship among multiple companies, the government and a university can lead to a direct identifiable advantage to U.S. economic competitiveness. A software development effort undertaken through a consortium under the second prototype JSR project is leading to a U.S. standard for aircraft design software. (Prior to this JSR project no one company had the incentive to pursue this research unilaterally).

While the AmTech research experiment on public-private R&D collaboration continues, the preliminary findings are as follows:

- The facilitation and formation of joint R&D projects is a labor intensive process. With further experimentation and experience, the efficiency of this process can be increased. However, at best it is likely to be no more efficient than perhaps the venture capital-investment-decision making process. This clearly demonstrates trade offs between effort and effectiveness and leads to a preliminary conclusion that increased effectiveness in the transfer and commercialization of technology would require increased investment in facilitation quality and efforts.

- A fair amount of experimentation will be necessary before the concept of a market-driven R&D arrangement with broad applicability will emerge. At this stage, public-private R&D collaboration appears to be generating one of a kind, specific customized relationships.

- The role of a neutral third party facilitator is critical to the success of R&D collaboration. Public and private institutions have developed a wide cultural void and distrust that cannot be easily or quickly remedied without offering a neutral playing field for the participants.

- At the policy level, incentives are needed to foster and reward innovation leading to development, experimentation and implementation of improved market-driven R&D programs.

- Formalization of knowledge, ideas and learning among and between many national organizations undertaking research and experimentation involving R&D collaboration and consortium building needs to be institutionalized as a research program, perhaps within business schools. In this regard IC^2 Institute already is leading the way.

- Finally, facilitation and formation of R&D collaboration at the earliest possible opportunity, even at the idea stage, is the wave of the future. The competitive advantage will be with those nations or institutions that can master and institutionalize an effective response to address this need for early collaboration.

In summation the following points can be made:

- Up-front collaboration by the government and the private sector on R&D accelerates technology transfer and commercialization. Traditional methods of transferring technology are passive and have had only limited success. Technology transfer is a direct contact, people-to-people activity. It cannot be achieved only by the government pushing its ready-made technology into the private sector. It is most successful when a private sector entity can pull the technology it needs out of the government laboratory, utilizing it in a cost effective manner to produce goods or promote services. This "pull" is more likely to occur when the company or industry directly collaborates with the government in the research that produces the technology and when industry is willing to put capital at risk.

- Joint sponsored research maximizes R&D efficiencies by leveraging R&D resources. Neither the federal government nor the private sector have the resources necessary to accomplish all R&D objectives. Combining resources and collaborating on mutually compatible R&D projects which the government has selected to pursue will maximize the usefulness of the resulting technology at a cost that is more affordable to the collaborating parties.

- Effective joint sponsored research and advanced technology development requires government/private sector collaboration on a neutral "playing field." In most traditional contracting and assistance relationships with the private sector, the government directs the work and specifies the results. Collaborative research requires negotiation and a much closer co-venturing relationship. The private sector can be distrustful of the government's intent and capabilities as a potential partner, and many companies will refuse to work with the government in any form. Because of this distrust, the use of a neutral facilitator becomes essential to the success of the joint venture, and provides each participant with a forum for negotiation.

- AmTech is cultivating the experience, capability and desire to facilitate collaborative research efforts between the government and the private sector. AmTech was founded for the sole purpose of facilitating collaboration between the public and private sectors in order to promote U.S. economic competitiveness. Research is an integral part of AmTech's function. The AmTech staff has examined numerous legal, financial, business, and public policy issues inherent in joint government/private sector collaboration. While other organizations may provide facilitation services for joint R&D efforts, no other organization has the background, knowledge, expertise or capability to provide specific joint R&D program facilitation services to its sponsors, including the government. The AmTech model is designed to use funds it generates only to attain self-sufficiency, to improve its own efficiency, and to maintain the neutrality necessary to continue serving its sponsors.

EXPLORATION TECHNOLOGY PRIORITIZATION

NASA INTEGRATED TECHNOLOGY PLAN INPUT

REVISED PRIORITIZATION CRITERIA FOR THE NEAR-TERM SEI TECHNOLOGIES

NASA Office of Exploration

- **Assumptions**
  - Two prioritized list are developed: one for early manned Lunar missions and one for permanently manned Lunar missions and Mars
  - No priority is implied within a group
  - First Lunar outpost, missions and design guidelines dated 1/7/92 and SEI Strategic Plan Dated 12/10/91 are used for mission requirements
  - Early manned Lunar mission by 1999 with up to 45 day stay capability for a crew of 4
  - No long-term cryo storage required for initial Lunar missions (storable return propulsion)
  - Emphasize common Lunar mission - Mars mission technology and H/W and S/W
  - All technology will be developed to TRL 5 or 6 prior to project start (Phase C/D)
  - Required permanent Lunar and Mars technology/advanced development will be initiated between now and 2000
  - All technology/advanced development must have clearly defined cost/benefit justification or mandatory mission need rationale
  - NTR development in critical path for manned Mars mission
  - Mars missions will include stays of up to 500-600 days at Mars
  - For each project advanced development starts before project start at Phase C/D and terminates within the year PDR is held

PRIORITIZATION CRITERIA

NASA — Office of Exploration

NOTE: This chart is used to develop the technology needs for the SEI missions

	Rating		
	High	Medium	Low
• **Mission Leverage**			
- Performance leverage of technology to system, mission, and crew			
- Ability of technology to reduce risk to crew and mission			
- Ability of technology to reduce cost by reducing Earth delivered mass and life cycle costs			
- Evolution capability			
- Ability to support multiple missions (commonality)			
• **Timing**	Long	Medium	Short
- Development time to reach TRL 5 (years)	T>=8	3<T<7	T<=3
- Time needed before project start (years)	T>=8	3<T<7	T<=3
• **Special Factors**	High	Medium	Low
- Transportability/spin-off to commercial sector			
- Ability to stimulate universities and public for support of mission			

Barnes2/Smith/Technology Prioritization/Technology Need 2/5/92 Ver 1/1-31-92

NASA — Office of Exploration

1992 - 1995
CRITICAL TECHNOLOGIES

PRELIMINARY CRITICAL TECHNOLOGY PRIORITIZATION
FIRST LUNAR OUTPOST (1992 - 1995)

NASA — Office of Exploration

Category 1 Priority (Near Term)

- **Lunar EVA Systems**
  - Durable, lightweight, high mobility suit and EVA gloves
  - Lightweight, serviceable, PLSS
- **Autonomous Terminal Landing**
  - Sensors
  - S/W algorithms
  - Hazard avoidance
- **Life Support**
  - Contamination and particulate control
  - Trash & waste/collection & processing
  - Loop closure
- **Surface Power - Non Nuclear**
  - High efficiency thermal to electric conversion
  - Heat rejection
  - Long-life energy storage
- **Cryo Fluid Systems**
  - Cryo storage
  - Cryo transfer (zero-g)
  - Quick disconnect couplings
  - Zero-g gaging

Category 1A Priority
(Mars and Permanently Manned Lunar Missions)

- **NTP**
  - Fuel development
  - Turbo pumps
  - Test facility
  - Reactor development
- **Surface Habs and construction**
  - Radiation shielding
  - Dust control
- **Surface nuclear power**
  - Power conversion
  - Radiators
- **ISRU (Technology demo capability)**
  - Oxygen process chemistry
  - Mining
  - Construction material test

Barnes2/Smith/Technology Prioritization/Technology Need 2/5/92 Ver 1/1 31-92

NASA

(1995 +)
CRITICAL TECHNOLOGIES

PRELIMINARY CRITICAL TECHNOLOGY PRIORITIZATION
PERMANENTLY MANNED LUNAR AND MARS MISSIONS
(1995 +)

NASA — Office of Exploration

Category I (Highest Priority)

- **NTP**
- **Mars EVA Systems**
  - Durable, lightweight, high mobility suit and EVA gloves
  - Lightweight, serviceable, PLSS
- **Surface Power - Nuclear**
- **Life Support Systems/Thermal Control Systems (Long-term use)**
- **Radiation Protection**
  - Light weight shielding
  - SPE prediction
  - Transport code validation
- **ISRU**
  - Liquefaction
  - Materials compatibility
  - Electrolysis technologies

Category II

- **Telerobotics**
  - Sensors
  - Vision
  - End effectors
- **Aerobraking**
  - TPS
  - CFD codes
  - High temperature structural material
  - Adaptive GN&C
- **Planetary Rovers**
  - Motors lubricants (Long-term use)
  - Dust control
  - Power

Barlow2/Smith/Technology Prioritization/Technology Need 2/5/92 Ver 1/2 3-92

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category

- EVA Systems

Technology Areas

- Durable lightweight dexterous high mobility suit
- Lightweight, serviceable PLSS
- Environmental dust control
- Highly dexterous gloves

Performance Goals

- EVA system lifetime: ≥ 5 yrs
- Duty cycle: ≥ 200 days/yr @ 6-8 hrs/day
- Suit oper. pressure: 3.8 - 6 PSIA
- Lunar EVA system mass: ≤ 110 Kg venting
  ≤ 125 Kg regen.
- Mars EVA system mass: ≤ 90 kg venting
  ≤ 70 kg regen.

Benefits/Leverage

- Increase crew safety and EVA productivity
- Reduce suit servicing time
- Enabling for use on surface
- Lower life cycle cost
- Evolvable technology baseline for Mars

Technology Readiness Dates

- Current TRL: 3 - 4
- Required time to reach TRL 5: 3 years

Need dates: Lunar: 1996
Mars: 2000

Barlow2/Smith/Technology Prioritization/Technology Need 2/5/92 Ver 1/1 31-92

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Surface power-non nuclear

Technology Areas
- Long-life energy storage, e.g., regenerative fuel cells (RFCs)
- Power management and distribution (low mass, long duty cycle, low maintenance)
- Thermal control (high efficiency, long duty cycle, long-lived, low maintenance)
- Generation: solar PV

Performance Goals
- RFCs: Specific energy: 670 $\frac{W \cdot HR}{kg}$ (Lunar)
  200 $\frac{W \cdot HR}{kg}$ (Mars)
- Specific power: 250 w/kg (Lunar and Mars)
- System efficiency: 65% FC, 90% electrolyzer
- Lifetime: 500 - 4000 hrs (SOA)
  ≥20,000 hrs (advanced)
- PMAD: 20 kg/kW
- Generation: PV arrays 300 W/kg (Lunar)
  80 w/kg (Mars)
  ≥40,000 hr.lifetime

Benefits/Leverage
- Reduced mass
- Reduced maintenance
- Improved reliability, lifetime
- Increased performance
- Applications to terrestrial systems

Technology Readiness Dates
- Current TRL: 3 - 4 Storage
  4 PMAD
  4 Thermal
  4 Generation
- Years to TRL 6: 4 - 6

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Autonomous terminal landing

Technology Areas
- Hazard avoidance
- Sensors
- S/W algorithms
- Adaptive mechanisms and effectors

Performance Goals
- Landing accuracy: ≤ 100 m
- Hazard avoidance: ≥ 1 m (surface hazards)
- Hazard endurance: ≤ 1 m (surface hazards)
- Reliability: ≥ 99% probability of safe landing

Benefits/Leverage
- Reduce ground support
- Reduce EVA support for vehicle mating
- Allow landing if crew unable to manually perform task
- Land at predefined coordinates
- Robotic Mars missions to return samples from rover is enabled

Technology Readiness Dates
- TRL: 3 - 4
- 2 - 4 years to TRL 5

Need dates: Lunar: Robotic: 1993
Outpost: 1995
Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Cryogenic Fluid Systems

Technology Areas
- Cryo storage (Thermal & Pressure Control)
- Cryo management for propellant slosh control and acquisition
- Cryo transfer for in-space fueling/refueling
- Cryo zero-leak quick disconnect coupling and zero-G gaging system
- Cryo production on planet surface

Performance Goals
- Cryogens: Hydrogen and oxygen
- Cryo system acceleration environment: 0 to high G level
- Lunar boil-off rate: 2 to 6%/month (mission dependent)
- Mars boil-off rate: ≤1%/month
- Transfer losses: ≤ 5%
- Unusable propellants (residuals):≤ 2%

Benefits/Leverage
- Enabling for in-space assembled space transfer vehicles (all Mars concepts)
- On-orbit fueling/refueling enables reusable vehicle concepts and significantly reduces vehicle departure mass
- IMLEO reduction of 25-30% for cryogenic propulsion system used for return from Lunar surface when compared to storables for direct Lunar injected missions

Technology Readiness Dates
- Thermal control is TRL 4/5
- All other areas are TRL 2/3
- Cryo transfer and 0-G pressure control are 8 yrs. to TRL 6
- Thermal control is 3 yrs. to TRL 6
- All other areas require up to 5 yrs. to TRL 6

Need dates: Lunar: 1998
Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Life support systems/crew accommodations

Technology Areas
- Contamination and particulate control
- Trash and waste collection and processing
- Water management
- Bio regeneration
- Food management and biomass production

Performance Goals
- System lifetime: 7 - 15 yrs (Lunar)
  3 + yrs (Mars)
- System closure (water): 95%
- System closure (air): 95%
- System closure (total): TBD
- System power req: TBD kW/person
- Operating environment: Lunar/Mars
  Minimal servicing

Benefits/Leverage
- Saves up to 40 lbs/day resupply
- Reduce trash build-up
- Integration of biological and physiochemical regenerative systems

Technology Readiness Dates
- TRL: 2 - 4
- Development to TRL 5: 5 - 6 yrs

Need dates: Lunar: 1995
Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- ISRU

Technology Areas
- Oxygen process chemistry
- Mining
- Electrolysis technologies
- Materials compatibility
- Liquefaction
- Construction material test

Performance Goals
- Equipment life time: ≥10 years
- Liquid oxygen production: initial: .5 - 10 mT/yr
  OPS: 10 - 25 mT/yr
- Regolith mined annually: ≤ 5 KmT/yr
- Duty cycle: ≥ 90% (day/night)
- System mass: OPS ≤ 15 mT
- Power: TBD KWe

Benefits/Leverage
- Reduce resupply
- Make up oxygen for safety and redundancy
- Increase stay time

Technology Readiness Dates
- TRL: 2 - 4
- 4 - 6 years to TRL 6

Need dates: Lunar: 1995
Mars: 2000
Lunar robotic (demo): 1993

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- NTP (Solid core)

Technology Areas
- Fuel development
- Turbo pumps
- Test facility design/construction
- Shielding and control systems
- Pressure vessels and nozzle technology
- High temperature materials
- Reactor development

Performance Goals
- Lifetime: 5 - 15 years, multiple flights
- Thrust: 25 - 75 k lbs
- Specific impulse: 900 - 1000 sec
- Specific mass: 120-240 kW/kg
- Thrust-to-mass: > 3 to 30
- Space base, limited servicing, multiple restart

Benefits/Leverage
- Significant reduction in Earth delivered mass
- Reduce Mars trip times
- Crew safety
- Operational flexibility

Technology Readiness Dates
- TRL: 4-5
- 5-10 years to TRL 6 (uprated NERVA technology)

Need date: Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Surface power - nuclear

Technology Areas
- High efficiency thermal to electric conversion
- Power conditioning and transmission
- Heat rejection/radiator concepts
- Dust effects on system performance
- Generation: Reactor and isotope/Heat sources

Performance Goals
- Stationary applications: 50 kg/kWe @ 100 kWe (static conversion)
  25 kg/kWe @ 500-800 kWe (dynamic conversion)
- Mobile applications: 5 W/kg @ 300 We (RTG)
  7 W/kg @ 2.5 kWe (DIPS)
- Lifetime: 7 - 15 yrs

Benefits/Leverage

Technology Readiness Dates
- Current TRL: 3 - 4 SP - 100
  4 - 5 DIPS
  > 5 RTG
- Years to TRL - 6: 6 - 10 depending on system, subsystem

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Surface habs and construction

Technology Areas
- Autonomous deployment of systems
- Surface/stability determination
- Dust control
- Hab to Hab IVA interface
- Inflatable structures

Performance Parameters
- Habitat lifetime: ≥ 10-15 years
- Habitat environmental pressure: TBD
- Heat rejection requirement: TBD
- Construction equipment load: TBD
- Set up time: TBD
- Crew required for set up: TBD

Benefits/Leverage
- Increase crew living/working area
- Allow building of large structures
- Prepare landing site
- Enhance crew productivity/safety
- Reduce launch mass/volume

Technology Readiness Dates
- TRL: 1-2
- 4-5 years to TRL 5

Need dates: Lunar: 1997
Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category:

Radiation protection

Technology Areas:

Shielding materials (light weight)
- Prediction of SPE and monitoring
- Crew high z, high energy limits
- Transport codes enhancement & validation
- Active crew personal dosimeter
- Particle Spectrometer for GCR and solar flare particles
- Tissue Equivalent Proportional counter for charged particle detection
- Neutron Energy Spectrum spectrometer

Performance Goals:

Shielding lifetime: > 10-15 years

Shielding requirement: 20 gm/sq. cm. (200 gm/sq.cm. sleep quarters)

Prediction error: <20% (initial)
<10% (final Mars)

SPE prediction: TBD hrs. prior to occurrence

Benefits/Leverage

- Crew protection from solar and cosmic radiation during transit and on surface
- Data to determine appropriate shielding strategy for crew and electronics to reduce mass

Technology Readiness Dates

TRL: 3

Development to TRL 6: 5-7 years

Need dates: Lunar: 2000
Mars: 2000

J. Brown:afu:rev. 2/5/92

Ver 2

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Telerobotics

Technology Areas
- Joint actuators
- Sensors
- Vision
- Man-machine interface
- End effectors
- Intelligent controls

Performance Goals
- Manipulator dexterity: TBD
- Manipulator loading: TBD
- Radiation field: TBD

Benefits/Leverage
- Reduce crew exposure to EVA
- Perform operations at a distance
- Servicing of hazardous systems

Technology Readiness Dates
- TRL: 3 - 4
- 3 - 5 years to TRL 5

Need dates: Lunar: 1996
Mars: 2000

...rsea2/Smith/Technology Prioritization/Technology Need 2/5/92

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TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category
- Planetary Rovers (Long-term autonomous use)

Technology Areas
- Motors/lubricants (Long-term use)
- Dust control
- Power

Performance Goals
- Semi-autonomous traverse: ≥ 10M (early)
  ≥ 100M (interim)
- Mobility (obstacle endurance): ≤ 1M
- Power system: ≥ 5W (kg (robotic))
- Lifetime: 1-2 years
- Life support requirement: TBD
- Range robotic: 100 km
- Range manned: ≤ 100 km

Benefits/Leverage
- Allow extended operations from base
- Support science investigation

Technology Readiness Dates
- TRL: 2-3
- 4-6 years to TRL 5

Need dates: Lunar: Outpost: 1996
Mars: 2000

TECHNOLOGY NEEDS

NASA — Office of Exploration

Technology Category:
Aerobraking

Technology Areas:
- Reusable and ablative TPS material
- Validated CFD Codes
- Adaptive GN&C
- Lightweight, launchable structures

Performance Goals:
- Entry velocity range
  Lunar return -- 11 km/s
  Mars entry -- 5 to 6 km/s
  Mars aerocapture -- 6 to 10 km/s
  Mars return to Earth -- 12 to 15 km/s
- Aerobrake mass fraction < 20%
- L/D ratio: 0 to 1.5 (Varies with mission application)
- Reuse for lunar permanent base - 7 flights

Benefits/Leverage
- Required for Mars entry/landing and Earth entry/landing
- Enables Mars quick return trajectories
- Enhances all-chemical propulsive mission performance, reduces IMLEO
- Can backup or compliment NTP

Technology Readiness Dates
- TRL: 3 - 4
- Lunar: 4 years to TRL 6
- Mars: 8 years to TRL 6

Need dates:
Lunar early: 1995
Lunar permanent: 2000
Mars: 2000

OMIT TO END

ISSUES TO BE CONSIDERED (ITBCs)

1. Author: Mario Acuna Session: Working Panel #1

   Issue Statement: Technology transfer should be a two-way street within NASA -- adoption of technology developed in other areas (e.g., electronics, automobiles and defense) should be equally pursued.

   Suggested Resolution/Action:

2. Author: Joel Greenberg Session:

   Issue Statement: The government is a high-risk client. This reduces private sector investments, including those relating to technology transfer.

   Suggested Resolution/Action: Government agencies should be capable of entering into a multi-year contract, with a funding commitment, and/or the assumption of termination liability.

3. Author: Thomas Handley Session: Working Panel #1

   Issue Statement: How will Code S and Code R fund, manage, select, etc. the "technical transition projects" illustrated in the NASA Civil Space Technology Maturation Strategy -- see the figure on Page 14 of Section A.

   Suggested Resolution/Action: Have R&S document the process for solution, funding, management, etc. of these projects.

4. Author: Thomas Handley Session: Working Panel #1

   Issue Statement: As Code R sends more funds to its own centers, NASA needs a better technology transfer process between its centers.

   Suggested Resolution/Action: On-going, positive technology marketing programs between the NASA centers at the project level.

5. Author: Roger Neeland Session: General

   Issue Statement: There is no clear recognition that the primary flow of technology is from and to American industry, since industry is the normal implementary agent. Without this recognition, the transfer mechanisms will be mis-focused.

Suggested Resolution/Action: Explicit recognition of industry as the change mechanism, by making industry the focal point of communication mechanisms and selected investments. More participation of industry in the planning of technology transfer mechanisms and activities.

6. Author: Roger Neeland Session: Working Panel #2

Issue Statement: The transfer of technology between government agencies, and from government to industry, would be expedited if the construction and upgrading of test facilities were coordinated and steered by a joint government-industry panel. Neither government nor industry as a whole should have to bear the economic burden of duplicated facilities. This could be an international competitiveness issue.

Suggested Resolution/Action: Use the Space Technology Intereagency Group (STIG) to initiate action to coordinate new and upgraded space-related test facilities. Use this as a first step, and then include industry associates in an advisory role to screen candidates for the highest payoff of government test facility investment.

7. Author: Jon Paugh Session:

Issue Statement: Institutional efficiency.

Suggested Resolution/Action: Review and revise the administrative/legal procedures for technology transfer/collaboration with industry to minimize delays and disincentives.

8. Author: Jonathan Root Session: Working Panel #4

Issue Statement: We need to examine how the FAR and the federal procurement process adversely impacts the two-way transfer of technology, specifically the harvesting of commercially-developed technology. we need a thorough understanding of the objectives of different players in technology transfer.

Suggested Resolution/Action:

9. Author: Martin Sokolski Session: Working Panel #5

Issue Statement: DOD contractors (due to a loss of funding) are now talking "dual use" technology with both military and commercial usage.

Suggested Resolution/Action: NASA needs to see if the "dual use" concept is applicable to the agency's contactors.

10. Author: Martin Sokoloski Session: Working Panel #5

Issue Statement: There is a lack of personnel mobility both inside and outside the agency due to the risk of losing a promotion.

Suggested Resolution/Action: Have the movement of personnel be one of the agency's tech transfer goals. Hence, each manager, as part of his job evaluation, would be measured on the number of personnel on inter-center, inter-agency, and industrial/academic sabbaticals as part of tech transfer.

11. Author: Martin Sokoloski Session: Working Panel #5

Issue Statement: Intellectual patent rights -- patenting by academia as part of a NASA grant or proposal.

Suggested Resolution/Action: If NASA can internally efficiently expedite filing of NASA patents, then NASA should help universities patent "good" ideas that were, and are, supported by NASA contracts and grants.

12. Author: Martin Sokoloski Session: Working Panel #5

Issue Statement: Intellectual patent rights, patent processes. The replacement of "first to invent" by "first to file." This places the burden on the NASA centers' patent offices and investigators to file. Note: From the time of submission to the official file date is a period of strict public non-disclosure (university and government scientists could not give peer-reviewed papers and publications).

Suggested Resolution/Action: We need to increase the patent office staff or contract out to reduce the paperwork and expedite the filing process to minimize the non-disclosure period.