PROCEEDINGS OF THE

SECOND ANNUAL SYMPOSIUM

ON INDUSTRIAL INVOLVEMENT AND SUCCESSES

IN COMMERCIAL SPACE

TUESDAY, MAY 14, 1991

HOTEL WASHINGTON
WASHINGTON, D.C.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

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ATTENDANCE BY CONGRESSIONAL MEMBERS

Jim Bacchus (D-FL)

Bud Cramer (D-AL)

Dick Zimmer (R-NJ)

Phone messages are available for pick up at the table just inside the Ballroom lobby.

Video tapes on NASA's Commercial Use of Space Program and the Centers for the Commercial Development of Space will be playing in the rear of the Ballroom during the breaks.

Participants are encouraged to enjoy the local cuisine at the lunch break. A list of near-by restaurants is included for your use.

Please join us immediately following the Symposium at a reception in The Washington Room on the rooftop of the Hotel Washington.

Proceedings of this Symposium will be distributed to each participant.

SECOND ANNUAL SYMPOSIUM

ON INDUSTRIAL INVOLVEMENT AND SUCCESSES

IN COMMERCIAL SPACE

TUESDAY, MAY 14, 1991
8:15 a.m. - 6:00 p.m.

HOTEL WASHINGTON
Pennsylvania Avenue at 15th Street
WASHINGTON, D.C.

Sponsored by NASA's Office of Commercial Programs and the Centers for the Commercial Development of Space

8:15 a.m. **Welcome and Introductory Remarks**
Mr. James T. Rose, Assistant Administrator for Commercial Programs, NASA Headquarters

8:30 a.m. **The Implementation of Commercial Space Policy**
Dr. Mark J. Albrecht, Executive Secretary, National Space Council

9:00 a.m. **NASA Missions and the Role of the CCDS's**
Mr. J. R. Thompson, Deputy Administrator, NASA Headquarters

9:30 a.m. ***Coffee Break***

10:00 a.m. **A Balanced Commercial Access to Space**
Moderator: Dr. Charles Lundquist, Director
Consortium for Materials Development in Space
University of Alabama in Huntsville

- **Suborbital Missions: The Joust**
  Mr. Bruce Ferguson, Executive Vice President, Orbital Sciences Corporation

- **Launch Vehicle for Orbital Missions: COMET**
  Mr. Deke Slayton, Director, EER Systems, Space Services Division

- **Systems for COMET**
  Mr. Harry Andrews, Manager of Commercial and Civil Space Department, Westinghouse Space Division

- **SPACEHAB**
  Mr. David Rossi, Vice President, Spacehab, Inc.

- **Wakeshield: A Space Experiment Platform**
  Dr. Joseph Allen, President and Chief Executive Officer Space Industries, Inc.

- **Space Station Freedom**
  Mr. Gilbert Keyes, President, Program Manager, Space Exploration Initiative, Boeing Commercial Space Development Company

12:30 p.m. ***Lunch Break***

2:00 p.m. **Industry Initiatives Through the CCDS's**
Moderator: Dr. Raymond Askew, Director, Center for the Commercial Development of Space Power and Advanced Electronics, Auburn University

Center for Macromolecular Crystallography, University of Alabama in Birmingham

Presentation by Dr. Manuel Navia, Senior Scientist Vertex Pharmaceuticals, Inc.

2:30 p.m. **Center for Space Power, Texas A&M University**

Presentation by Mr. Ken Jones, Manager, Nickel Hydrogen Batteries, Johnson Controls, Inc.

3:00 p.m. **Advanced Materials Center, Battelle**

Presentation by Dr. Harold Bellis, Research Fellow E. I. DuPont de Nemours and Co., Inc.

3:30 p.m. ***Coffee Break***

4:00 p.m. **Center for Cell Research, Pennsylvania State University**

Presentation by Dr. Mike Cronin, Director of Endocrine Research, Genentech, Inc.

4:30 p.m. **Center for Space Power and Advanced Electronics, Auburn University**

Presentation by Dr. Dan Deis, Manager of Engineering Science, Westinghouse Science and Technology Center

5:00 p.m. **Center for Mapping, Ohio State University**

Presentation by Mr. Lowell Starr, Technical Advisor for International Marketing, Intergraph Corporation

5:30 p.m. **Special Presentation: Remote Sensing**

Presentation by Dr. Jacqueline Michel, Director of Environmental Technology Division, Research Planning, Inc.

6:00 p.m. ***Adjourn to Evening Reception - The Washington Room***

Welcome and Introductory Remarks

Mr. James T. Rose
Assistant Administrator for Commercial Programs
NASA Headquarters

WELCOME AND INTRODUCTORY REMARKS

WELCOME!

COMMERCIAL DEVELOPMENT OF SPACE IS AN IMPORTANT ELEMENT IN THE FUTURE COMPETITIVE POSTURE OF THE INDUSTRIAL NATIONS OF THE WORLD. THE RESOURCES AND CHARACTERISTICS OF SPACE WILL PLAY A MAJOR ROLE IN OPENING A NEW ECONOMIC FRONTIER FOR ALL THE SPACEFARING NATIONS OF THE WORLD.

IN THE FACE OF FOREIGN COMPETITION, THE PACE OF DEVELOPMENT IS ALSO IMPORTANT. MARKETS CAN BE LOST BECAUSE OF SLOW TIMING OR IMPRECISE ACTION. OTHER COUNTRIES ARE TARGETING SEGMENTS OF COMMERCIAL DEVELOPMENT IN A FOCUSED, COHESIVE MANNER.

FOR U.S. INDUSTRY TO COMPETE EFFECTIVELY AGAINST FOREIGN FIRMS RECEIVING DIRECT OR INDIRECT GOVERNMENT SUPPORT, COOPERATION BETWEEN THE PUBLIC AND PRIVATE SECTORS OF THIS COUNTRY IS NECESSARY.

BASED ON THE FOUNDATION THAT TRUE COMMERCIAL SPACE IS ACHIEVED WHEN INDUSTRIES ARE ESTABLISHED THAT GENERATE NEW PRODUCTS AND SERVICES FOR PRIVATE MARKETS, AND DEVELOPMENT OF THESE NEW PRODUCTS AND SERVICES WILL, IN TURN, SUPPORT THE GROWTH OF OTHER COMMERCIAL SPACE INDUSTRIES, SUCH AS TRANSPORTATION AND INFRASTRUCTURE, THE CHALLENGE IS TO CONDUCT A PROGRAM THAT HELPS INDUSTRIES DEVELOP COMMERCIAL SPACE MARKETS, AND COST-EFFECTIVE COMMERCIAL SPACE TRANSPORTATION SYSTEMS AND INFRASTRUCTURE.

NASA HAS CARVED OUT SUCH A PROGRAM. WE BELIEVE THAT WE HAVE BEEN SUCCESSFUL IN STRUCTURING A COMPREHENSIVE AND AGGRESSIVE PROGRAM WHICH MEETS THIS CHALLENGE. THE ACTIVITIES OF THIS PROGRAM WILL ESTABLISH A TECHNOLOGY BASE WHICH WE HOPE WILL LEAD TO THE CREATION OF NEW PRODUCTS AND SERVICES, LEADING TO NEW MARKETS AND BUSINESSES. THESE ARE AND WILL CONTINUE TO DRIVE THE NEED FOR NEW COST-EFFECTIVE COMMERCIAL SPACE TRANSPORTATION AND INFRASTRUCTURE.

THE CCDS'S ARE THE CORNERSTONE OF THIS PROGRAM. THROUGH CCDS'S, 238 COMPANIES AND 72 UNIVERSITIES HAVE INVESTED IN COMMERCIAL SPACE RESEARCH. THE CENTERS WILL MOVE INDUSTRIALLY DRIVEN EMERGING TECHNOLOGIES FROM THE LABORATORY TO THE MARKETPLACE WITH SPEED AND EFFICIENCY BY LEVERAGING A BROAD RANGE OF RESEARCH WITH COMMERCIAL POTENTIAL.

TRUE COMMERCIALIZATION OF SPACE WILL NOT HAPPEN OVER NIGHT. IT WILL TAKE THE GREATER PORTION OF THE DECADE TO DEVELOP THE TECHNOLOGY FOUNDATION NECESSARY FOR FUTURE PRODUCTS AND SERVICES.

YOU ARE GOING TO BE HEARING A LOT ABOUT OUR SUCCESSES TODAY. WE ARE JUSTIFIABLY PROUD OF WHAT WE HAVE ACCOMPLISHED OVER THE PAST YEAR - AND WITHOUT STEALING ANYONE'S THUNDER, I'D LIKE TO MENTION JUST A FEW:

- 0 INDUSTRY CONTRIBUTIONS ARE EXPECTED TO DOUBLE IN FY 91 (35-70 M)
- 0 59 PATENTS ARE IN PROCESS
- 0 7 SPINOFF COMPANIES HAVE BEEN CREATED
- 0 10 LICENSING AND/OR EQUITY AGREEMENTS HAVE BEEN CONSUMMATED

- A 311 FLIGHT TEST PROGRAM HAS BEEN DEFINED TO MATURE 61 TECHNOLOGIES TO A POINT WHERE INDUSTRIES CAN JUDGE WHETHER SPACE CAN SPAWN NEW PRODUCTS FOR PRIVATE MARKETS.
    - 64 FLIGHT TESTS WILL HAVE BEEN FLOWN BY THE END OF 1991
- TO CARRY OUT THIS FLIGHT TEST PROGRAM IN ADDITION TO THE STANDARD SPACE SERVICES PROVIDED BY THE SPACE SHUTTLE:
    - WE HAVE LEASED SPACE ON 2/3 OF THE FIRST 6 SPACEHABS TO AUGMENT THE MIDDECK CAPABILITY.
    - IN ADDITION TO ~~THE~~ TWO SOUNDING ROCKETS PER YEAR, WE HAVE PURCHASED THE SERVICES FOR THREE COMETS.
    - THESE PROCUREMENTS WERE CARRIED OUT THROUGH THE CCDS'S.
- WE HAVE A COMPETITION NOW UNDERWAY FOR ONE OR MORE CCDS'S IN COMMUNICATIONS.
- CCDS'S ARE PLANNING AND INITIATING A VARIETY OF HARDWARE DEVELOPMENT PROJECTS TO PROVIDE CCDS RESEARCHERS WITH A COST-EFFECTIVE, ENTIRELY COMMERCIAL MEANS OF CONDUCTING EXPERIMENTS IN SPACE. ONE SUCH PROJECT, IN ITS THIRD YEAR OF DEVELOPMENT BY THE SPACE VACUUM EPITAXY CENTER AT THE UNIVERSITY OF HOUSTON, IS A "WAKE SHIELD" FACILITY FOR HIGH VACUUM MATERIALS RESEARCH FOR USE ON THE SPACE SHUTTLE.

- o NASA IS ALSO ESTABLISHING AN INTELLECTUAL INFRASTRUCTURE FOR SPACE COMMERCE BY INVOLVING A NUMBER OF PROFESSORS AND STUDENTS IN THE CCDS WORK. CURRENTLY THERE ARE 105 PROFESSORS, 71 POST DOCTORATES, 258 GRADUATE STUDENTS, AND 120 UNDERGRADUATES. IN ADDITION, 214 STUDENTS WHO HAVE WORKED ON CCDS PROJECTS HAVE BEEN AWARDED DEGREES AND 149 OF THEM ARE WORKING IN THE PRIVATE SECTOR IN SPACE TECHNOLOGY DISCIPLINES.

IN SHORT, IT'S BEEN AN EXCITING YEAR FOR NASA AND THE NATION'S COMMERCIAL DEVELOPMENT OF SPACE PROGRAM!

IT'S CLEAR FROM THESE EXAMPLES THAT WE HAVE ACHIEVED A BALANCED PROGRAM - WE ARE DEVELOPING A TECHNOLOGY BASE FOR POTENTIAL PRODUCTS AND SERVICES. WE ARE HAVING A POSITIVE IMPACT ON COMMERCIAL SPACE TRANSPORTATION AND INFRASTRUCTURE.

THESE SYSTEMS ARE BEING DEVELOPED FOR THE CCDS PAYLOADS - BUT THEY WILL BE MADE AVAILABLE IN THE INTERNATIONAL MARKET, AND WILL THEREFORE HELP U.S. INDUSTRY COMPETE IN A GLOBAL ECONOMY.

BUT THESE ADVANCES AND ACCOMPLISHMENTS DON'T COME FREE. MONEY MAKES THEM HAPPEN. OUR BUDGET REQUIREMENTS WILL GROW OVER THE NEXT SEVERAL YEARS, AND SUPPORT OF THESE BUDGETS IS A NECESSITY.

THIS MORNING WE ARE GOING TO HEAR FROM REPRESENTATIVES OF COMPANIES THAT ARE SUPPLIERS OF INFRASTRUCTURE SYSTEMS TRANSPORTATION VEHICLES. THEY WILL BE DISCUSSING THEIR PROGRAM, THEIR STRUGGLES AND MOST IMPORTANTLY THEIR SUCCESSES.

AND THIS AFTERNOON, SEVEN COMPANIES WILL DISCUSS THEIR INVOLVEMENT IN COMMERCIAL SPACE. EACH OF THESE COMPANIES HAS INVESTED CORPORATE FUNDS - AND THEY HAVE DONE SO WITHOUT ASSURANCES OF HIGH RATES OF RETURN IN THE SHORT TERM, WITHOUT COST-PLUS PRICING - THEY HAVE INVESTED THESE FUNDS AS ENTREPRENEURS IN A RISKY BUSINESS.

THEY BELIEVE, AND WE BELIEVE, THAT THEIR COMPANIES HAVE MADE A GOOD BUSINESS DECISION - THEY RECOGNIZE THE POTENTIAL IN COMMERCIAL SPACE COMPARABLE TO OTHER INVESTMENT OPPORTUNITIES AND THEY SEE IT AS AN INVESTMENT IN OUR NATION'S ECONOMY. I AM LOOKING FORWARD TO HEARING ABOUT THEIR EXPERIENCES, AND I WANT YOU TO HEAR THEM TO.

WE ARE VERY FORTUNATE THAT THE NATIONAL SPACE COUNCIL HAS RECENTLY PUBLISHED COMMERCIAL SPACE IMPLEMENTATION GUIDELINES WHICH WILL LEAD THE NATION AS WE SEEK TO ASSIST U.S. INDUSTRY IN THIS IMPORTANT ENDEAVOR. THE POLICIES SET FORTH IN THIS DOCUMENT NOT ONLY SUPPORT THE WORK WHICH WE ARE DOING TODAY, BUT ALSO ENABLES US TO CONTINUE IT IN THE FUTURE.

The Implementation of Commercial Space Policy

Dr. Mark J. Albrecht
Executive Secretary
National Space Council

REMARKS BY MARK J. ALBRECHT
SECOND ANNUAL SYMPOSIUM
ON INDUSTRIAL INVOLVEMENT AND SUCCESSES
IN COMMERCIAL SPACE
TUESDAY, MAY 14, 1991
8:15 a.m. - HOTEL WASHINGTON

Thank you, Jim (Rose), for those kind remarks.

I apologize for the fact that, due to prior schedule commitments, I will be able to stay with you for only a few moments this morning.

I am very pleased to have this opportunity to kick off what I'm sure will be a useful and informative conference. In particular, this forum gives me a chance to emphasize the importance which the Space Council attaches to carrying out one of the most challenging goals of the President's National Space Policy -- "expanding private sector investment in space by the market-driven commercial sector."

By any reasonable measure, the President and Vice President have consistently demonstrated their commitment to ensuring that, where appropriate, the concerns of the private sector will be considered in all our major policy pronouncements -- be it the Space Exploration Initiative, or the New Launch System, or the Space Launch Policy, or the Space Station. And, of course, I know that this audience is particularly well versed on two recent commercial space policy initiatives -- the Commercial Space Launch Policy and the U.S. Commercial Space Policy Guidelines.

I say "I know" that you are well informed about these initiatives because I've begun to notice a pattern -- there tends to be a surge in correspondence to the Vice President from certain places around the nation (approximately 16) any time the Space Council finds itself in the midst of one of these commercial space policy deliberations.

In all seriousness, we are grateful for the helpful inputs we've received from all of you during the past two years. In addition, I know the Vice President is grateful for the very kind comments he has received from many of you regarding the Space Council's efforts to help expand the private sector role in space. Your perspectives are valued because we think the CCDS initiative represents the type of market-led commercial space development which is precisely what our commercial space policy is aimed at fostering.

In fact, the CCDS program is highlighted in our 1990 Annual Report as an example of what we are encouraging agencies to pursue vis-a-vis developing innovative agreements with the private sector to share costs and risks. The Administration's commitment to this program is reflected in our ongoing efforts to have Congress restore the funds deleted by the House

Authorization Committee from NASA's Office of Commercial Programs Budget. We understand the importance of these funds to ensuring that the Commercial Experiment Transporter (COMET), which is so critical to launching and retreiving your payload needs, stays on schedule.

With the announcement of the U.S. Commercial Space Policy Guidelines last February, I believe that we have in place a policy framework which addresses many of the concerns you have brought to our attention over the past year -- (1) to clarify and rationalize the current hodge podge of regulations and policies into a coherent whole; (2) to attempt to flesh out some critical definitions and concepts (e.g., what constitutes commercial space activity or what is meant by "cost-effective"); and (3) to spell out the whats, hows, and wherefores of doing business with the federal government.

As one of the CCDS Directors stated in his letter to the Vice President, these Guidelines establish "a long overdue operational policy framework" which provides the private sector the type of stability and predictability it is owed in in its dealings with the U.S. government.

The Commercial Space Working Group which produced these guidelines remains active. It continues to meet with commercial space organizations to ensure that we are staying on top of developments in the commercial space community. We regard this document as a "living document" subject to further refinement as the government and the private sector gain additional experience in working through commercial space projects. And, of course, we maintain an open door policy in terms of encouraging you to come to us with your ideas and concerns.

We are also closely monitoring agency efforts to fully implement the specific provisions of the policy. As many of you know, agencies have been directed to report to the Space Council on specific steps they've taken to implement the Guidelines by October 1. Somehow I have a feeling that none of you will feel shy about giving us feedback in the weeks to come about how you think the agencies are actually doing in carrying out the policy.

In conclusion, we believe that you are part of an exciting experiment in how the government can be a catalyst in bringing together key elements of the private sector to further our national space goals. And we believe that this program is very much in line with the overall thrust of our commercial space policy.

Thank you for your time this morning.

NASA Missions and the Role of the CCDS's

Mr. J.R. Thompson
Deputy Administrator
NASA Headquarters

Remarks by Mr. J.R. Thompson
NASA Deputy Administrator

Second Annual Symposium on Industrial Involvement and Successes in Commercial Space

I've taken a very active interest for some time now in this aspect of NASA. That is, how do we bolster up some of the private sector? I know that Dick Truly is taking just as active an interest in this issue and we are trying to do whatever we can.

I would only echo Mark's comments relative to the effort that both he and Courtney and others inside the Administration -- and I don't want to leave out OMB -- have put forth in terms of trying to set the environment into a framework for the job that has to be done. We are plowing a new field, and it is a new frontier in that sense because you have to deal with government regulations, getting the capital, and dealing with Congress and the ups and downs in that budget cycle. I'm optimistic!

Let me state that these are times of change, but they are also times of opportunity in the civil space program. Certainly, as a part of that, I would include the commercial aspect of this. Frankly, I see it across the whole board. Mark mentioned that right now we are dealing with the 602-B allocation in the House, with the Senate soon to follow. It comes under the overall umbrella of the budget summit last summer, and it was followed by several months of the war in the Gulf. We are trying to deal with the deficits across the country and at the same time we are trying to conduct an across the board, robust, space program.

Technology has come to the forefront, as we have all seen on TV from the activities in the Gulf, just in aeronautics alone. I was at Langley yesterday, and we are starting now, here with the DOD, to shift into high gear in some of the brand new aspects of aeronautics, the National Aerospace Plane for instance. Perhaps many of you have heard a lot about that. We are also ready to shift into high gear and focus on the commercial aspects, supersonic civil transports, and in space technology where we are now seriously evaluating the options. For example, we may be using nuclear power in space not only for surface utilities, but also for deep space propulsion.

These are times of change and opportunity and in our space science program which has been on a roll now for some decades, and I think that we are only turning up the wick there. The focus is also turning inward on using the capabilities of the applied sciences to the Earth Observing System or the Mission to Planet Earth. Of course, for those of you who have read the Augustine report, the very heart of that report was to make the space transportation system more robust, not only for the civil but also the military side of that system, and to build on the contribution of the private sector that was started primarily by the DOD several years ago. We are in various stages of planning and development on programs across the board that start with the Space Station Freedom and hopefully will end up one day on the planet Mars.

I know that as we deal with this Congress, this budget, this Administration, and even within NASA, certain questions arise: Is this worth it? Who's going to pay for all of this? And where's the payoff? It's a tough budget environment we are in. Certainly, there are tugs all over town, in other agencies just as worthy as NASA. But, if you go back and look at what has transpired over the last four to five years, I believe it is reasonably clear that this Administration is highly committed, not just to the space program but to the investment in the future that falls from it. I would say the same about Congress. If you go back and review the history of NASA's budget from about 1985 back fifteen years to 1970, by and large it was basically flat. But just in the last four or five years, in terms of real growth (excluding inflation), that investment has gone up fifty percent. Whereas this year, as Mark was referring to, we are trying to defend the President's budget of almost 15.7 billion dollars. Someone asked earlier how the commercial side of NASA's involvement fared in this environment. I frankly don't recall the same numbers between 1970 to 1985, but as Jim mentioned this current year in the President's budget, in 1992, it's about 118 million dollars of NASA's total budget of 15.7 billion dollars. If you go back those same four or five years and look at the growth, you easily have to conclude that it is the fastest growing budget inside the entire NASA program. Where the NASA total, in real terms, has gone up some fifty percent, Commercial Programs have gone up almost 250 percent in real growth.

There is talk of budget cuts -- you hear talks of one to two billion dollars -- but I do know that the Space Council, the Vice President, Darman in OMB, and as Mark indicated, the President today, are getting involved with the appropriations process to try to make sure that we do the right thing relative to our investments in the future. Clearly, there are a lot of probing questions. I mentioned the questions: Is it worth it? Who is going to pay for it? Where's the payoff? Also, you have to deal with the technology side of it -- is it ready? The science, how does it rate in this whole process? The Augustine group says that this is the number one question. I would almost state or add that it has been number one, almost from the early days of NASA. Several weeks ago we completed the first decade of operation of the Space Shuttle. Almost seventy percent of the payloads to date have been dedicated to science. Certainly, Space Station Freedom is an excellent example, and I would optimistically see commercial opportunities once we get that world-class facility ready.

However, you don't get a free ride in this. There is risk and I think nobody knows that more than you folks in this room. As I indicated, it is one of the fastest growing budget areas in NASA and we are very much committed to it. I think we are reasonably aware of the issues and risk factors you are trying to deal with and the fact that it is new. Then perhaps the federal government does change its mind as we go through Administration changes and OMB changes. But because of the growth rate, the visibility is getting higher. For the first time I can recall in this sector, there is talk about getting a GAO report soon. Jim says it's okay, but we are also starting to get questions in Congress. I think that we will all do all right -- it is going to be a long haul but we all will do all right. Looking at the agenda today, you are going to be talking about a whole spectrum of topics; Jim touched on some. Just the access to space, and the private sector's involvement in the Joust program, COMET and Spacehab, and the Wakeshield will give us tremendous capability combined with our Space Shuttle program.

And there are a number of select activities that we are going to bring into focus on the CCDS program. I believe that Jim indicated earlier that it is the heart and soul of this commercial activity at least if you go back and you look at what has happened in the last several years. As a matter of fact, just look at what is happening today at the University of Houston Center (CCDS) where they are developing a free-flying facility which is going to produce a large quantity of semi-conductors and superconductor thin films in a new vacuum environment that is going to be considerably better than that which we can duplicate on the ground.

And there is the story of the COMET program, where we have the first totally commercial launch and recovery system. It was a fast-take procurement initiated by Jim's organization and NASA where the first launch was scheduled only eighteen months away from the contract award.

And we have the industrial partners down at Auburn University with their advanced electronic project pretty much "upping the ante" relative to their contribution toward upgrading the facilities with the state-of-the-art silicon carbide research work that is ongoing there.

Also, there is the story of the first fully commercial sounding rocket, the Consort series, that is currently carrying CCDS payloads scheduled for launch only nine months after the first RFP was released.

And the ITD Space Remote Sensing Center is teaming up with Ohio State University and the Stennis Space Center to provide a very critical technology in remote sensing satellites to commercial users with resolution down to two to five meters in contrast to the ten to fifteen meter resolution that is available today for the commercial sector.

And there is the Ohio State University, Center for Mapping that I personally believe is going to be a winner. I have had an opportunity to go up and talk with their people and see what it is they are working on. I understand that they have some 38 states involved, a Canadian province, the Federal Highway Administration, and they have also directly involved a half-dozen private companies. All of this will lead to a better transportation system planning process for the country.

Of course I could go into a lot of detail, but I think that throughout the day you are going to hear about the progress that is continuing relative to materials science in space. It continues to be a high interest item on the Hill. I would hope over the next several years we will continue to see progress and perhaps see some breakthroughs there.

There are also a number of problems as we attempt to open up commercial opportunities in space. As I indicated earlier, it is you who see them in space a lot better than I do -- budget, risk, payoff. You've got to deal with the first two, and you have to answer the questions just as we at NASA do on the latter, the payoff issue. These are old issues with space flight that predate the Apollo program. There is a new dimension now, and it is a high priority within NASA: it is the commercial opportunities.

I personally wish that the Augustine report had more to say about the commercial future of space, since it dealt with the future of the civil space program in this country, because I think an opportunity was missed. I believe that a greater effort was made in trying to capture and answer some of the questions that were raised by blurry mirrors, by leaky pipes, and by overweight space stations. Of course, you know what the final outcome was: science is number one. A question was raised earlier regarding Mission from Planet Earth, which you have some activity in: is there commercial opportunity there? I'll be honest with you, I think that it will be a long time coming. We still have a long hill to climb in this area. In the Augustine report they wanted to double and triple the technology budget, and as I indicated earlier, focus on a new national launch transportation system, which I believe NASA and the DOD are working on. But, I believe, as I have indicated in other public forums, that this is a good road map to the future. I feel this road map missed mapping some of the side road that we have going on today that may become the main roads of the future in our civil space program. Of course, I'm talking about the commercial aspects.

Some of the output from the CCDS program has begun riding in the middeck lockers and will soon be in the Spacehab. CCDS output can be found in sounding rockets today, and in some of the zero-G aircraft, but I believe that eventually wanting more time in Space Station Freedom is a natural. I have to comment regarding this since it is such a hot topic. We need your support. You have got a lot invested and are interested in the success of the Space Station program. We have talked about it being the first major step of the exploration program for this Mission from Planet Earth. In my own judgement, I do not think that this means that the Space Station is going to become a way station or docking facility for outward journeys which have been discussed, such as going back to the lunar surface and then going on to Mars. I do believe that it will help to lay the foundation in materials science, certainly in the life sciences, and it is also going to open up opportunities, with time and patience, in the commercial sector. The restructuring of this Space Station meets the affordability guidelines put down by Congress which we have now completed, and it is solidly endorsed by the National Space Council and OMB. It meets all of the criteria: we can afford it, we can launch it, it is maintainable, and in my own judgement, it is worth it. But recently it has been argued that just based on a purely scientific argument, the returns on the investment are not sufficient to warrant these up-front costs and commitments to achieve it. Perhaps one can make this argument, and perhaps one can make it strongly in a very narrow view. But I think, in my own judgement, it is much more than research in either life sciences or microgravity sciences, and it is much more than cracking the door of opportunity where your interests lie, and that is in the commercial sector. It is much more than all of that. I do not think that you can measure the worth of Space Station Freedom by the length of its truss, the number of racks it has, the temperature of its internal furnace, or even the diameter of its centrifuge. I think it gives America an opportunity to go and stay where we have never been before for the durations that we are talking about. It gives us the opportunity to uncover new sciences and also provides you the opportunity to see if we can make a buck in space from the commercial aspects. I think the opportunity is there for you. I have asked Jim to go ahead and lay out the plan that would do just that. And, for assumptions sake, assume that you have somewhere between twenty-five and thirty percent, for starters, of the allocation of the initial Space Station as measured in the middeck lockers, the equivalents to what we have flying on the Shuttle today. And, hopefully, it will be a continuum from those lockers into the Spacehab, perhaps into the Spacelabs and then into the Space Station. That is quite an investment that NASA is putting aside for the growth of this sector if indeed we can make it happen.

There are issues coming up which I would be remiss if I did not comment on this morning. The OMB report has already been mentioned, these things have a way of developing a life of their own. Who knows how they are going to be picked up? I am already hearing, and perhaps you are as well, that NASA, with the large increases in budget in just a fairly short period of time, is laying the ground work for what some may view as entitlement over the long haul. I personally do not believe any of that. I think we have a strong program. As a matter of fact, I think that the CCDS program and the commercial space program were initiated in NASA, and it was not just during the last several years; it has a start that goes back as early as Jim Beggs and perhaps ideas before that. Even then I think it has grown with each Administration. Certainly there have been ups and downs. I think it is one of the real success stories in the Agency. Certainly, that is apparent with the interest we have here and the attendance that it constitutes.

I think it is also time to look in the mirror and see where we are going. Are we meeting some of the original criteria that we started out with? It is for that reason that I have asked the National Academy of Public Administration to come in and look at our program. I have not made that request because of concerns of the GAO or any concern I have received from any committee, but I think it would be healthy for us to look at the track record established to date, and look at our road map for the future (since it was not touched on as part of the Augustine report), so we can build on the budget and the opportunities in the future and not stagnate at the level we are on now. A lot of that will depend on the success we get from our launch vehicles. We can only talk about better crystals for so long; we have reached a point where we finally have to show some kind of a thread toward the future.

We at NASA are committed. I know Dick Truly is committed, and within the working group that Dick has set up, which I chair, working with Jim's organization, we are to defining not only the opportunities but where we have set up internal roadblocks in the federal government, and specifically within NASA, so that we can try to address those items. I would encourage you to keep up the good work. I think the progress that has been made over the past four to five years has been truly impressive, but we have a long way to go and I think, as you all know, we are treading on new ground.

A Balanced Commercial Access to Space

Dr. Charles Lundquist
Director
Consortium for Materials Development in Space
University of Alabama in Huntsville

UAH
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE
NewsLead

REMARKS BY
DR. CHARLES LUNDQUIST
DIRECTOR
UNIVERSITY OF ALABAMA IN HUNTSVILLE
CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE

Since the establishment of NASA's Office of Commercial Programs (OCP) and the Centers for Commercial Development of Space (CCDS), the need for easy access to space has been fundamental. Commercial success in space is possible only with economical and frequent opportunities to perform space operations. Another recognized need is an evolutionary path from simple, low-cost investigations to more complicated, costly operations.

The OCP-CCDS team has implemented a balanced access to space to satisfy these needs. The first component of this plan is a schedule of suborbital rocket flights. The next component in complexity is an orbital launch and recovery system. Other components include provisions on the Space Shuttle for many locker-sized packages and for a shuttle tended free-flyer. Ultimately, this commercial team intends to be a major user of Space Station Freedom.

These components are the groundwork for a balanced access to space provided by a wide-variety of commercial entities. This approach builds a vigorous commercial infrastructure supporting business development in space.

The OCP-CCDS team is proud that many of these commercial capabilities are underway, thereby recognizing the need to have adequate access to space. This morning, we have the privilege to hear industry representatives describe their work and available capabilities.

UAH Office of University Relations, Alumni House, Huntsville, Ala. 35899 Phone (205) 895-6414 FAX (205) 895-6462

N92-23644

Suborbital Missions: The Joust

Mr. Bruce Ferguson
Executive Vice President
Orbital Sciences Corporation

JOUST Spaceborne Materials Processing Missions on the Prospector™ Suborbital Vehicle

Second Annual Symposium
on Industrial Involvement and Successes
in Commercial Space

Prepared By
Orbital Sciences Corporation

14 May 1991

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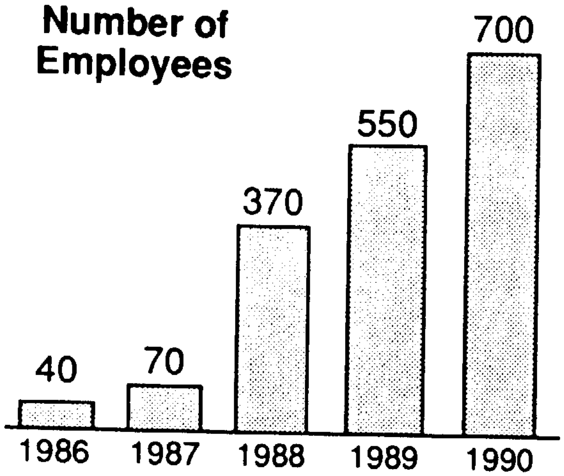
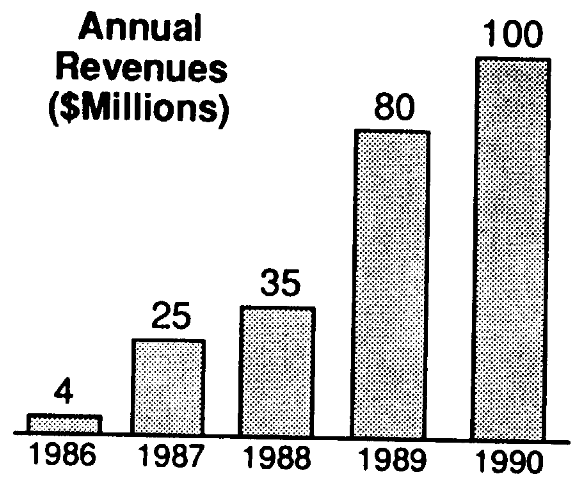
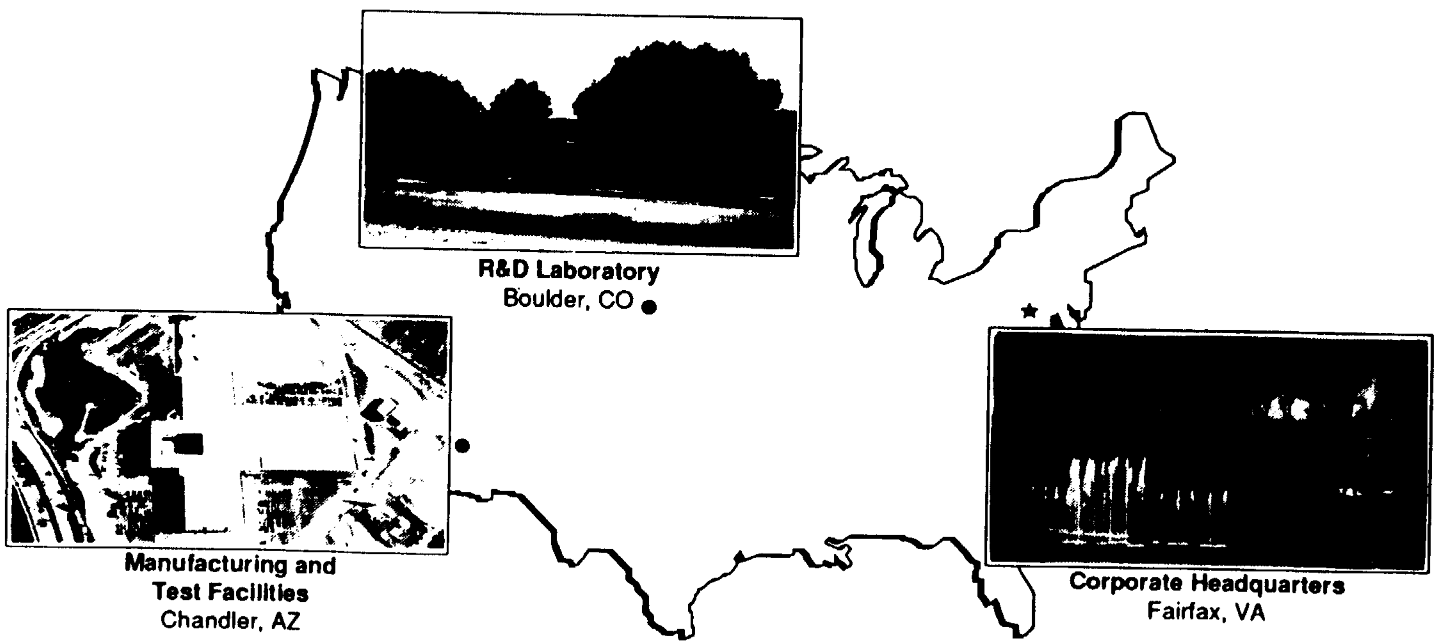
Orbital Sciences Corporation Overview

Orbital Sciences Corporation







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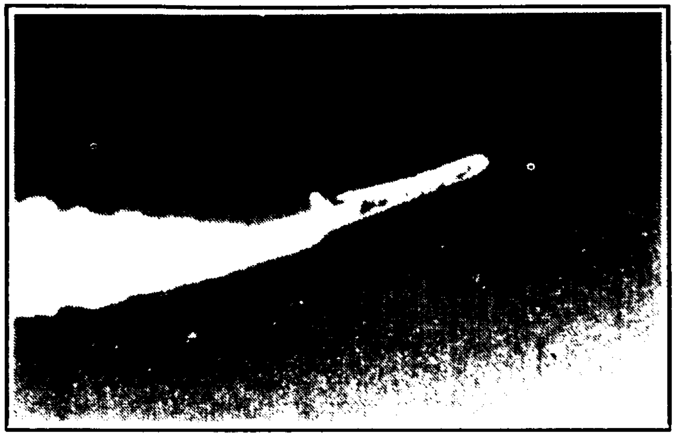
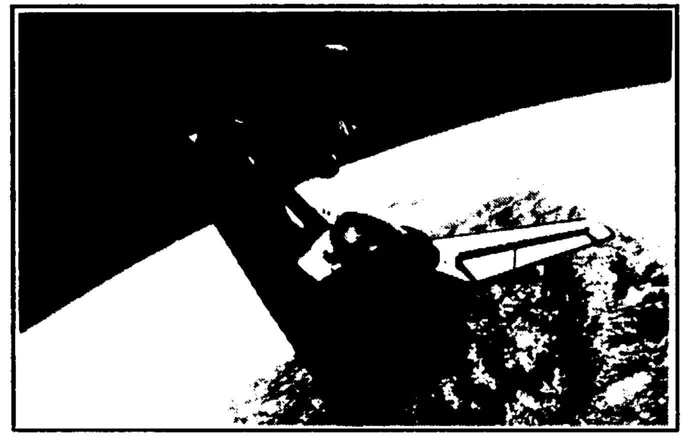
Orbital Is a Leader in Key Market Segments

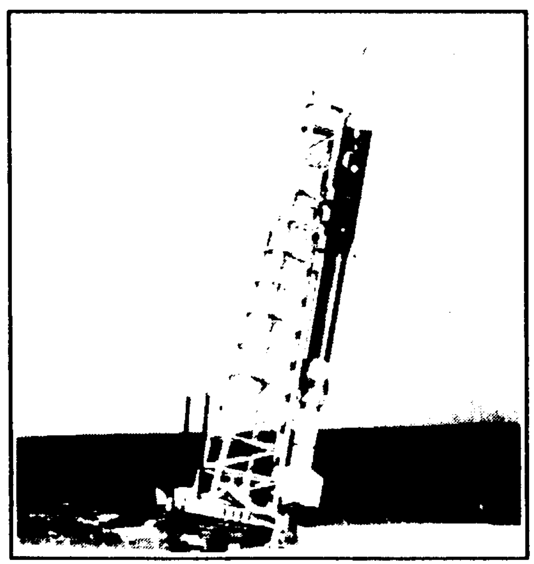
Orbital Sciences Corporation



Space Launch Vehicles



Orbit Transfer Vehicles



Suborbital Launch Vehicles

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And an Innovator of Breakthrough Space-Based Services

Orbital Sciences Corporation

ORBCOMM Mobile Communications Service

SeaStar™ Environmental Monitoring Service

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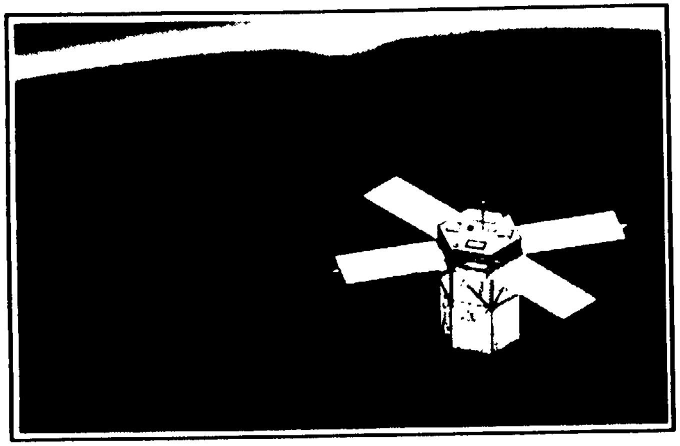
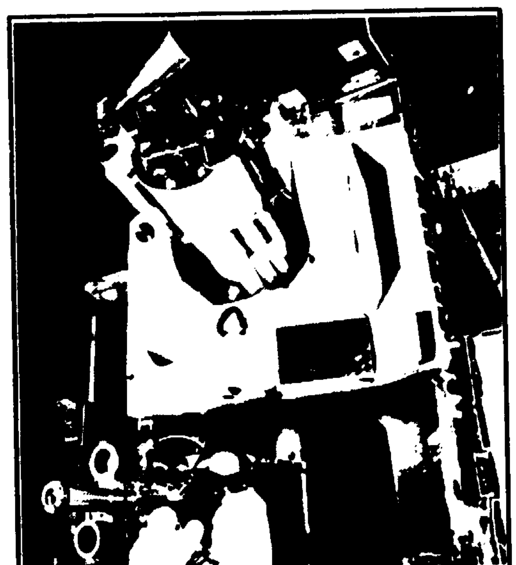
With Broad Capabilities in Other Product Areas

Orbital Sciences Corporation



Spacecraft Systems

Space Support Products



Space Payloads

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JOUST Mission Overview

History

- Series of Suborbital Launches Carrying Experiments by UAH CMDS, One of NASA's 16 Centers for the Commercial Development of Space
- All 16 CCDS are Funded by NASA's Office of Commercial Programs and by Private-Sector Partners
- Orbital Sciences Corporation Selected to Provide Rocket and Launch Services in 1989 with First Mission Within Two Years

Description

- Prospector Vehicle Part of Orbital's Starbird™ Family of Suborbital Vehicles Utilizing State-of-the-Art Technology
- First Mission Scheduled This Month with 10 Microgravity Experiments
- Rocket to be Launched From Launch Complex 20 at Cape Canaveral AFS

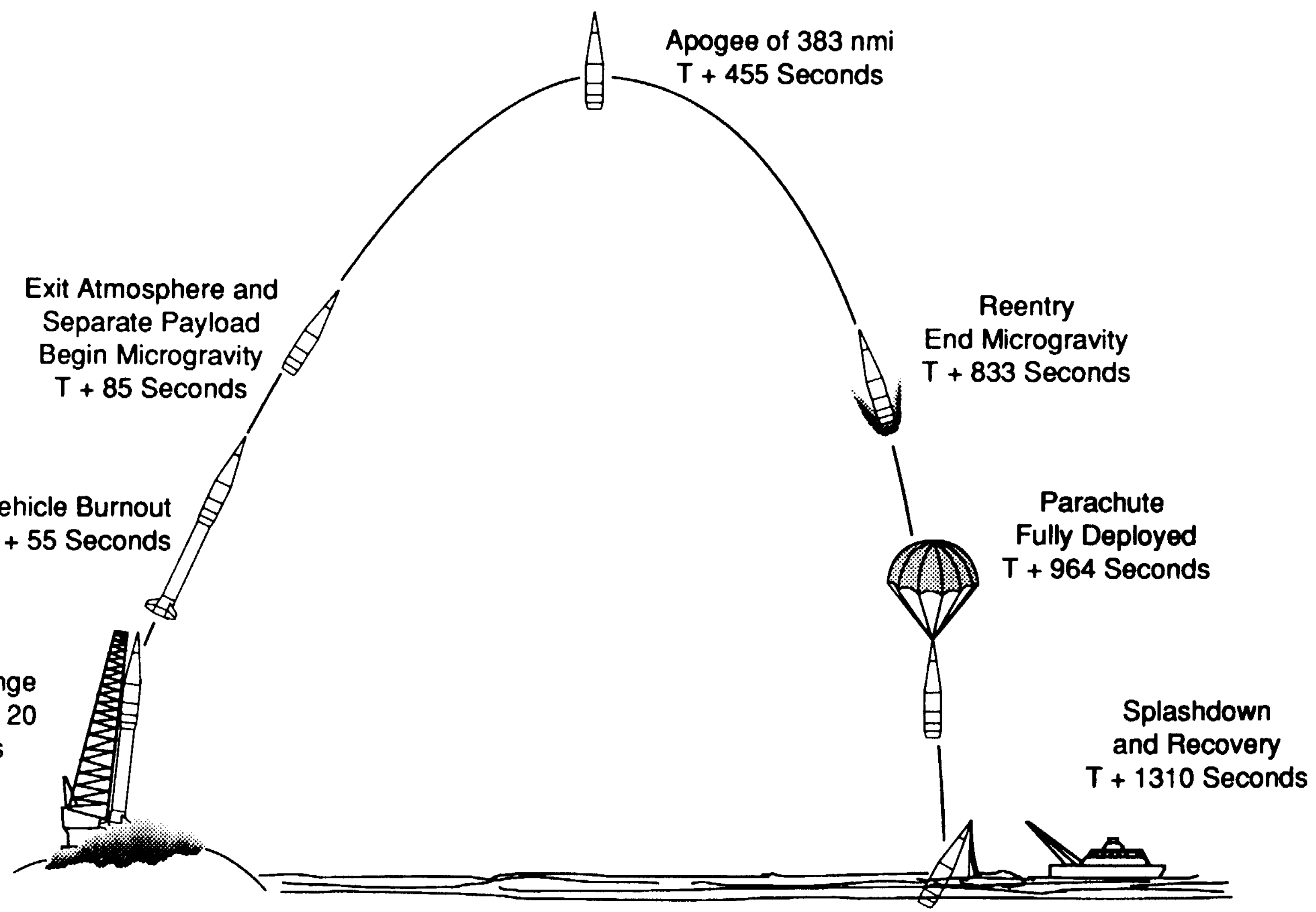
JOUST Mission Plan

Orbital Sciences Corporation OSC

- Prospector Vehicle is a 27,000 Lb, 46 Foot Tall, Single Stage Suborbital Rocket
- Vehicle Powered By a Castor IVA Solid Rocket Motor Built By Thiokol Corporation
- 10 Experiments Will Be Flown in Recoverable Module
- Gross Payload Mass of 1,800 Lbs
- Mission Will Last Approximately 21 Minutes, Providing at Least 13 Minutes of Microgravity Time
- Trajectory is Approximately 380 Miles High and 280 Miles Down Range
- Payload Will Be Located Via Plane and Retrieved Via Ship to Cape Canaveral
- Eastern Space and Missile Center (ESMC) Will Provide Support for the Launch

Joust 1 Mission Scenario

Orbital Sciences Corporation



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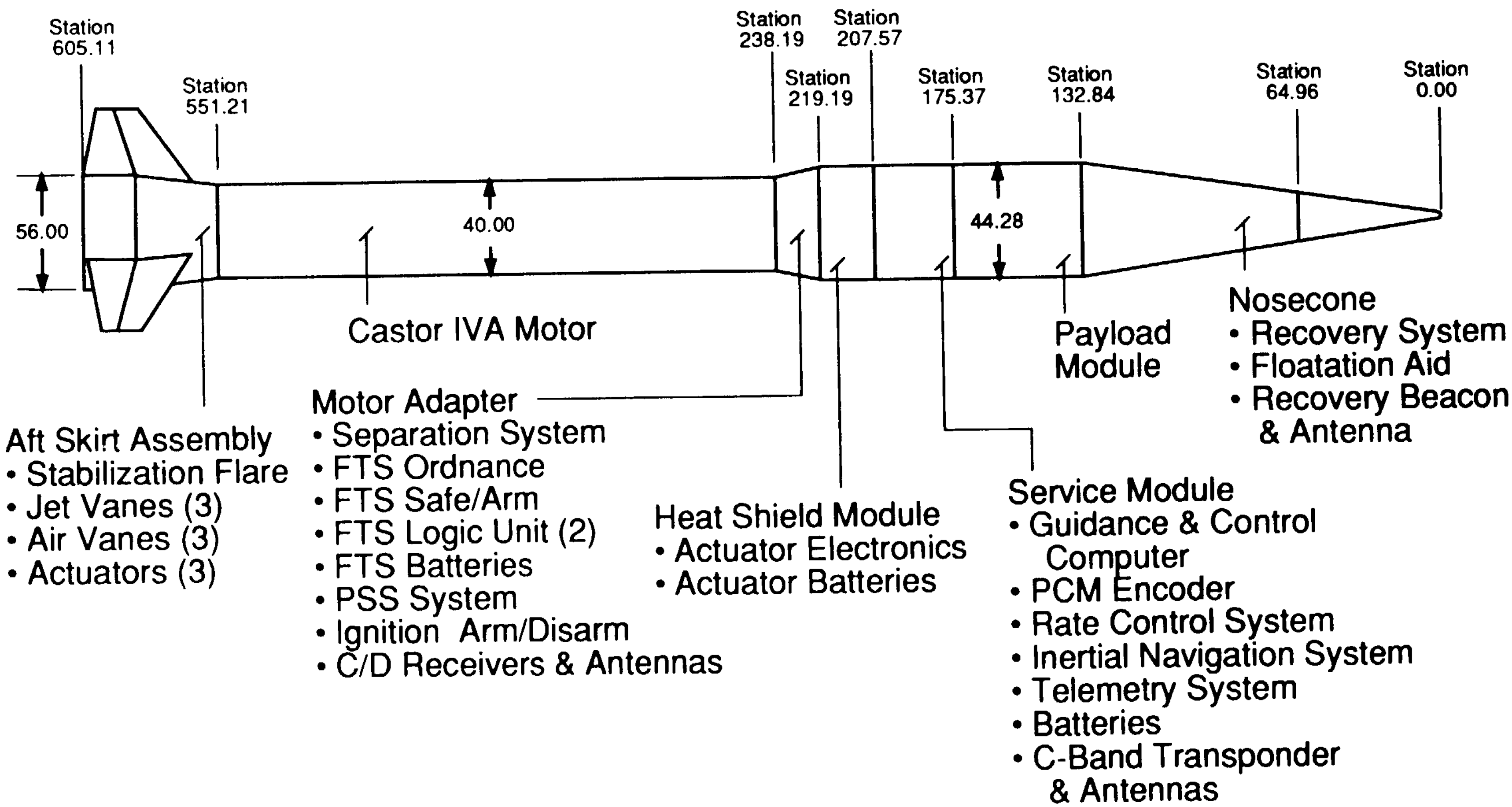
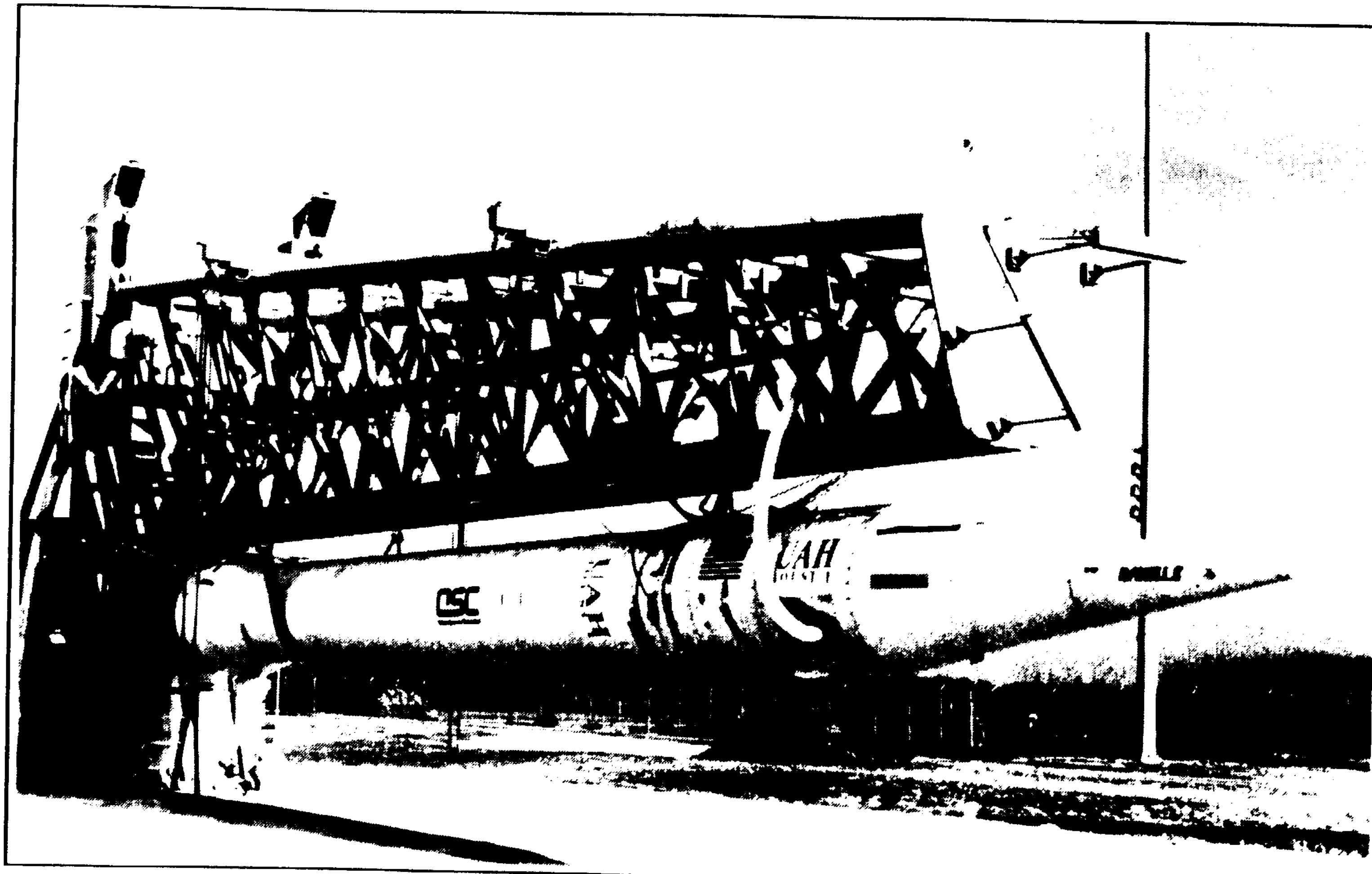
Prospector Design



JOUST Rocket

Orbital Sciences Corporation



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JOUST Contributions to Commercial Space Development

Orbital Sciences Corporation OSC

- Single Prospector Rocket Mission Carries Equivalent of Commercially Allocated Space on Five STS Missions
- Provides CCDS Independent Launch Capability and Stimulates Development of Other Market Applications
- Enables CCDS to Expand Capability and Capacity for Materials Processing in Space
- Provides Low-Cost Proof-of-Concept Testbed for Future Orbital Experiments
- Helps to Keep America First in Space-Based Research in Face of Increasing International Competition

HISTORY

This is the first in a series of Joust launches planned over the next three years by the UAH CMDS. The name Joust was selected for this launch series because it signifies the competition stimulated in the aerospace industry by commercial rocket ventures. The Joust 1 emblem symbolizes that competition through the mounted knight and lance which was popular during the Middle Ages.

Orbital Sciences Corp., Space Data Division was selected to provide the rocket and launch services in 1989. The UAH CMDS has contracts with Space Data to provide up to three launches. Each would be at the Air Force's Eastern Test Range. The cost for the rocket, payload and launch services is approximately $3 million.

NASA's Office of Commercial Programs is responsible for establishing and managing 16 Centers for the Commercial Development of Space. The UAH CMDS has focused on investigations in space as a means to develop new materials and processes.

Current corporate partners are Boeing Aerospace, Deere & Co., Frontier Research, IBM's Almaden Research Center, McDonnell Douglas, Teledyne Brown Engineering, Instrumentation Technology Associates, Thiokol Corp., and Wyle Laboratories. Marshall Space Flight Center, Huntsville, is the consortium's prime NASA partner. Other NASA centers provides substantial support.

Dr. Charles Lundquist is director of the UAH CMDS. Dr. Francis Wessling is associate director and Joust Project Manger and Valerie Seaquist is assistant director.

Space Data, a division of Orbital Sciences Corp., Fairfax, Va., has been developing, building and launching suborbital boosters for over 25 years. Their contracts include the Air Force, Defense Nuclear Agency, U.S. Army, NASA and various non-government customers. Space Data has launched numerous single and multi-stage boosters weighing up to 70,000 pounds to altitudes up to 560 miles carrying payloads up to 6,000 pounds. Space Data is located in Chandler, Ariz.

PROSPECTOR LAUNCH VEHICLE

Space Data is providing its Prospector rocket which is a single-stage, solid-fuel vehicle which stands approximately 46 feet tall and weighs 27,000 pounds. The vehicle will boost a 548 pound payload to an altitude of approximately 400 miles.

The rocket will use a single stage propulsion system provided by a Castor IVA rocket motor. The motor is a derivative of the Castor IV successfully flown over 300 times as a Delta II strap-on booster and as a single stage sounding rocket. The Castor IVA has flown successfully 153 times. The motor is manufactured by Thiokol Inc. The motor will burn approximately 59 seconds after ignition.

The Litton Guidance and Control Systems inertial navigation system will generate the steering commands for the vehicle control system to keep the rocket on course. The system will allow the rocket to be launched under wind conditions up to 40 mph and assist in controlling thrust misalignment.

Attached to the payload will be the nose cone containing the parachute recovery system. Space Data will use a derivative of a nose cone regularly flown on the Aries sounding rocket. A heat shield will be attached to the base of the payload.

JOUST 1 MISSION PLAN

The Prospector is designed to provide about 13 minutes of microgravity time for the UAH payload. Its trajectory is approximately 400 miles high and about 200 miles down range depending on wind conditions from Launch Complex 20 at the Eastern Test Range.

The Eastern Space and Missile Center (ESMC) will provide support for the launch including weather information and other range services. ESMC oversaw the $2.5 million renovation of Complex 20. Complex 20 had been used to launch Titan missiles during the 1960s.

The Castor IVA motor will burn 59 seconds lifting the payload to an altitude of approximately 50 miles. During the boost period, the rocket's guidance system will keep the trajectory from being affected by winds.

At 68 seconds, the payload is separated from the motor and microgravity begins at about 60 miles. The experiments are activated when acceptable microgravity conditions are achieved and continue until the payload begins to re-enter the atmosphere.

The payload will reach its apogee of 395 miles just over eight minutes into the mission. At slightly over 13 minutes, the mission's microgravity stage will end and the payload will reenter the earth's atmosphere. Following reentry, a parachute will be deployed and splashdown into the Atlantic Ocean is expected about 200 miles from Complex 20 at just over 21 minutes after liftoff.

A plane will be used to assist in locating the payload following splashdown. A ship from Harbor xxxx will retrieve the payload and return it to Cape Canaveral. Experiment samples will be removed from the payload and analyzed on board ship during the return to Port Canaveral.

JOUST 1 PAYLOAD

Joust 1 will carry a payload of 10 experiments. The experiments in the payload module will be mated with a service module containing accelerometers, avionics, a low gravity rate control system and battery packs. These two modules will stand over six feet tall and are 44 inches in diameter. They weigh approximately 1,100 pounds.

Payload integration was done jointly by UAH and Teledyne Brown Engineering, Huntsville, Ala. Vibration testing was completed by Wyle Laboratories, Huntsville, Ala., and at Space Data.

EXPERIMENTS

Battelle Advanced Materials Center, Columbus, Ohio
Principal Investigators:
Vince McGinniss
Lisa McCauley
Frank Jelinek

EXPERIMENT: INVESTIGATION INTO POLYMER MEMBRANE PROCESSES

A thin film is formed into a membrane on the ground and is kept saturated with a solvent in a special chamber prior to launch. On reaching the microgravity state, a valve is opened exposing the sample chamber to a vacuum, removing the solvent and allowing the membrane to cure.

Polymer membranes have been used by industry for more than 25 years to assist in desalination, filtering drugs and serums, atmospheric purification and dialysis. Polymer membranes are commercially processed by evaporation casting. It is expected that the resulting pores in the space-processed membrane will be more uniform than those processed on earth.

EXPERIMENT: POLYMER CURING

A heating tape is wrapped around 15 vials containing a polymer resin and a catalyst which cure at elevated temperatures. The heating tape is activated at launch and will reach the desired polymer curing temperature during microgravity.

The experiment will study dispersion under microgravity conditions. Current industrial processing involves the interaction of polymers with other materials such as fibers, metal oxides, glass or carbon fibers. The products of these interactions are non-uniform because gravity causes solids to settle or because materials of different densities disperse unevenly in gravity.

EXPERIMENT: PLASMA PARTICLE GENERATION

This experiment is designed to produce particulate forms of polymeric materials in a microgravity environment. The experiment consists of a particle generation chamber equipped with high voltage electrodes, a gas source for particles, and a laser and sensor system to observe the particle production. A camera in line with the laser beam records the particle diffraction patterns, and the sensor array at 90 degrees measures the laser scatter.

Researchers expect the particles will be suspended in the plasma discharge throughout their growth period permitting the growth of larger particles.

University of Colorado-Boulder
Center for Bioserve Space Technologies
Principal Investigators:
Marvin Luttges
Louis Stodieck

EXPERIMENT: AUTOMATED GENERIC BIOPROCESSING APPARATUS

This experiment consists of six sets of Lexan blocks, each containing 12 to 20 sample wells. A fixed block will contain the process materials. These materials will be mated with a second well in a sliding block initiating the desired experimental process. At the end of the microgravity period, the sliding block will move again to allow a third well to line up with the first to complete the process. In certain cases, the sample wells will have stirring devices to mix the products during the reaction phase.

The experiments will include the study of collagen, a basic building block for all body organs and tissues; microorganism nutrient uptake, which will play an important role in the design of water and oxygen purification systems; and liposomes which have biomedical and biotechnical applications.

Center for Cell Research
Penn State University
Principal Investigator:
Roy Hammerstedt

EXPERIMENT: BIOMODULE

This experiment uses the Penn State Biomodule. It contains 32 solenoids to trigger the release of fluids under computer demand.

The biomodule will test the hypothesis that secretory cells malfunction in microgravity because the internal cell structure is altered. The experiment will use chameleon skin because it is tough enough to withstand the stresses of launch, and its response is easily monitored as a change in color.

Thiokol Corp., Logan, Utah
Principal Investigator:
Charles Zisette

EXPERIMENT: THIN FILMS

Formation of light weight film structures on earth is affected by the density of the various solid particulates which may be added to the base liquid before forming and curing. The denser solid particles added for optical or electrical properties will settle out under gravity forces leaving the solidified membrane non-uniform.

This experiment will examine the creation of a thin film polymer containing iron particulate. The polymer will be examined for uniformity of distribution and optical and electrical properties.

Instrumentation Technology Associates, Exton, Penn.
Principal Investigator:
John Cassanto

EXPERIMENT: MATERIALS DISPERSION APPARATUS (MDA)

Two MDA minilabs will fly on Joust 1. Each consists of upper and lower blocks of inert material which have equal numbers of sample cavities which are held misaligned at launch. When the proper microgravity level has been reached, the blocks are moved into alignment to permit the two fluids in the upper and lower blocks to mix. Before the microgravity conditions are complete, the blocks are moved once more out of alignment.

The MDA will conduct experiments in the biomedical, manufacturing processes and fluid sciences fields.

Consortium for Materials Development in Space
University of Alabama in Huntsville
Principal Investigator:
Samuel McManus
Francis Wessling

EXPERIMENT: FOAM FORMATION

This experiment involves the creation of a polyurethane foam ball containing aluminum particles. Because of their insulating and mechanical properties, polyurethane foams may be prepared in space and used in construction of vehicles like the space station.

The experiment apparatus stores the foam components in separate compartments under pressure. When microgravity begins, the ingredients are released in a special chamber where they are mixed by a stirring motor, then forced through a funnel to cure.

Consortium for Materials Development of Space
University of Alabama in Huntsville
Principal Investigator:
Clyde Riley

McDonnell Douglas Space Systems Co., Huntsville, Ala.
Principal Investigator: George Maybee

EXPERIMENT: ELECTRODEPOSITION PROCESS

This experiment consists of an arrangement of 10 electrodeposition cells containing various electrolyte solutions which will be used to produce thin-deposited films under microgravity conditions. The electrolytes are contained in lucite cells which can be photographed during flight. Some of the cells also have stirring motors which are used to maintain the electrolyte suspensions during the deposition process.

The research will assist in finding better metal catalysts and improved wear resistant co-deposited surfaces.

Consortium for the Materials Development in Space
University of Alabama in Huntsville
Principal Investigator:
James Smith

EXPERIMENT: POWDERED MATERIALS PROCESSING

This experiment will attempt to take advantage of the microgravity environment in space to produce homogeneous ceramic powdered materials. The device will have two sample chambers which will be pre-mixed and stirred during microgravity. A special compaction motor and ram cylinder will capture the ceramic mix during the microgravity period. Pressure will be kept on the specimen through recovery at which time the sample will be fused in a commercial facility.

EXPERIMENT INTEGRATION AND INSTRUMENTATION

Teledyne Brown Engineering Co., Huntsville, Ala.

Teledyne Brown Engineering integrated the Joust 1 experiment hardware into a payload compatible with the Prospector. Major activities included payload assembly, end-to-end mission sequence testing and vibration testing. Mission sequence testing verified payload functions during physical simulations of the launch countdown and flight.

N92-23645

Launch Vehicle for Orbital Missions: COMET

Mr. Deke Slayton
Director
EER Systems
Space Services Division

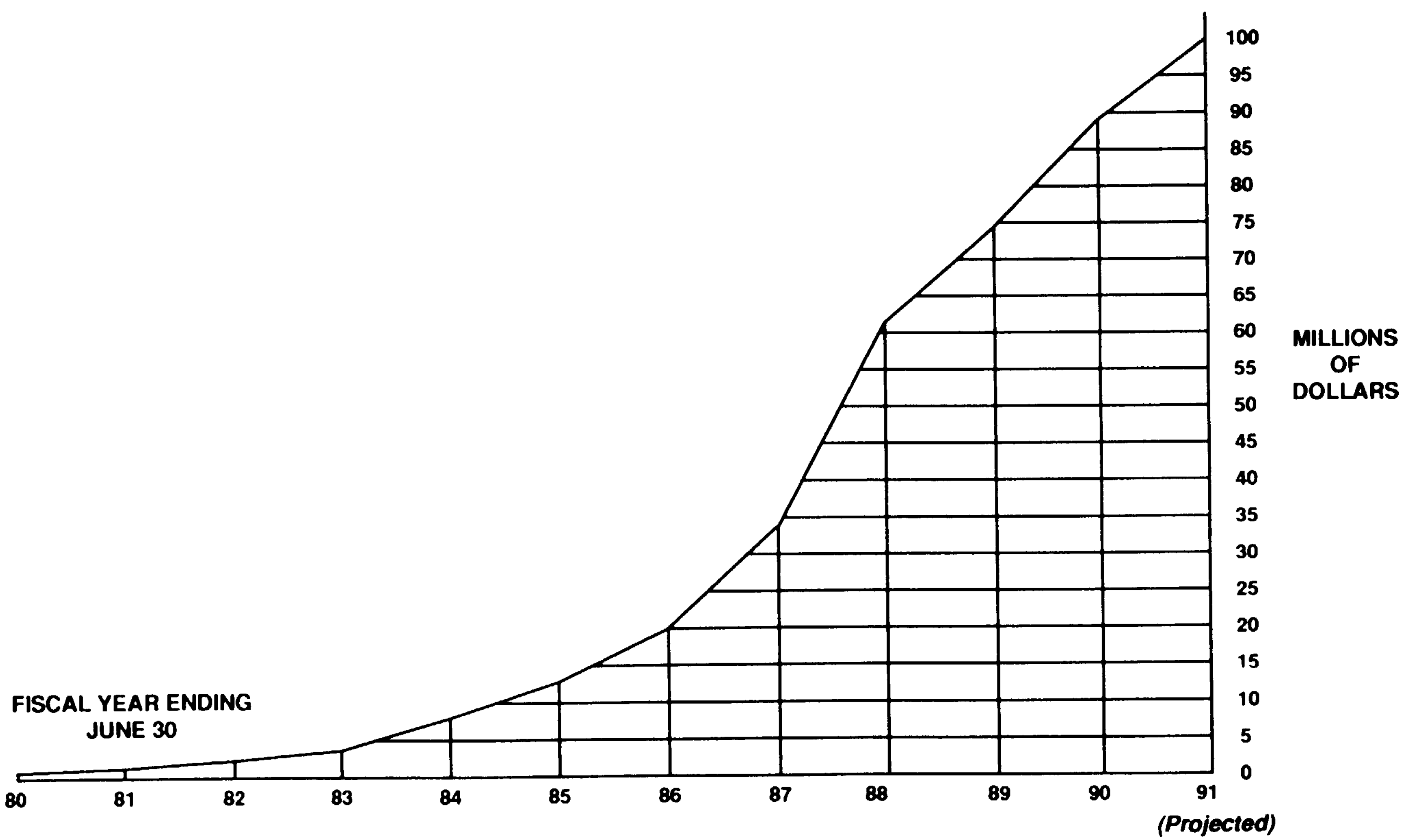
EER Systems
Engineering Services
and
Space Launch Services

May 1991

EER SYSTEMS

Corporate Overview

- Company Founded in 1979
- Eleven Years of Steady Growth
- Well Managed and Financially Sound
- Highly Qualified Professional Staff of 850 Individuals
- Providing System Engineering, Development, and Integration Support in the Areas of:
  - Aerospace Flight Systems
  - Information Systems
  - Training Systems


FISCAL YEAR ENDING
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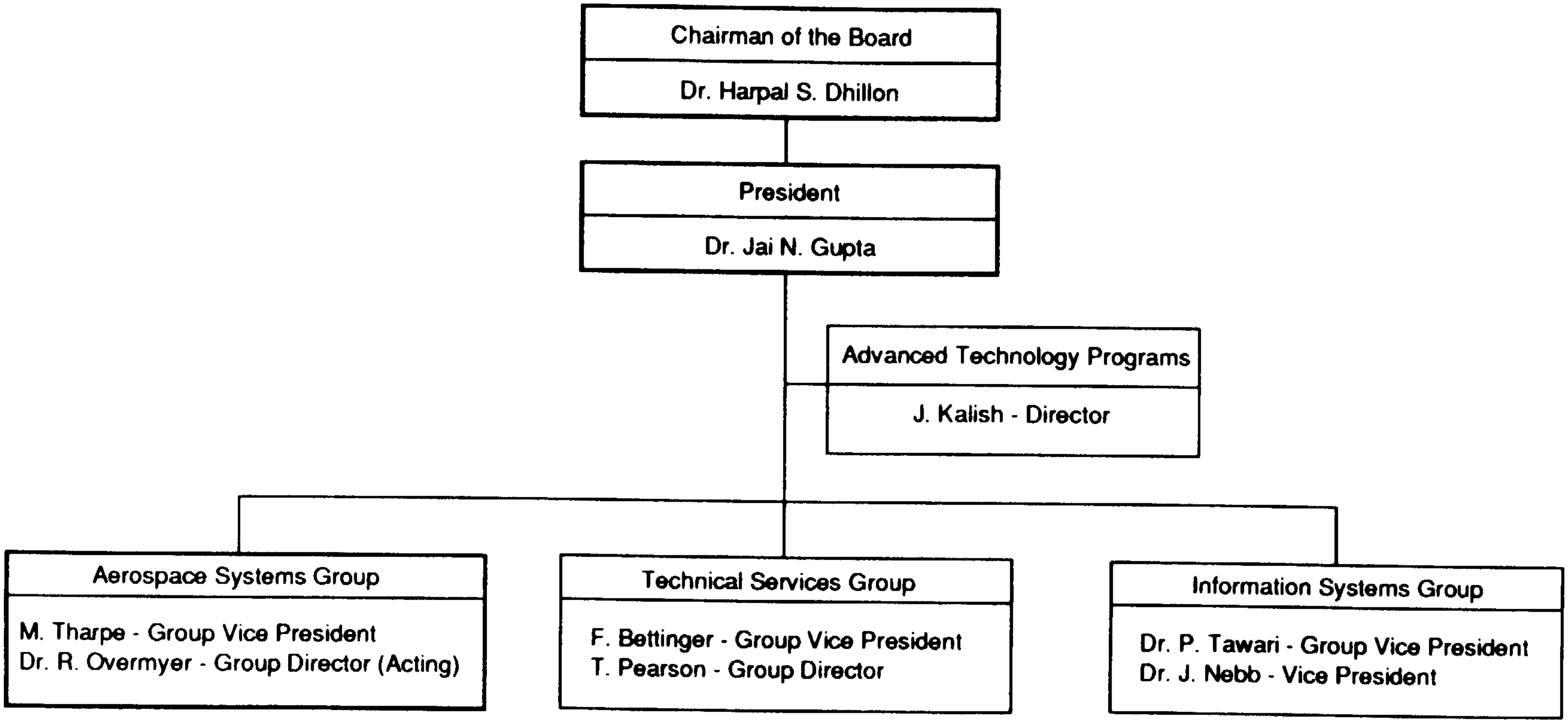

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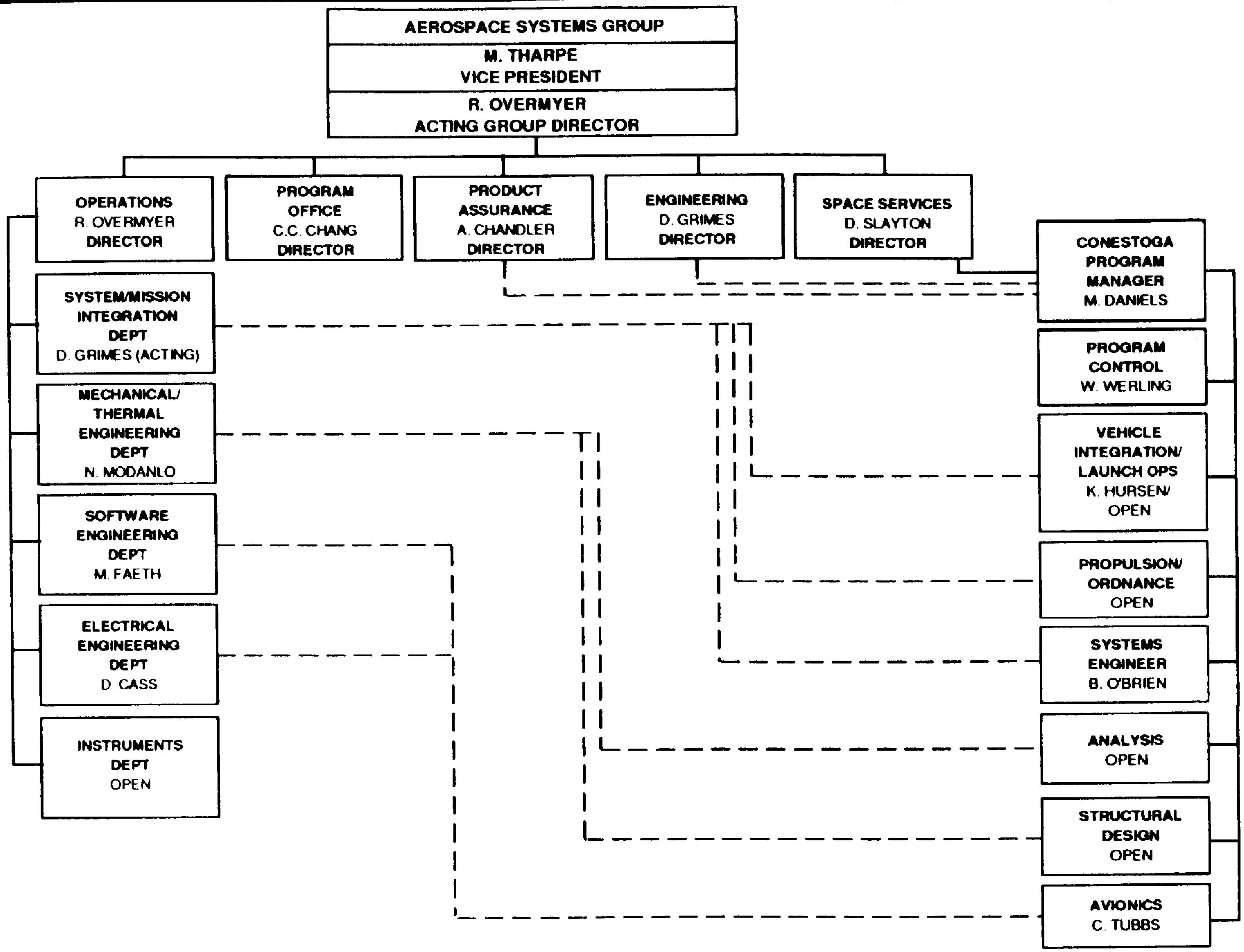
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ANALYSIS OPEN
STRUCTURAL DESIGN OPEN
AVIONICS C. TUBBS

Small Orbital/Suborbital Commercial Launch Services

- Launch Vehicle Design, Analysis, and Development
- Launch Vehicle Integration
- Spacecraft to Launch Vehicle Integration and Test
- Launch Services

Small Spacecraft and Suborbital Payloads

- System/Subsystem Design, Analysis, Fabrication, Assembly, Integration and Test
- Ground Support Equipment Development

- Bid USAF STEP as Prime
  - — Designed Small Spacecraft
  - — Made Best and Final
- Bid TOMS Spacecraft With Ball Aerospace
- Bid OCDS (SeaWiFS) Spacecraft With SCI
- Bid NASA/GSFC SELV Launch Services/Did Not Make Cut
- Bid Launch Services for Iridium
- Bid Launch Services for OCDS
- Bid Other Commercial Systems and Launches

- First Private Sector Space Launch in the World
- Marketing Conestogas Internationally Since 1982
- One of the Three Finalists in 1984 DOC Landsat Commercialization RFP
  - Managed Team of Major Aerospace Companies
  - Proposed and Sold Conestoga as Launcher
- First DOT Mission Approval – 1985
- $17 Million Invested in Conestoga Designs
- First Agreement to Use U.S. Government Range as a Commercial Launch Site (Wallops, 1986)
- Awarded One of Four DARPA SSLV Contracts – May 1988
- First Commercial Sounding Rocket Launch in U.S., Starfire I Launched March 29, 1989 at WSMR
- Acquired by EER Systems – November 1990
- EER Systems/Space Services Won COMET Competition December 1990
  - Three Firm Launches: September 1992, August 1994, June 1995
  - Two Optional Launches: June 1996, June 1997
  - Launch Specification – 818 kg (1800 lb) in 555 km (300 nmi), 40 Degree Circular Orbit

1982 Launch

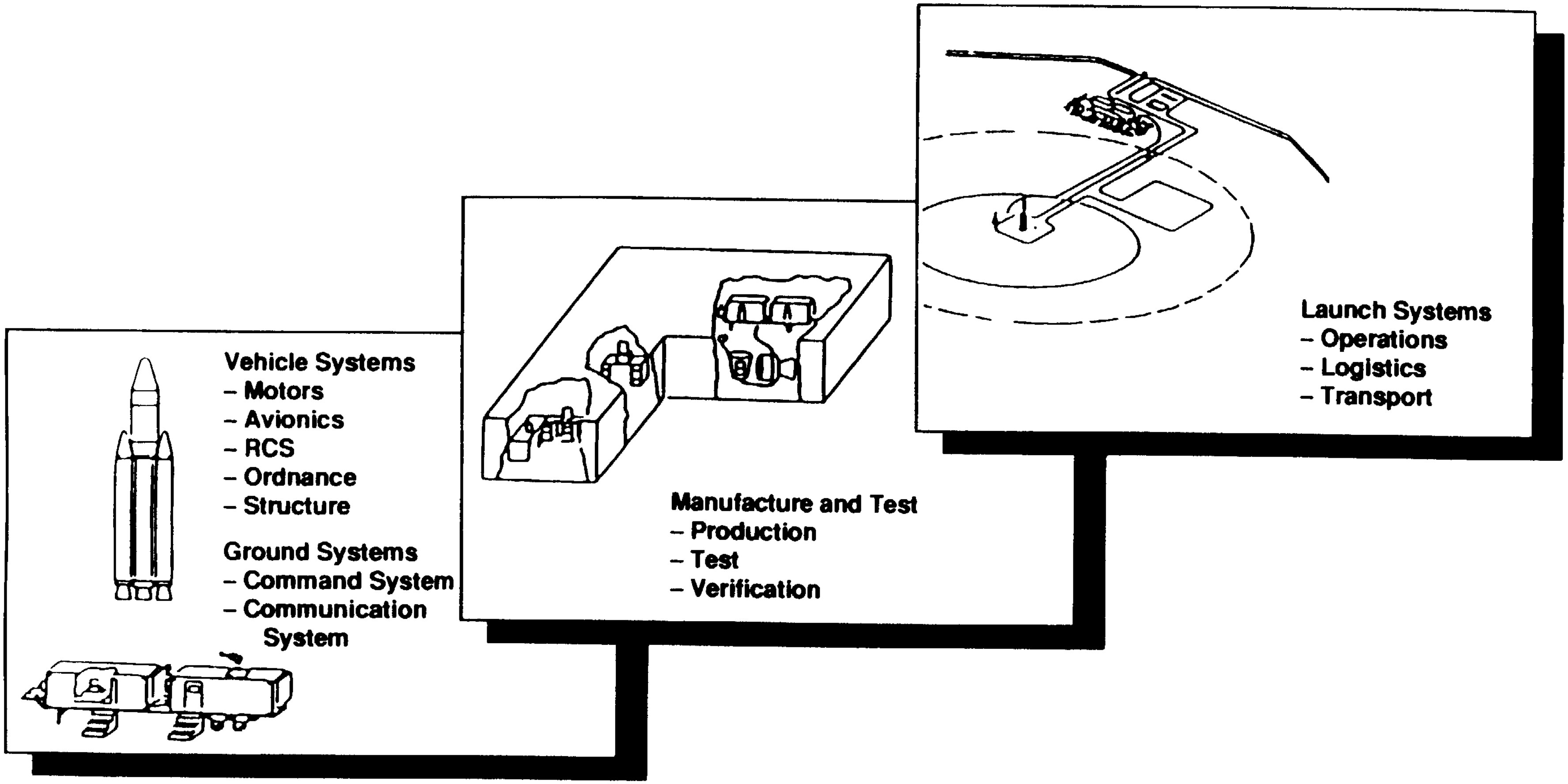
- Ability to Finance in Private Sector
- Ability to Obtain Necessary Government Approvals
- Selected and Managed Contractor Team
- Selected, Surveyed, and Constructed Launch Site
- Maintained an Expedited Schedule
- Established and Implemented Industry Standard
  - Design Review Procedures
  - Quality Assurance Procedures
- Maintained Commitment to Excellence
- Performed Own Range Safety
- 100% Successful Demonstration of Company's Launch Concepts
- Demonstrated Ability to Go Orbital

Starfire 1989 Launch

- Acquired DOT Launch License
- Acquired DOT-Required Liability Insurance
- Acquired DOT Authorization for Commercial Shipping of Solid Rocket Motors
- Acquired FCC Approval for Radio Frequency Usage
- Established Government Support Memoranda of Understanding With DOD and NASA
- Established, Integrated, and Managed a Highly Professional Program Engineering and Operations Team
- Conducted Commercial Launch Operations From a DOD Range in Total Compliance With Range Safety, Security, and Operations Requirements
- Conducted Fast-Track, Schedule-Driven, 100% Successful Mission – Launched Ahead of Schedule, 5 Months from Receipt of Contract, and Met All Mission Objectives
- Completed Mission Within Budget on a Fixed Price Contract

- Minimize Development Cost
  - Flight-Proven Hardware
- Minimize Recurring Cost
  - Volume Production
  - Turnkey Commercial Approach
- Maximize Reliability
  - Proven Components
  - Experienced Management
  - Experienced Subcontractors
  - Mature Reliability and QA

Commercial Launch Services

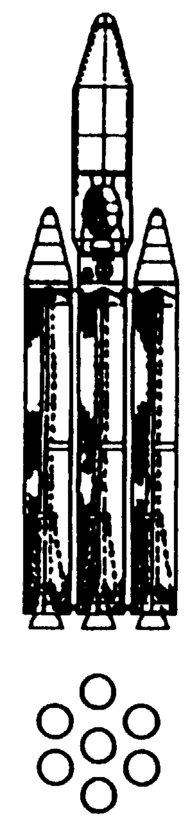


Structure	Avionics	Safety	Software	
Vehicle Pad GSE	Vehicle GSE	Vehicle Ground Range	Flight Ground	Integrated Test and Verification

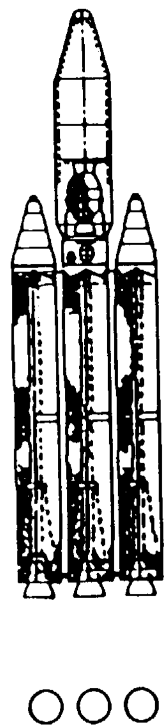
Turnkey Launch Services

- Fixed Price Option
- Launch Vehicle
- Launch Site and Modifications
- Liability Insurance
- Mission Control
- Mission Planning
- Payload Integration
- Launch Operations
- Range Safety
- Payload Control (Options)
- Postmission Analysis

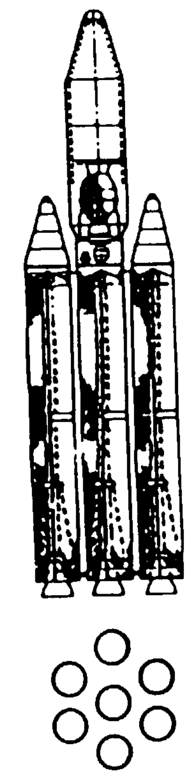
- Utilizes Only Two SRM Types (CASTOR and Star)
- Adaptable to Wide Payload Range
- Yields Volume Production Efficiencies
- Utilizes Modular Elements
- Utilizes Common Hardware
- Requires Only One Interstage for a Variety of Missions
- Minimizes Total Program Costs
- Provides Enhanced Vehicle Stability
- Minimizes Technical Risk
- Minimizes Schedule Risk
- Accommodates Advanced Technology Growth
- Accommodates Performance Growth Easily



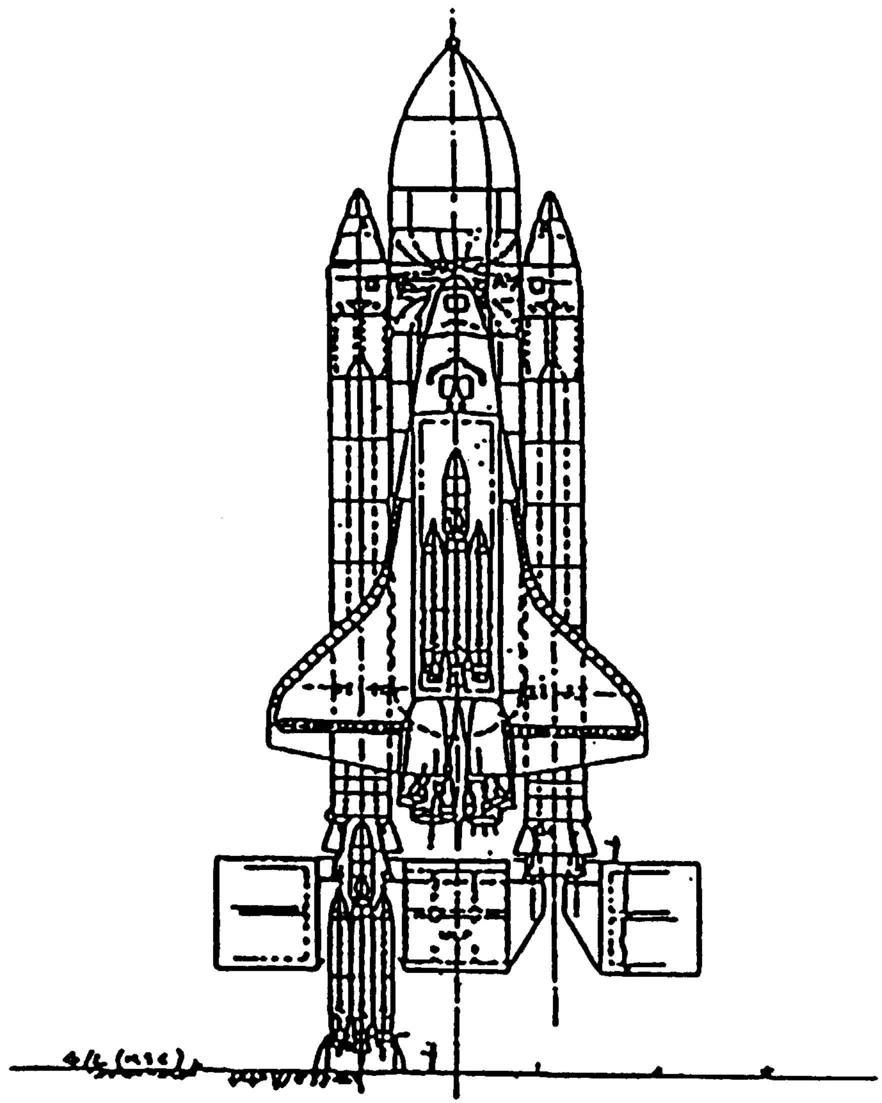
Conestoga 421-48 Is a Growth Version of Conestoga 210-48



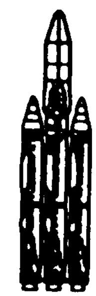
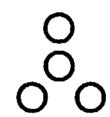
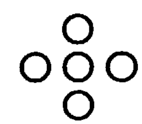
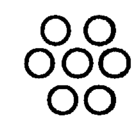
Conestoga 210-48
400 lb
400 nm Polar



Conestoga 421-48
1500 lb
400 nm Polar

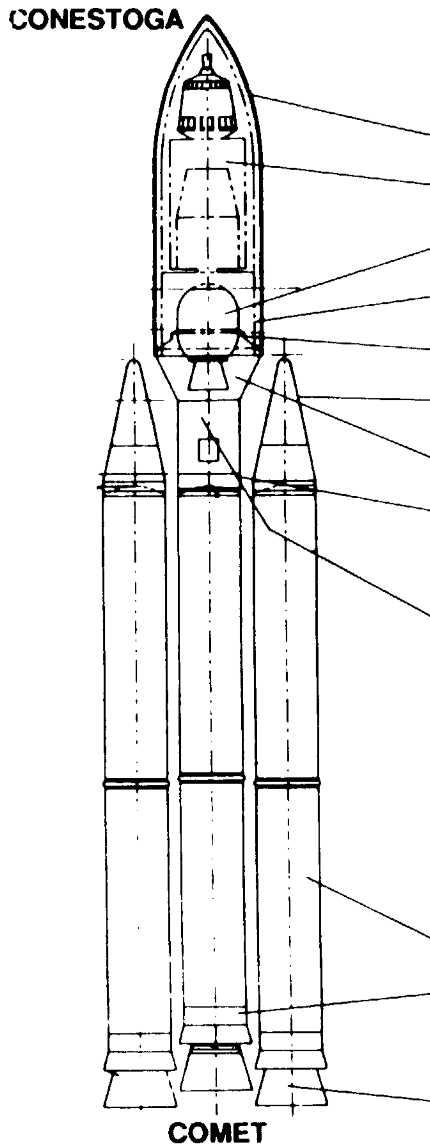


CASTOR IVB-BASED CONESTOGA VEHICLES

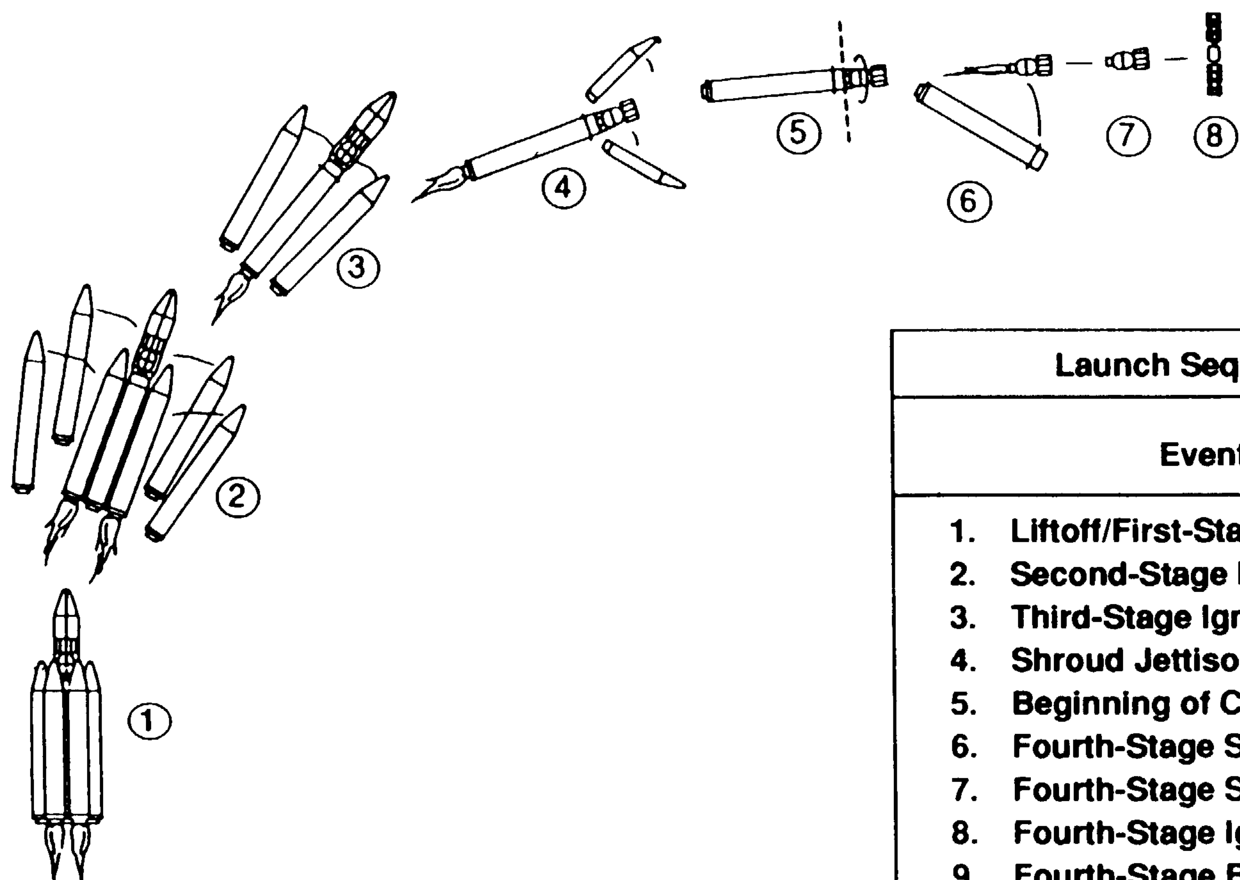
	Conestoga 210-48	Conestoga 310-48	Conestoga 221-48	Conestoga 421-48B
				
Payload Weight* to Orbit	lb (kg)	lb (kg)	lb (kg)	lb (kg)
200 nm Circ., 37° inclination	650 (295)	1100 (499)	1500 (680)	2800 (1270)
400 nm Circ., 90° inclination	420 (190)	650 (295)	905 (410)	1570 (712)
Geosynchronous Transfer	160 (73)	250 (113)	550 (250)	970 (440)
GEO Orbit (Estimated)	80 (36)	115 (52)	275 (125)	485 (220)
Motor Configuration 10:1 Nozzles				
Stage 1	2-CASTOR IVBs	3-CASTOR IVBs	2-CASTOR IVBs	4-CASTOR IVBs
Stage 2	1-CASTOR IVB	1-CASTOR IVB	2-CASTOR IVBs	2-CASTOR IVBs
Stage 3	1-Star 48B	1-Star 48B	1-CASTOR IVB	1-CASTOR IVB
Stage 4	--	---	1-Star 48B	1-Star 48B

*Spacecraft total weight (GTO figures include apogee kick stage weight)

EER SYSTEMS



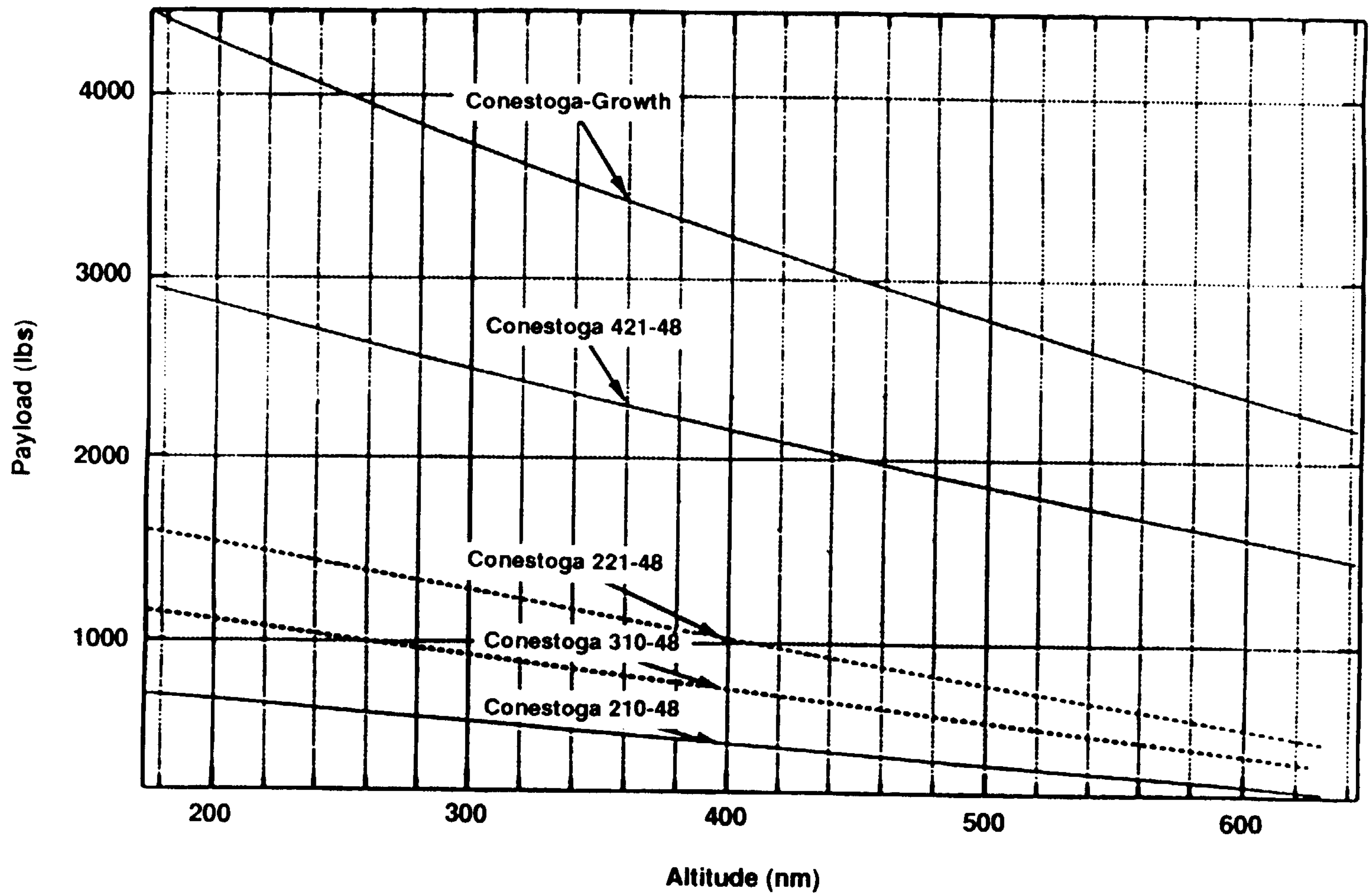
Area/Process	No. Flt	Responsibility		Remarks
		Design	Manufacture	
Payload Fairing	1	MDSC	MDSSC	Tracor – Alternate
Payload (Various)	1	Customer	Customer	
Star 48 TVC	1	Thiokol	Thiokol	
Star Separation System	1	EER/Tracor	MDSC/Tracor	TVC Star for Future
RCS	1	DSI	DSI	
Nose Cones (Strap On)	6	Thiokol	Thiokol	
Interstage Structure	1	EER	General Dynamics	Tracor – Alternate
Attachment H/W (Upper)	6	MDSC		Thiokol – Alternate
FWD Thrust Ring (Core)	1	EER	General Dynamics	Thiokol – Alternate
Avionics	1	—	—	
Power Dist. System	1	EER	EER	
GN&C (IGU & Control)	1	Canavco	Canavco	
Telemetry System	1	DSI	DSI	
Thrust Termination	8	EER	EER	
Flight Software	1	Intermetrics	Intermetrics	
Castor IVB Motors	7	Thiokol	Thiokol	
Attachment H/W (Lower)	6	MDSC	MDSC	Thiokol – Alternate
Aft Thrust Ring	1	EER	General Dynamics	Thiokol – Alternate
TVA	5	Thiokol	Thiokol	



Launch Sequence of Events	
Event	Time (sec)
1. Liftoff/First-Stage Ignition	0
2. Second-Stage Ignition	55
3. Third-Stage Ignition	110
4. Shroud Jettison	120
5. Beginning of Coast Phase	169
6. Fourth-Stage Spin-Stabilized	650
7. Fourth-Stage Separation	655
8. Fourth-Stage Ignition	660
9. Fourth-Stage Burnout	724
10. Payload Separation	729

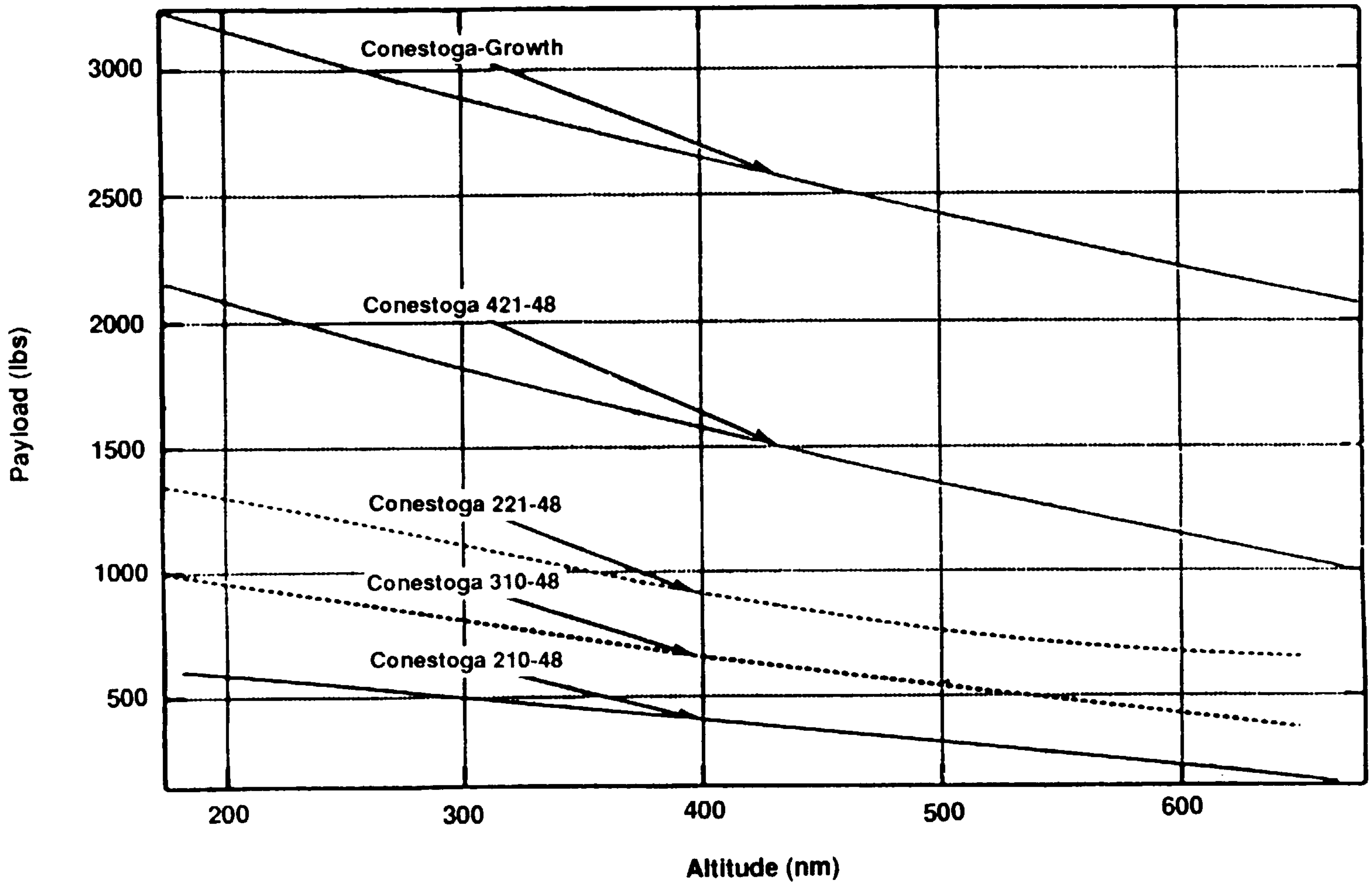
BASELINE VEHICLES

Circular Orbits, 37° Inclination



BASELINE VEHICLES

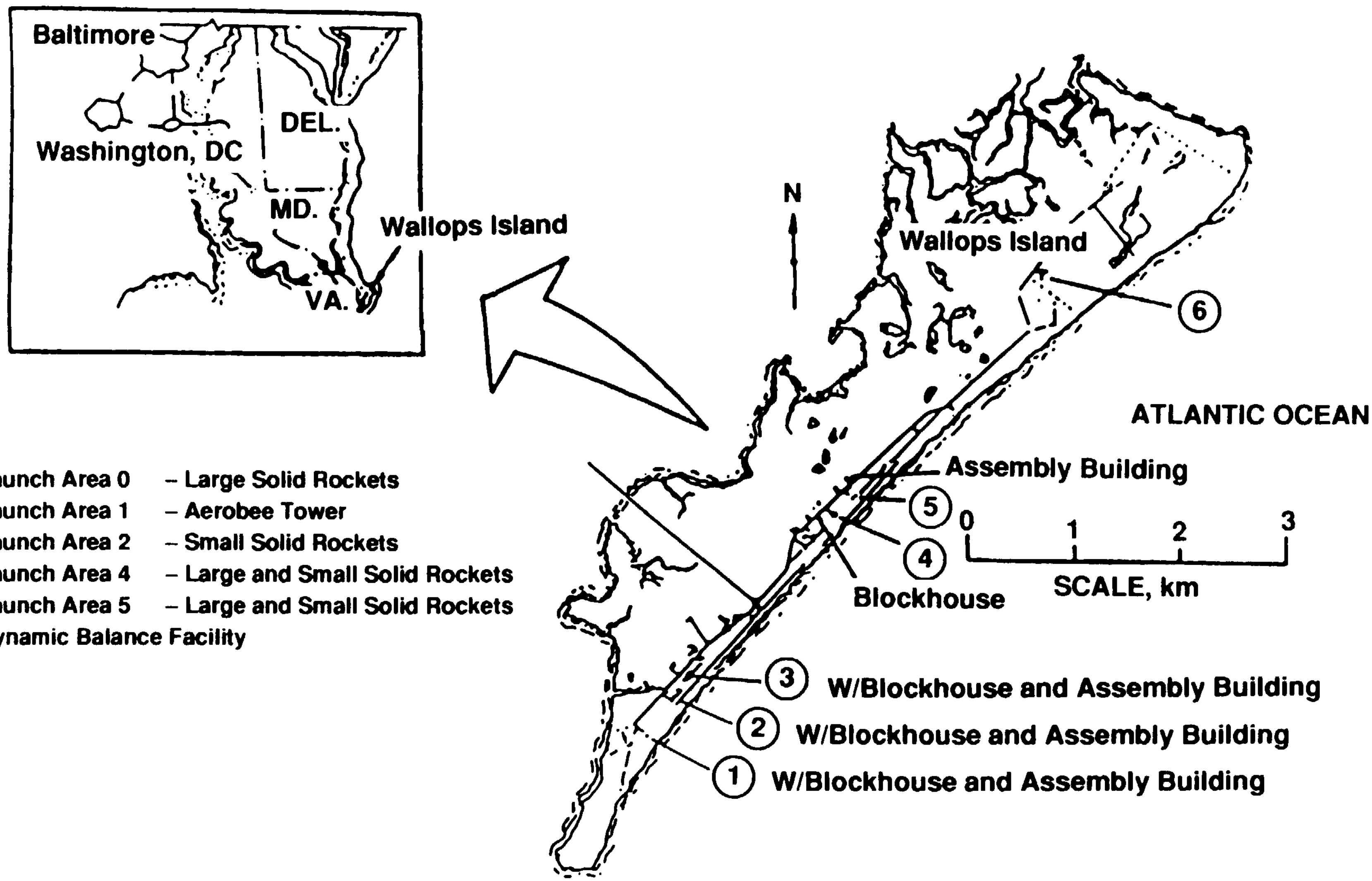
Circular Orbits, 90° Inclination



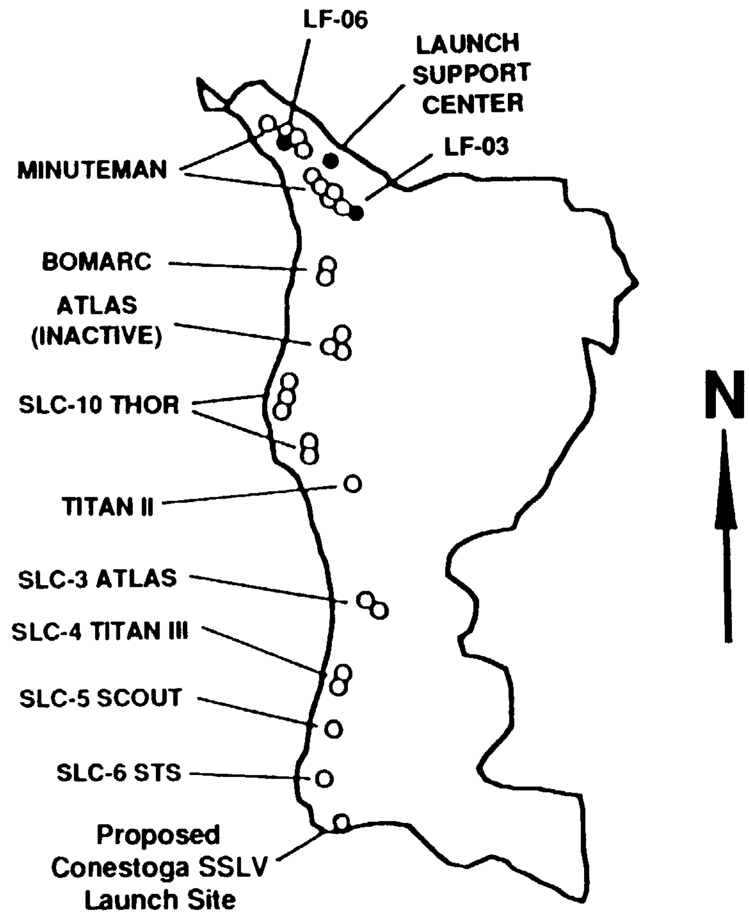
Conestoga Launch

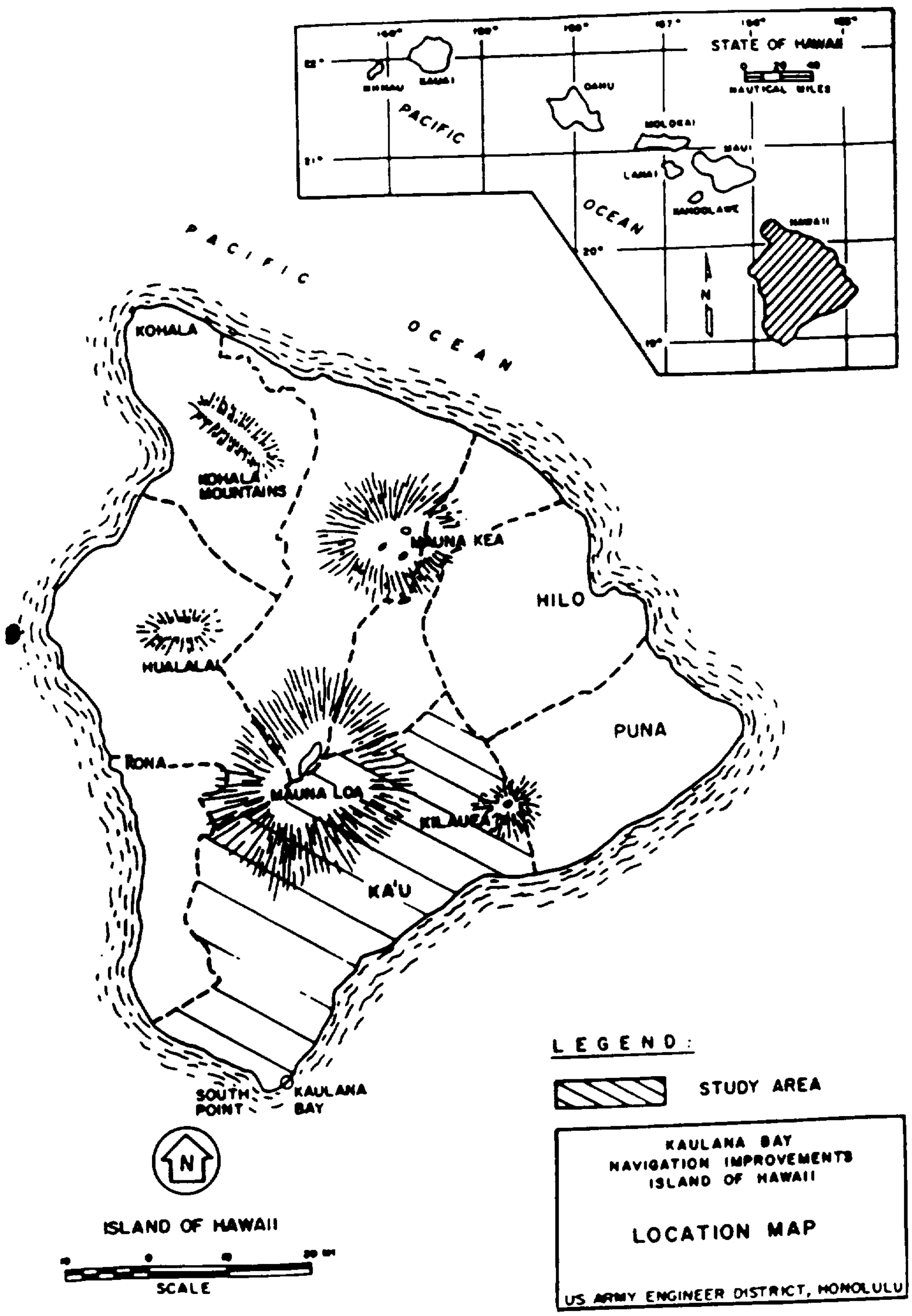
Agreements

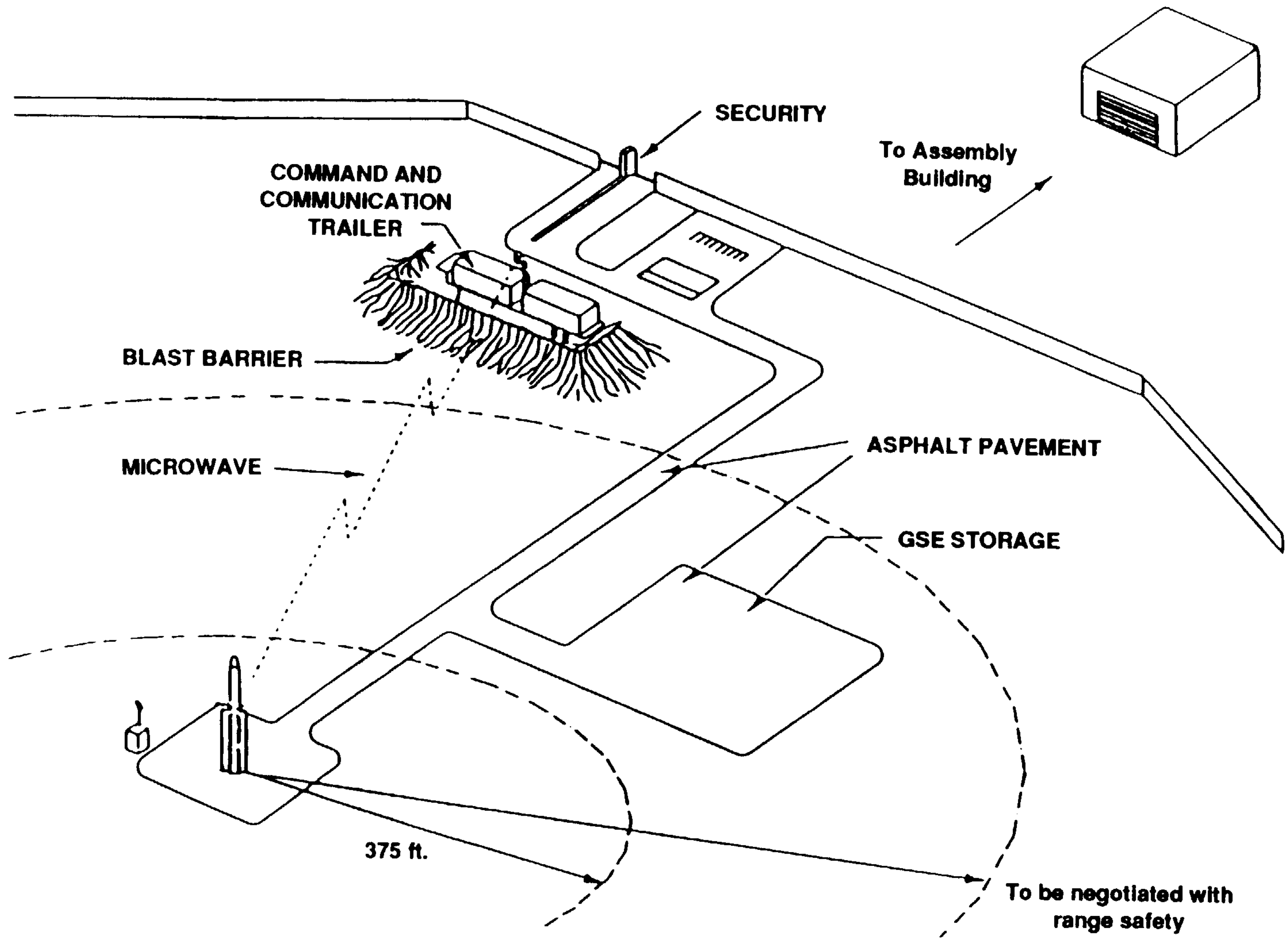
- Government Interagency Interactions With
  - Department of Commerce
  - Department of Defense
  - NASA
  - Department of Transportation
- Launch Site Agreements Exist With
  - Wallops Island, VA
  - White Sands Missile Range, NM
- Negotiating Memoranda Exist With
  - Western Test Range (VAFB, CA)
  - Eastern Test Range (PAFB, FL)
- Preliminary Investigations Regarding
  - Hawaii
  - San Marco Island, Kenya
  - Kourou, French Guinea
- Licenses Obtained for the Consort Starfire Program



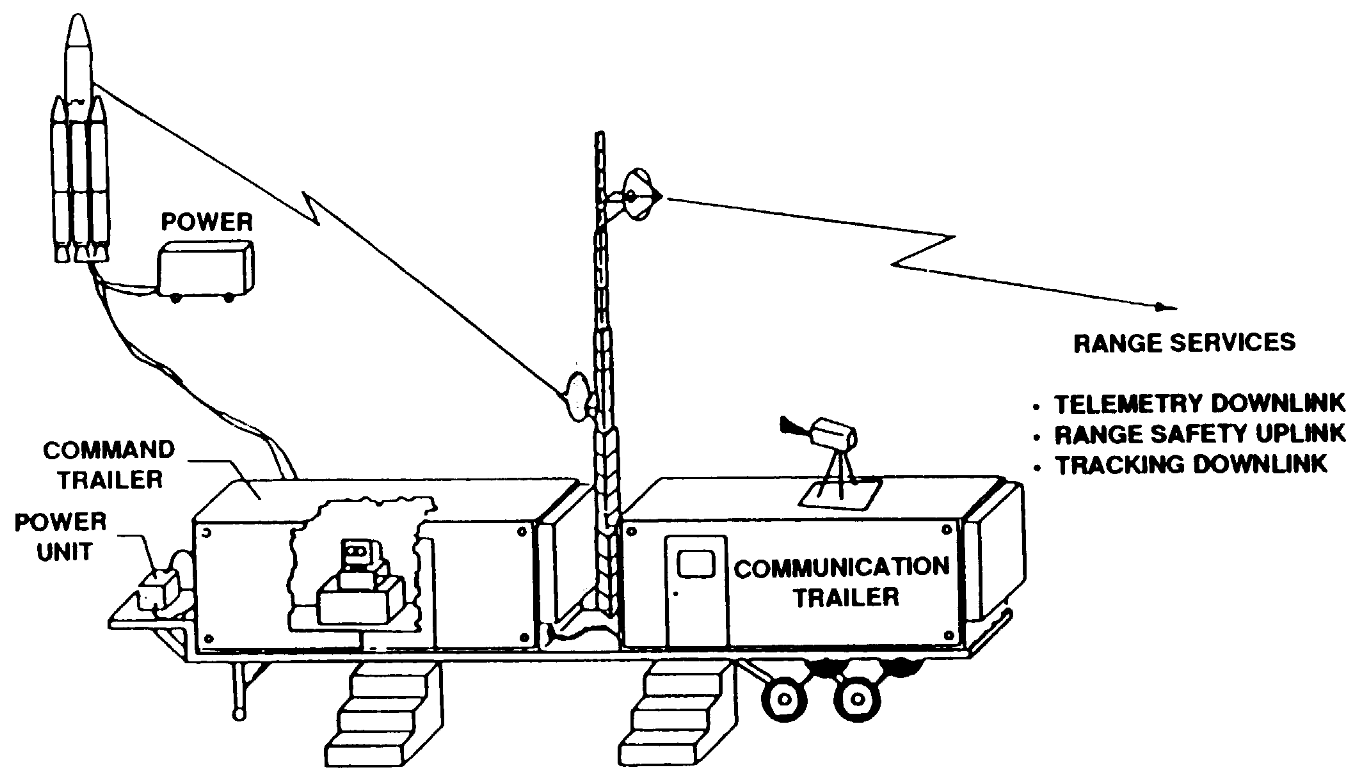
1. Launch Area 0 – Large Solid Rockets
2. Launch Area 1 – Aerobee Tower
3. Launch Area 2 – Small Solid Rockets
4. Launch Area 4 – Large and Small Solid Rockets
5. Launch Area 5 – Large and Small Solid Rockets
6. Dynamic Balance Facility


LF-06
LAUNCH SUPPORT CENTER
LF-03
MINUTEMAN
BOMARC
ATLAS (INACTIVE)
SLC-10 THOR
TITAN II
SLC-3 ATLAS
SLC-4 TITAN III
SLC-5 SCOUT
SLC-6 STS
Proposed Conestoga SSLV Launch Site
N

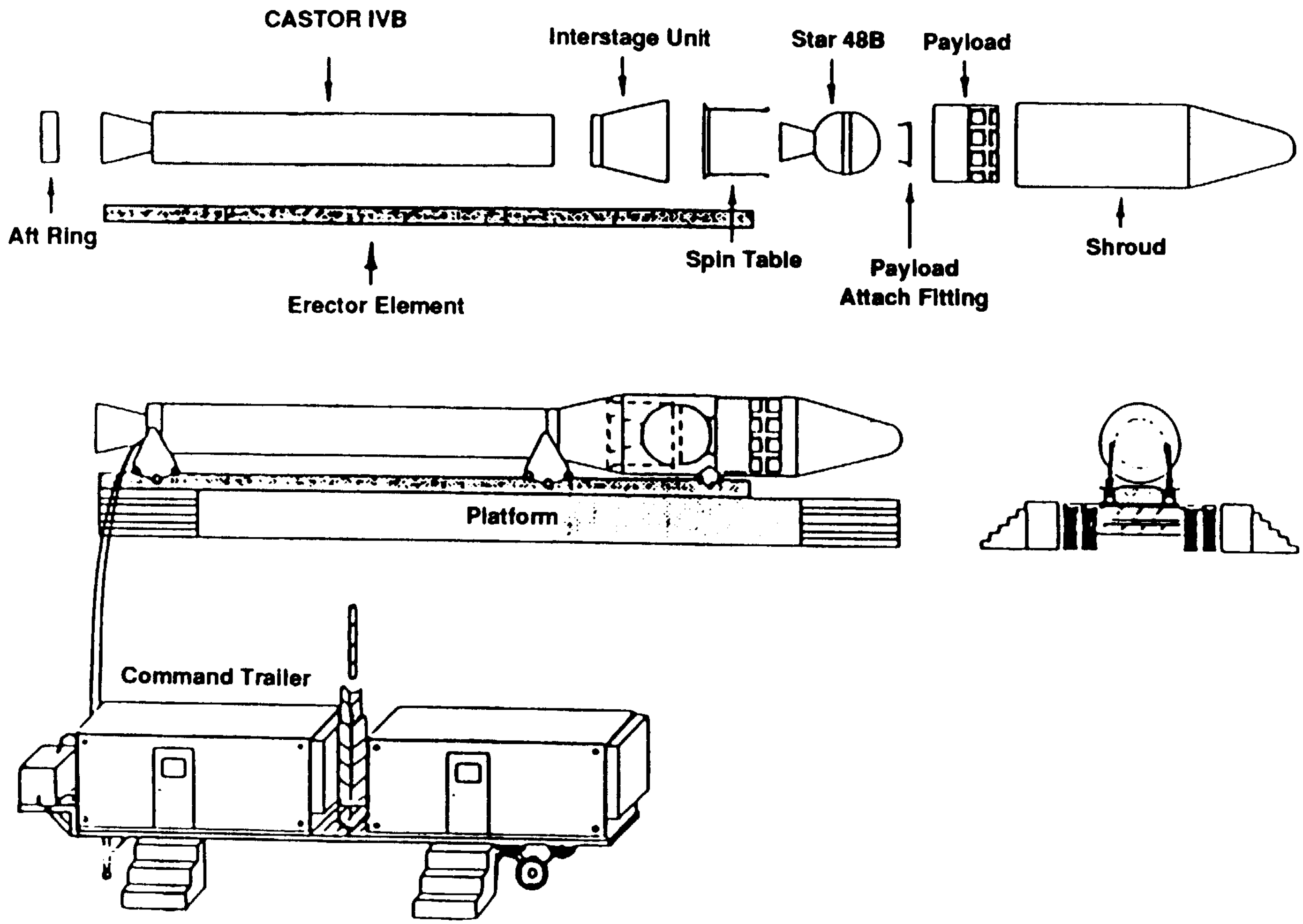

STATE OF HAWAII
NAUTICAL MILES
NIIHAU
KAUAI
OAHU
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
PACIFIC
OCEAN
N
PACIFIC OCEAN
KOHALA
KOHALA MOUNTAINS
MAUNA KEA
HILO
HUALALAI
KONA
MAUNA LOA
KILAUEA
PUNA
KA'U
SOUTH POINT
KAULANA BAY
N
ISLAND OF HAWAII
SCALE
LEGEND:
STUDY AREA
KAULANA BAY
NAVIGATION IMPROVEMENTS
ISLAND OF HAWAII
LOCATION MAP
US ARMY ENGINEER DISTRICT, HONOLULU


SECURITY
To Assembly Building
COMMAND AND COMMUNICATION TRAILER
BLAST BARRIER
MICROWAVE
ASPHALT PAVEMENT
GSE STORAGE
375 ft.
To be negotiated with range safety

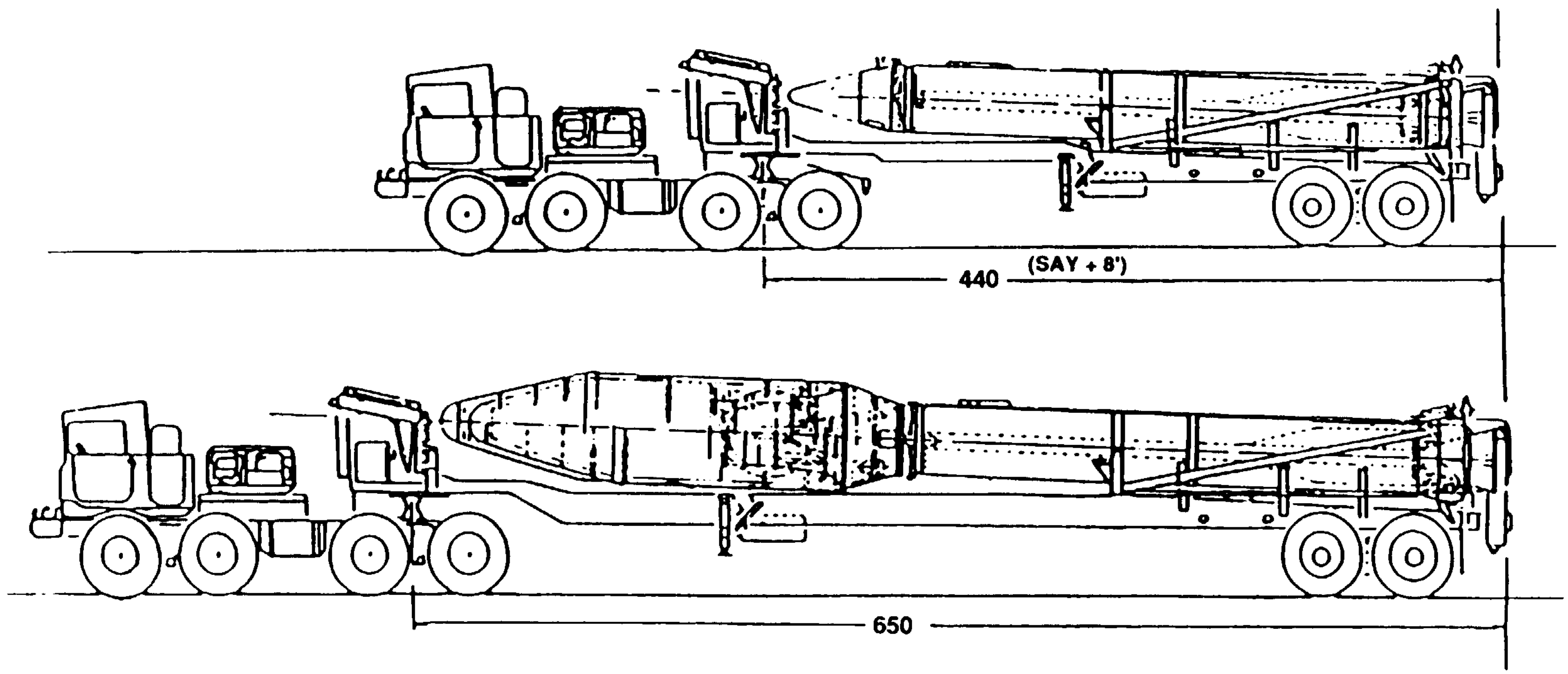
LAUNCH CONTROL SYSTEM



ASSEMBLY CONCEPTS

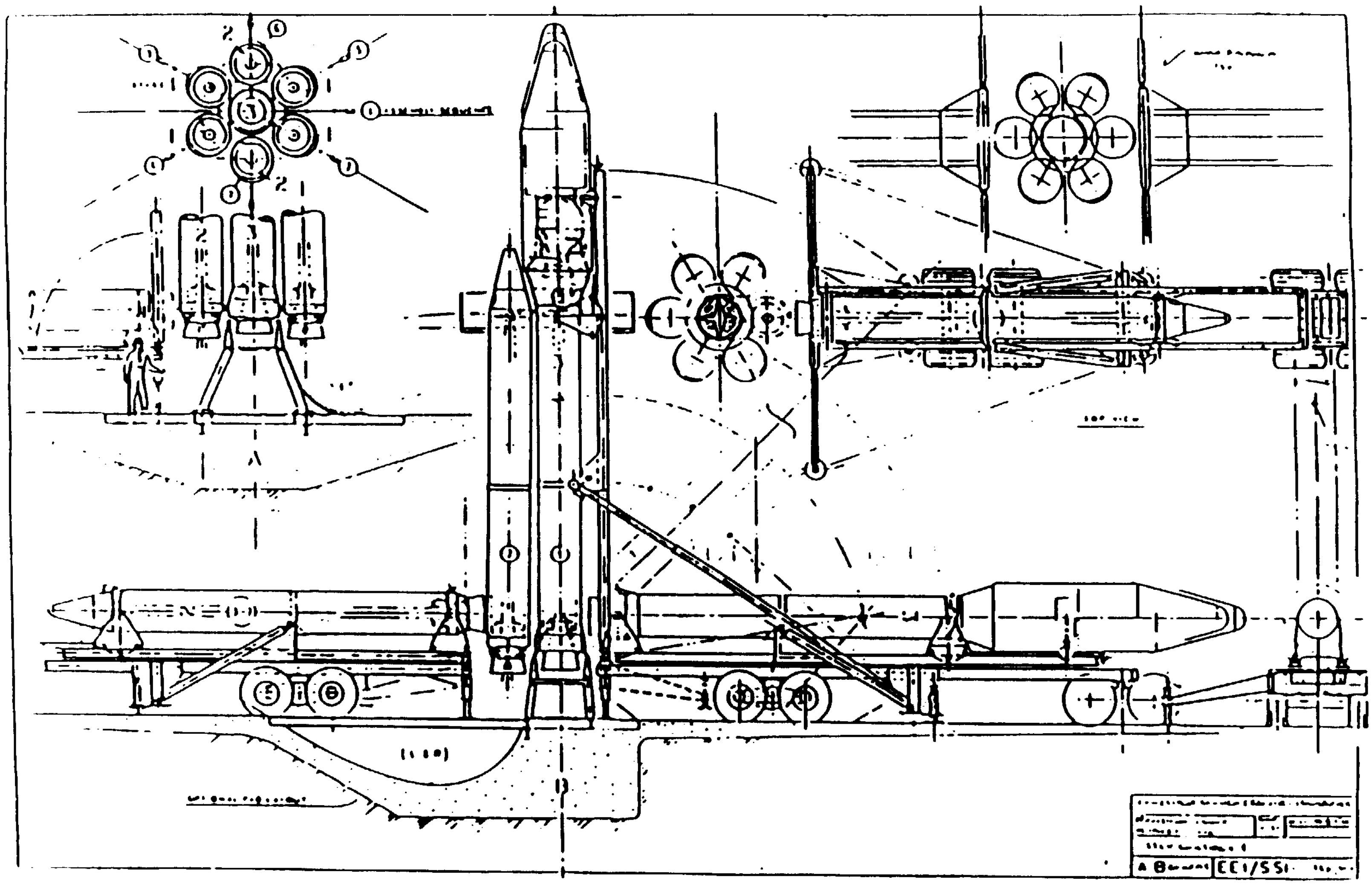


MOVE TO LAUNCH PAD

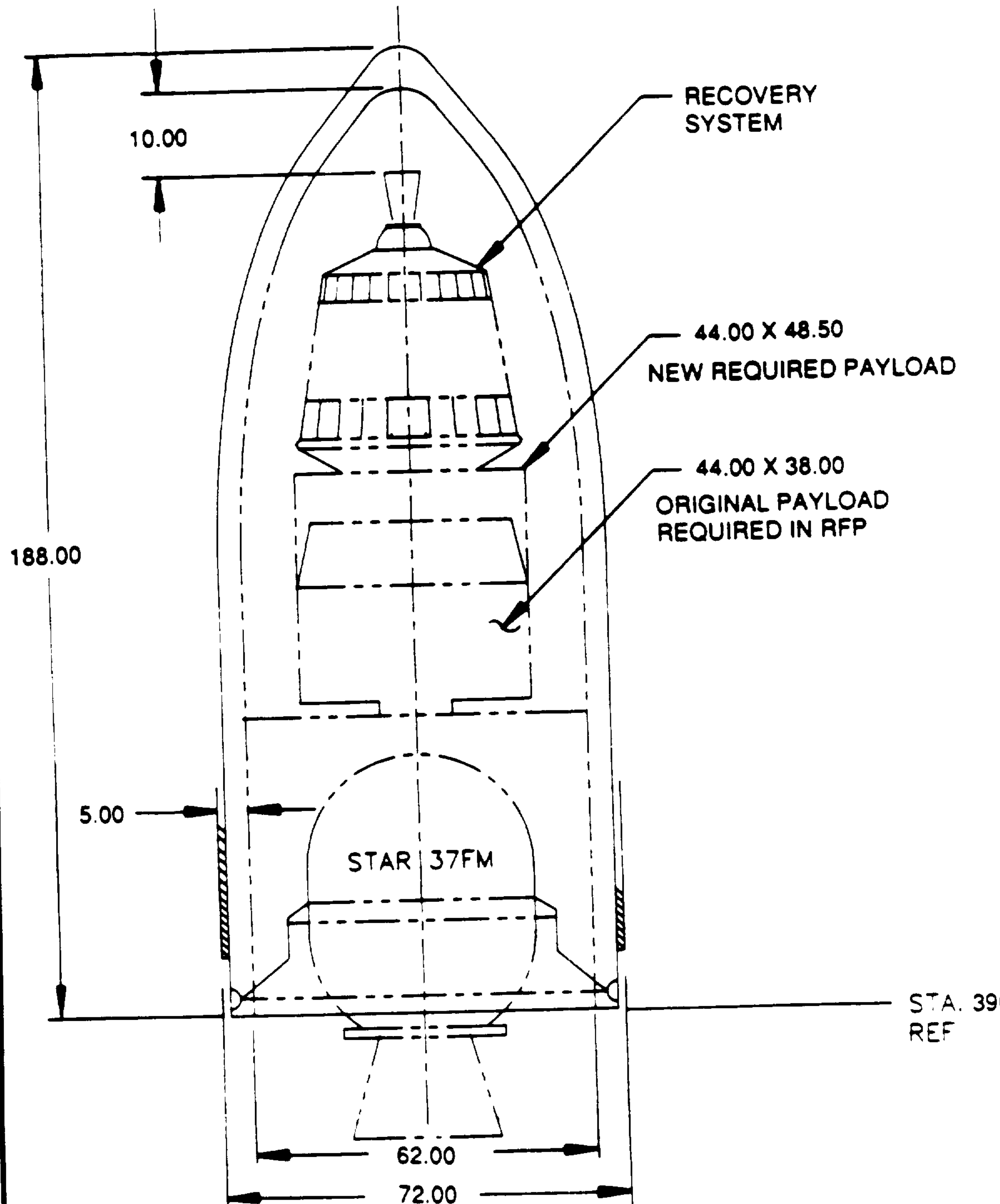


C-2

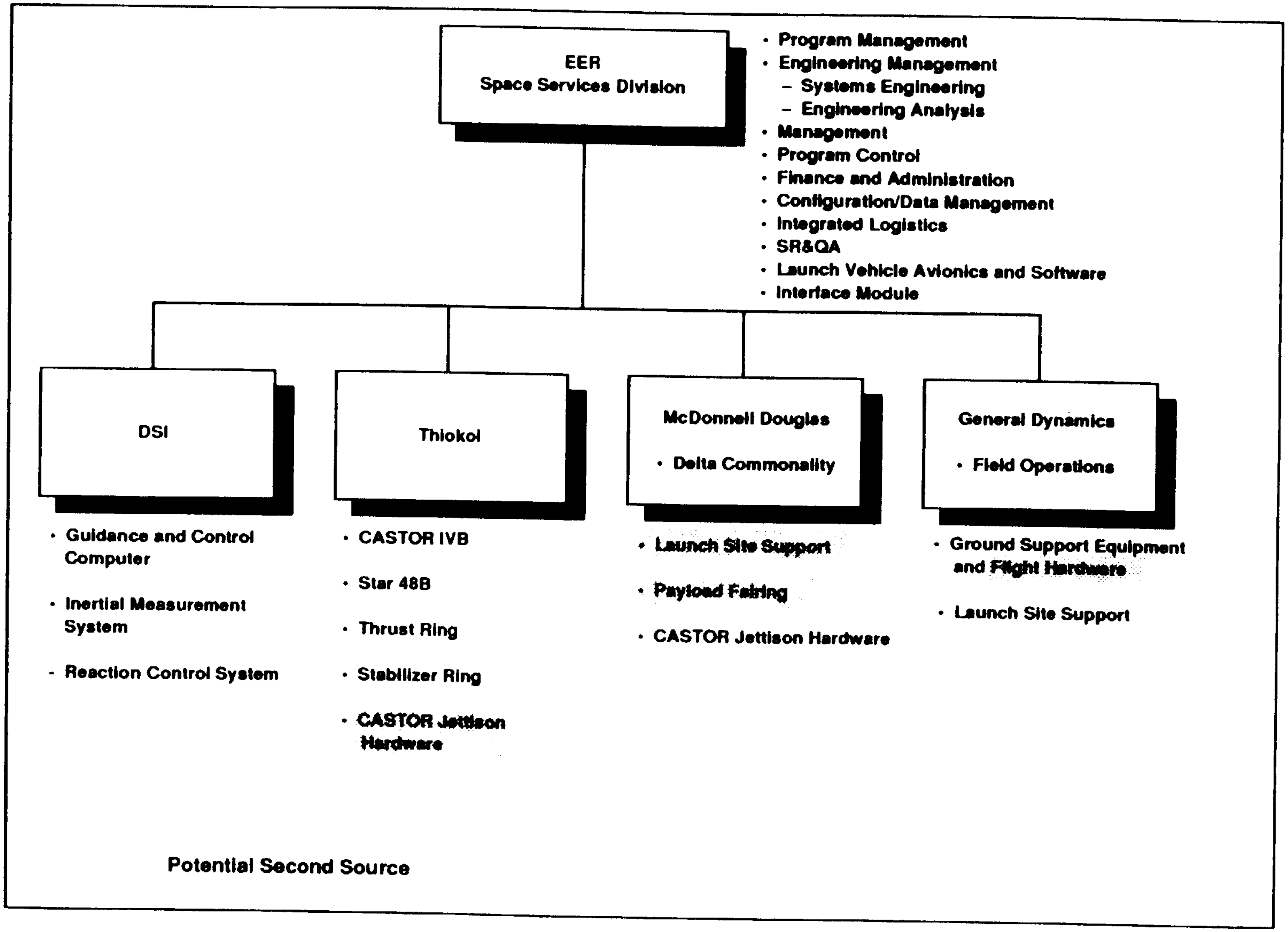
VEHICLE ASSEMBLY CONCEPT



CONESTOGA 421-37FM FAIRING ENVELOPE



Conestoga Team for COMET



Conestoga Services

- "Managed" Team Approach
- Optimized Flight-Proven Hardware
- Optimized Teaming/Subcontracts
- Minimum Technical Risk
- High Confidence Cost and Schedule
- High Confidence Launch Success Rate
- Range Experienced Operations Personnel
- Flexible Payload Weight/Altitude Range
- Fixed Price Commercial Approach

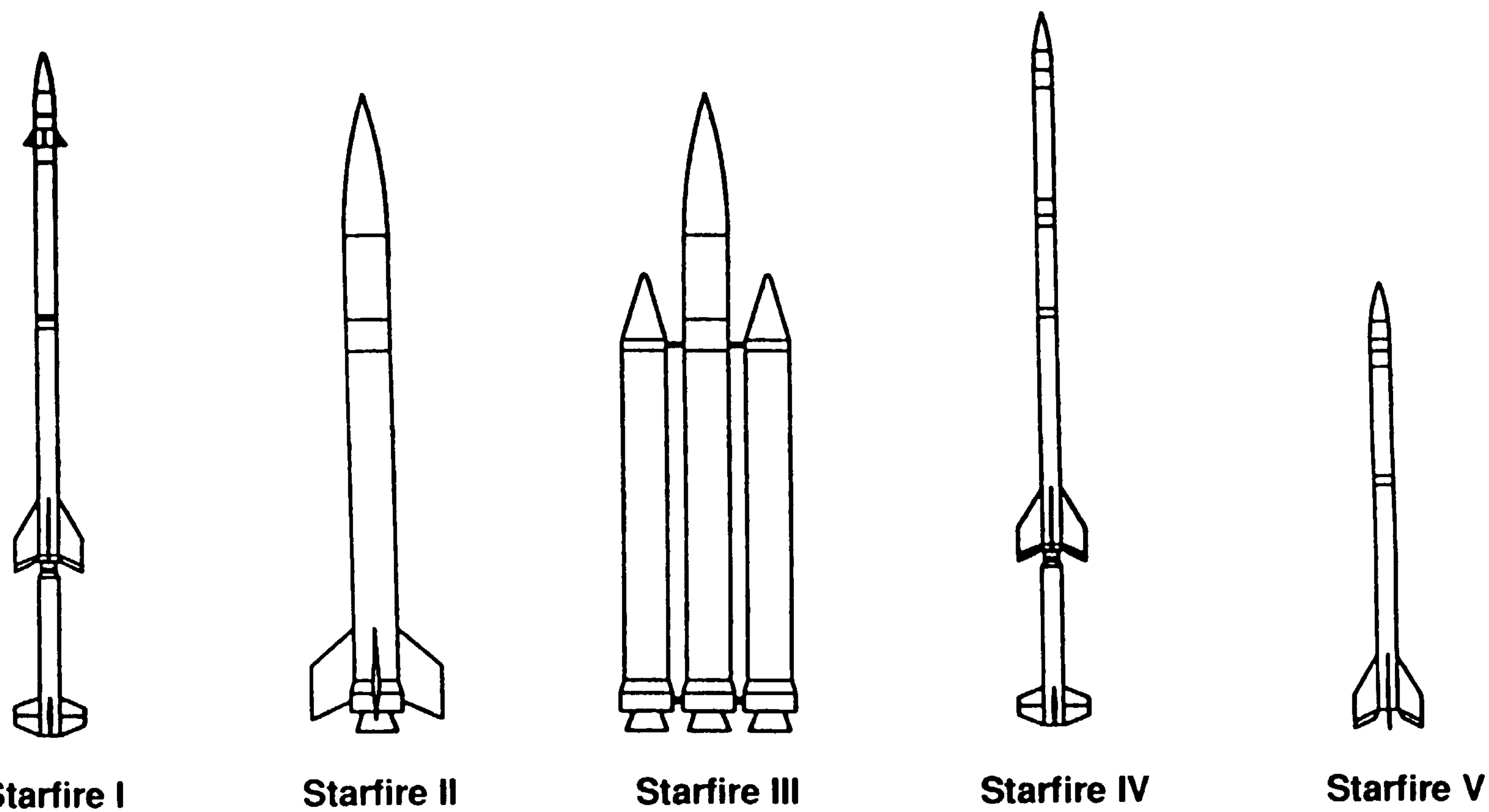
- Payment Schedule
  - Cost of Money, Financing Requirement
- Mission and Payload Schedule
  - Size of Vehicle, Unique Equipment
- Order Volume
  - Economies of Scale
- Delivery Schedule
  - Carrying Costs, Long-Lead Orders

- $17M Invested in Conestoga Pre-COMET by SSI
- $20M Nonreimbursed Nonrecurring Costs Prior to First Flight by EER Systems
- First Flight Costs Far in Excess of Requested Budget
- Fixed Price Contract
- 11 Percent Recovery of Nonrecurring From COMET

Budgetary Concerns

- Estimate 50-100 Percent Increase in Reflight Insurance
- Accelerated Fast Track Schedule
- Continued Pressure to Cut Budget

Starfire Sounding Rockets



Starfire I

1400 lbs max payload* weight to 126 nm

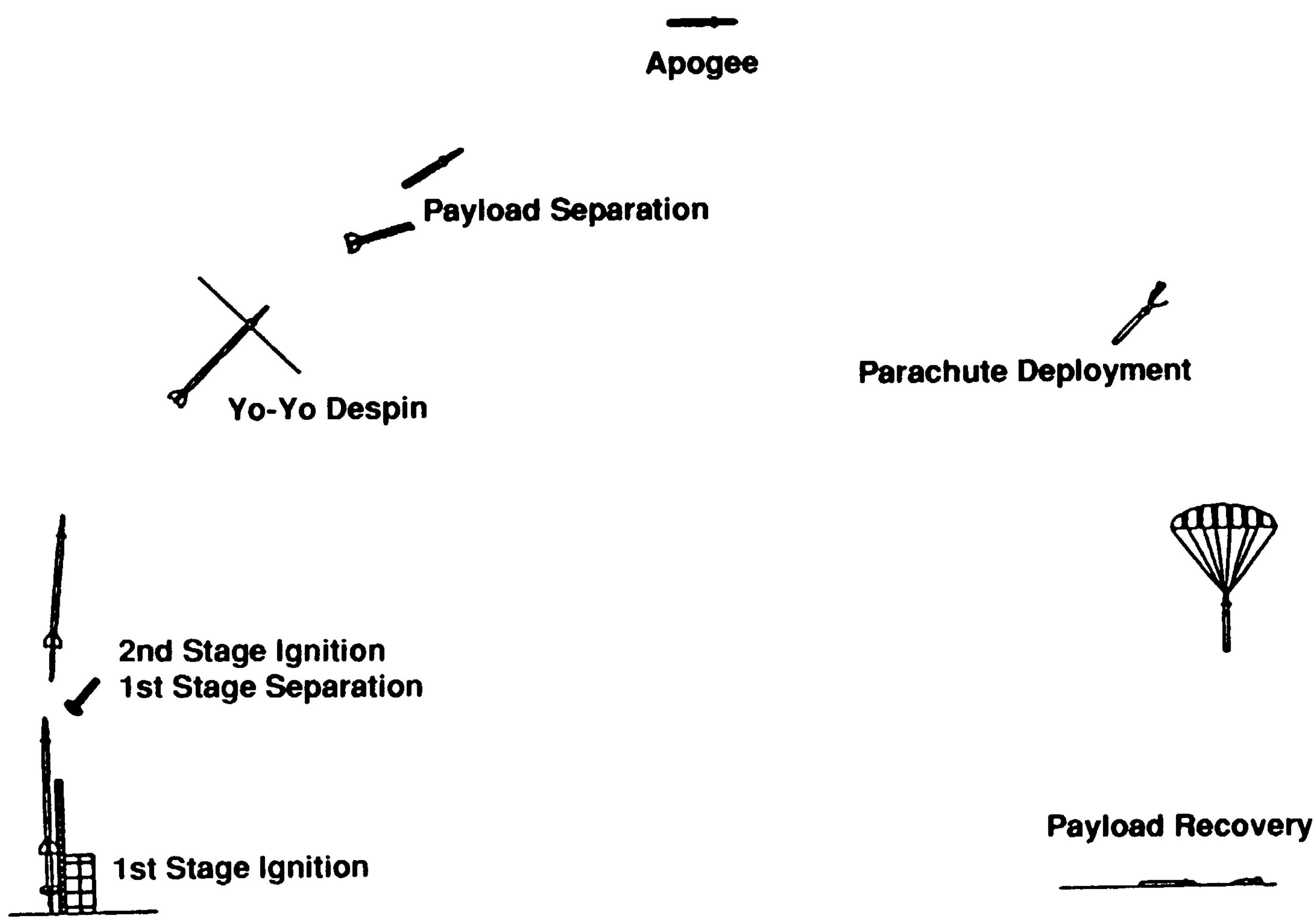
260 nm max altitude with 600 lb payload

10.8 max G (1000 lb payload)

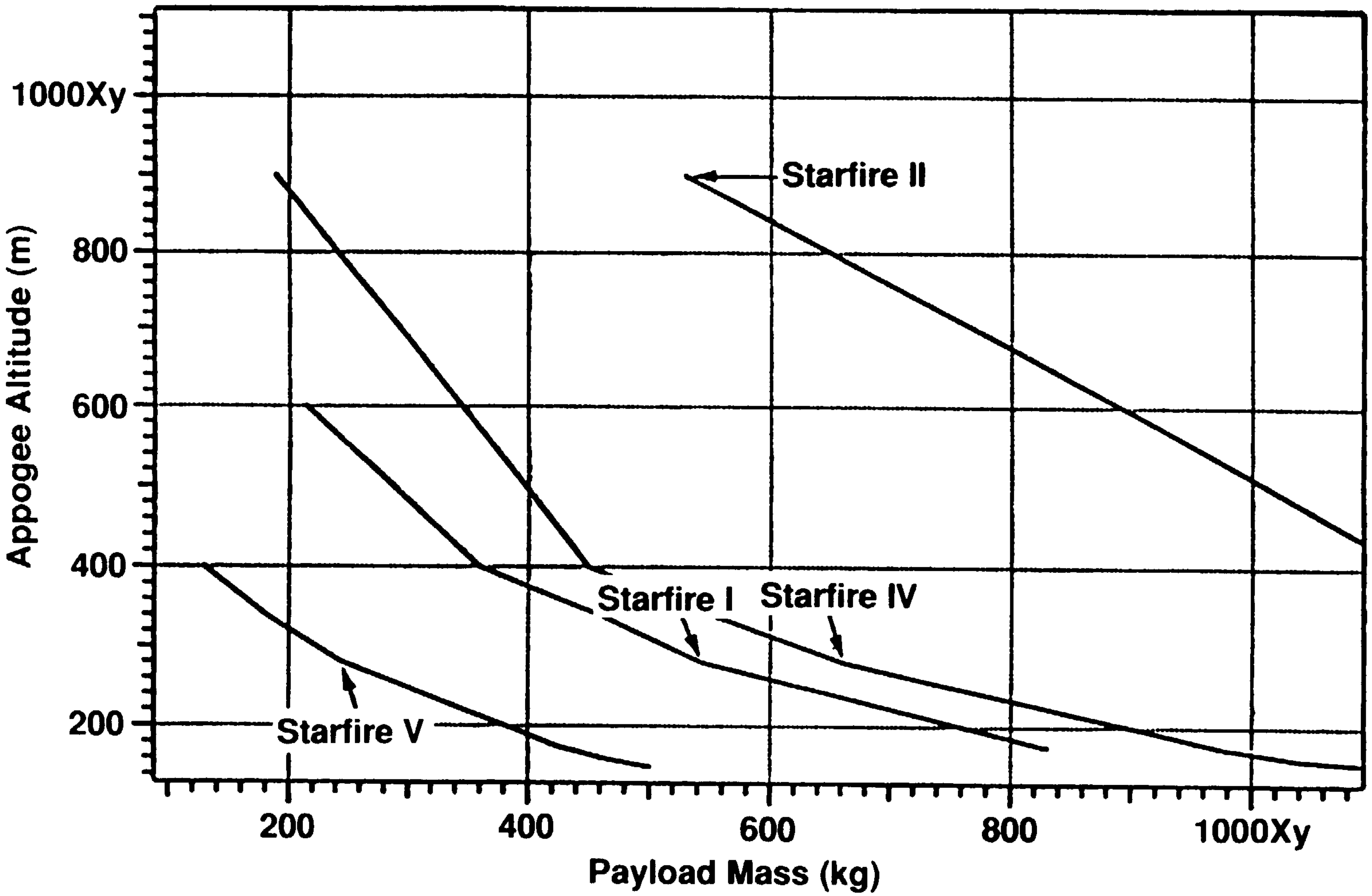
Configuration: TX 664-4, Black Brant VC
(Advanced Terrier-Black Brant)

*Payload is all hardware above Black Brant forward case joint.

Mission Sequence of Events



Standard Sounding Rockey Program
Starfire Vehicle Comparision
Altitude vs. Payload Mass



Summary

- **EER Systems Has an Established Systems Engineering Capability Within the Aerospace Industry.**
- **EER Systems' Aerospace Systems Group Is Committed to Becoming a Leader in Providing Engineering Services and Launch Services in the Small Satellite Market Arena.**
- **EER Systems' Aerospace Systems Group Is Committed to Providing Small Satellite, Conestoga Launch Vehicle, and Starfire Sounding Rocket Product Lines.**
- **EER Systems Is Committed to Providing the Required Aerospace Systems Group Resources Needed to Support Commercial Initiatives.**

N92-23646

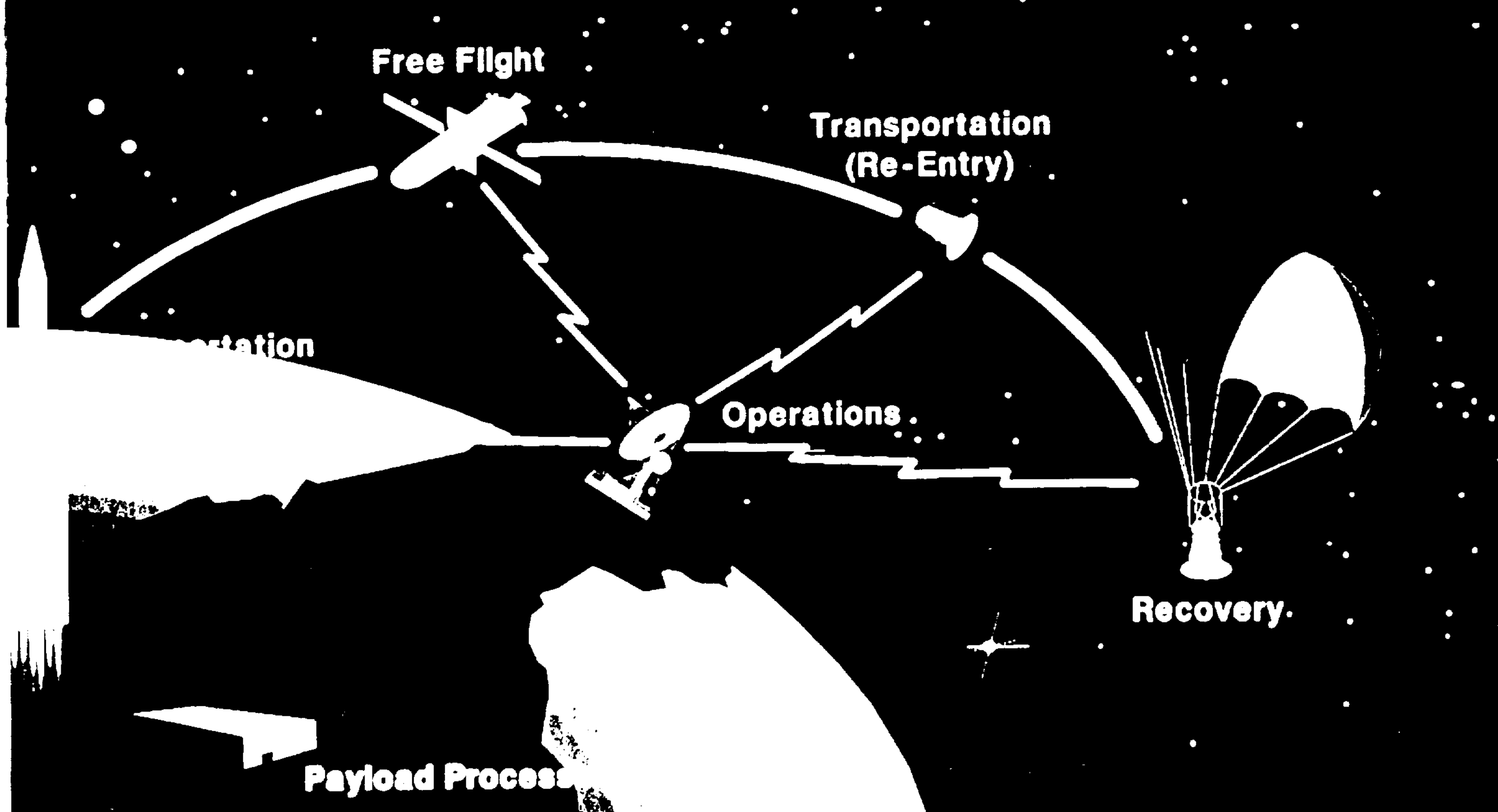
Systems for COMET

Mr. Harry Andrews
Manager of Commercial and Civil Space Department
Westinghouse Space Division

COMET

The COMmercial Experiment Transporter

United States' First Complete Commercial Space Servic



Directed by: The Center for Advanced Space Propulsion
A NASA Sponsored Center for the Commercial Development of Space

Provided and Operated by the Team of:

COMET

SPACE INDUSTRIES

Westinghouse

EER SYSTEMS
SPACE SERVICES DIVISION

SYSTEMS FOR COMET
H.N. ANDREWS
WESTINGHOUSE ELECTRIC CORPORATION

THE CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE (CCDS) HAVE BECOME OUR NATION'S PRIMARY FOCUS FOR STIMULATING PRIVATE SECTOR INVESTMENT IN SPACE. IN ESTABLISHING THE COMMERCIAL EXPERIMENT TRANSPORTER (COMET) PROGRAM, THE CCDS'S HAVE TAKEN A MAJOR STEP TOWARD THE FULL SCALE COMMERCIAL DEVELOPMENT OF SPACE. THE COMET PROGRAM WILL ENABLE THE CCDS COMMUNITY TO TURN THE GOAL OF COMMERCIAL SPACE INTO REALITY, AND IN THE PROCESS, ESTABLISH U.S. LEADERSHIP IN THE GLOBAL MARKET FOR SPACE SYSTEMS AND SERVICES.

THIS MORNING, IN OUR ROLE AS SYSTEM ENGINEERING CONTRACTOR AND PROVIDER OF SERVICE MODULE SERVICES, I WILL PRESENT SOME DETAIL ON THE SYSTEMS THAT MAKE UP THE COMET MISSIONS, SPECIFICALLY AS THEY DESCRIBE THE ACCOMMODATION FOR POTENTIAL USERS AND MISSION PARAMETERS.

FURTHER, I WILL DISCUSS SOME OF THE COMMERCIAL PLANS WE ENVISION FOR COMET DERIVED SPACE INFRASTRUCTURE.

IN THE COMET PROGRAM, W, SII AND EER, TOGETHER WITH THE CENTER FOR ADVANCED SPACE PROPULSION AT THE UNIV. OF TENN. WILL IMPLEMENT A SERVICE DESIGNED TO MEET THE NEEDS OF THOSE WHO REQUIRE ROUTINE LOW COST ACCESS TO SPACE. THIS SERVICE, SCHEDULED TO BEGIN OPERATION IN 1992, WILL CARRY EXPERIMENTS AND PRODUCTION PAYLOADS TO SPACE AND BACK, AND PROVIDE BASIC SUPPORT UTILITIES SUCH AS ELECTRIC POWER, COOLING, AND ATTITUDE CONTROL WHILE IN ORBIT. THE SYSTEM PROVIDES THE FLEXIBILITY TO ACCOMMODATE A WIDE VARIETY OF PAYLOADS; IN EITHER ENVIRONMENTALLY CONTROLLED, PRESSURIZED COMPARTMENTS OR WITH DIRECT EXPOSURE TO THE VACUUM OF SPACE. MISSIONS CAN BE

SCHEDULED ON A REGULAR BASIS TO ALLOW CONVENIENT TURNAROUND OF RESEARCH AND PRODUCTION RUNS.

EACH MISSION WILL LAUNCH A TWO PART SPACECRAFT CONSISTING OF A REENTRY CAPSULE WITH A RECOVERABLE PAYLOAD AND A SERVICE MODULE THAT PROVIDES BASIC SUPPORT SERVICES AS WELL AS ACCOMMODATIONS FOR NON-RECOVERABLE PAYLOADS. THIS CONCEPT PROVIDES THE CAPABILITY FOR TWO TYPES OF ON-ORBIT PAYLOAD SERVICES:

- RECOVERABLE PAYLOAD SERVICE - EXPERIMENTS FLOWN FOR APPROX. 30 DAYS, THEN RECOVERED IN A BALLISTIC REENTRY CAPSULE.

- NON-RECOVERABLE PAYLOAD SERVICE - EXPERIMENTS OR EQUIPMENT WHICH WILL REMAIN IN ORBIT FOR ABOUT 100 DAYS, WITH CONTINUED SUPPORT FROM THE SERVICE MODULE.

THIS FIRST OVERHEAD ILLUSTRATES THE SALIENT ASPECTS OF THE COMET PROGRAM.

(SLIDE #1)

- BEGINNING AT THE TOP, THE COMET PROGRAM AND THE LOGO WAS CONCEIVED BY THE CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE. THESE 16 CENTERS ARE DEPICTED BY THE 16 STARS CLUSTERED AROUND THE COMET.

- THE UNITED STATES' FIRST COMPLETE COMMERCIAL SPACE SERVICE IS ILLUSTRATED AS A SYSTEM AND INFRASTRUCTURE WHICH ALLOWS EXPERIMENTS TO BE PLACED INTO ORBIT, OPERATED, AND BROUGHT BACK TO A RECOVERY LOCATION WITHIN THE UNITED STATES.
- THE PROGRAM IS BEING MANAGED BY THE NASA'S CENTER FOR ADVANCED SPACE PROPULSION AT THE UNIVERSITY OF TENNESSEE.

- THE INDUSTRIAL TEAM SUPPORTING THIS CENTER IS:
  - SPACE INDUSTRIES OF HOUSTON, TEXAS
  - SPACE SERVICES DIVISION OF EER SYSTEMS CORPORATION OF SEABROOK, MARYLAND
  - AND WESTINGHOUSE ELECTRONIC SYSTEMS GROUP NEAR BALTIMORE, MARYLAND

THE WORK ELEMENTS COMPRISING THE SERVICE DEPICTED HERE ARE SIX:

SYSTEMS ENGINEERING (NOT SHOWN)	W
PAYLOAD INTEGRATION	SII
LAUNCH VEHICLE & SERVICES	SPACE SERVICES DIV. OF EER
SERVICE MODULE	W
RECOVERY VEHICLE	SII
ORBITAL OPERATIONS	SII

W SYSTEMS ENGINEERING WILL PROVIDE THE OVERALL SYSTEM SUPPORT TO THE CCDS PROGRAM MANAGER FOR SUCCESSFUL INTEGRATION OF THE SYSTEMS AND TO FACILITATE COMMUNICATION BETWEEN VARIOUS CONTRACTORS.

PAYLOAD INTEGRATION WILL CONVERT THE EXPERIMENTS INTO PAYLOADS, GENERATE ALL APPROPRIATE DOCUMENTATION AND SUPPORT THE INTEGRATION AND OPERATION OF THE PAYLOADS.

DEKE AND THE GUYS AT EER (AS HE HAS DESCRIBED) WILL SUPPLY THE VEHICLE AND ALL SERVICES NECESSARY TO GET THAT FREE-FLYER YOU SEE INTO THE PROPER ORBIT, WHICH FOR COMET IS 300 NAUTICAL MILES.

THIS FREE-FLYER CONSISTS OF THE SERVICE MODULE AND THE RECOVERY SYSTEM. THE SERVICE MODULE CONTAINS POWER, ATTITUDE CONTROL, COMMUNICATIONS AND THERMAL SYSTEMS TO SUPPORT EXPERIMENTS MOUNTED IN BOTH THE RECOVERY SYSTEM AND SERVICE MODULE. THIS SATELLITE BUS WILL HAVE

A PAYLOAD VOLUME OF AT LEAST 3 FT^3 AND CARRY 150 LB. OF PAYLOAD (MIN.)

THE RECOVERY SYSTEM WILL CONTAIN AT LEAST 6 FT^3 OF PRESSURIZED PAYLOAD VOLUME AND ACCOMODATE 300 LB. OF PAYLOAD WEIGHT (MIN.)

FINALLY, ORBITAL OPERATIONS INCLUDE TRACKING THE SATELLITE, COMMUNICATIONS FOR DATA RECEPTION AND COMMAND AND CONTROL AND THE LIKE.

THESE SIX ELEMENTS, PERFORMED BY THESE THREE COMPANIES, AND CONDUCTED BY THE CCDS COMET PROGRAM MANAGER, JOE PAWLICK AT CASP, WILL FORM THE INTEGRATED SPACE SERVICE SHOWN HERE.

THE MISSION SCENARIO LOOKS LIKE THIS:

1. CANDIDATE PAYLOADS ARE SELECTED BY A COMMITTEE LED BY THE CCDS CENTER FOR ADVANCED MATERIALS LOCATED AT BATTELLE COLUMBUS LABORATORIES IN COLUMBUS, OHIO.

2. THE PAYLOADS ARE INTEGRATED WITH THE RECOVERY SYSTEM AND THE SERVICE MODULE.

3. THE RECOVERY SYSTEM AND SERVICE MODULE WITH THE EXPERIMENTS ARE INTEGRATED WITH THE LAUNCH VEHICLE.

4. LAUNCH TAKES PLACE MOST LIKELY AT WALLOPS ISLAND.

5. THE FREE-FLYER WITH EXPERIMENTS IS INSERTED IN A 300 NAUTICAL MILE ORBIT AT A 40° INCLINATION.

6. THE RECOVERY MODULE WILL HAVE A 30-DAY FLIGHT SEPARATE AND RETURN TO EARTH. THE SERVICE MODULE AND ITS PAYLOADS WILL CONTINUE IN ORBIT FOR ANOTHER 100 DAYS.

MORE DETAILS ON THE MISSION PARAMETERS ARE SHOWN HERE (SLIDE #2). WE ARE DESIGNING TO ACHIEVE $< 10^{-5}g$ ON ORBIT TO GET THE MOST STABLE, CONTINUOUS ENVIRONMENT FOR OUR USERS. SOME PAYLOAD ACCOMMODATION PARAMETERS ARE PRESENTED ON THIS NEXT SLIDE.

(SLIDE #3)

OUR CURRENT DESIGN CONCEPTS WILL ALLOW US TO FLY AND RECOVER AT LEAST 6 FT^3 OF PAYLOAD VOLUME IN THE RECOVERY SYSTEM AT A MINIMUM WEIGHT OF 300 LB. THAT PAYLOAD VOLUME AND WEIGHT COULD INCLUDE SEVERAL EXPERIMENTS OR JUST ONE DEPENDING ON USER NEEDS.

THE CURRENT PRELIMINARY DESIGN FOR THE SERVICE MODULE WILL ALLOW US TO FLY AT LEAST 3 FT^3 AT ABOUT 150 LBS. PAYLOAD WEIGHT. THE SERVICE MODULE, TOO, COULD ACCOMMODATE MULTI OR SINGLE EXPERIMENTS - HOWEVER THEY WILL NOT BE RECOVERED FROM ORBIT.

IN ADDITION TO 400W OF PEAK POWER, PRESSURIZED AND UNPRESSURIZED ENVIRONMENTS, AND VIDEO DOWNLINK, A CONTROLLED LOADING ON PAYLOADS FROM LAUNCH TO TOUCHDOWN WILL BE PROVIDED.

(SLIDE #4)

YOU CAN SEE IN THIS SERVICE MODULE CONCEPT THAT THE GENERAL DIMENSIONS ARE __________.

SALIENT FEATURES INCLUDE, SOLAR ARRAYS, DEPLOYABLE RADIATOR, AND A PAYLOAD DECK SEPARATE FROM THE SYSTEMS DECK. THE WEIGHT OF THE SERVICE MODULE WILL BE 800#.

(SLIDE #5)

AN EXPANDED VIEW OF THE RECOVERY CAPSULE REVEALS SOME UPPER LEVEL DETAIL OF ITS MERCURY CONCEPTUAL DESIGN.

THE PRESSURIZED COMPARTMENT AND ABLATIVE SHIELD ARE VISIBLE. THE WEIGHT OF THE RE-ENTRY VEHICLE WILL BE 1000#. AFTER RECOVERY, CERTAIN KEY COMPONENTS WILL BE RE-USED TO HELP MINIMIZE COST.

(SLIDE #6)

FINALLY, THE COMBINED SERVICE MODULE AND RECOVERY SYSTEM IS ILLUSTRATED HERE AS THE FREE-FLYER IN ITS CONCEPTUAL FORM. OVERALL BASIC DIMENSIONS ARE APPROXIMATELY X FT. LONG BY 40" TO 48" IN DIAMETER.

YOU CAN SEE THE DEPLOYABLE SOLAR ARRAYS AND RADIATORS. THE 4TH STAGE OF THE LV IS KEPT WITH THE SM.

(SLIDE #7)

THE COMET CONTRACT IS FOR 3 MISSIONS PLUS 2 OPTIONS. THE FIRST MISSION LAUNCH TARGET DATE IS SEPTEMBER 9, 1992.

#2 IS 23 MONTHS LATER (APPROX. AUG. 94)
#3 IS 10 MONTHS AFTER THAT (APPROX. JUNE 95)

OPTIONS, IF DESIRED, WILL BE EXERCISED WHEN IT MAKES SENSE IN TERMS OF THE CCDS PAYLOAD FLIGHT NEEDS, FUNDING AVAILABILITY, ETC. CURRENT LAUNCH SCHEDULE FOR THESE TWO OPTIONS CALLS FOR JUNE 96 AND JUNE 97.

(SHUT OFF PROJECTOR)

THE STATED GOAL OF THE COMET PROGRAM IS "TO DEVELOP THE MEANS FOR THE U.S. INDUSTRY TO SERVICE THE NEEDS OF COMMERCIAL USERS OF SPACE" BY GROWING COMET INTO A FULLY INTEGRATED, INDUSTRIALLY CONTROLLED, AFFORDABLE SPACE SERVICE FOR LAUNCH, CONTROL AND RECOVERY OF COMMERCIAL PAYLOADS.

IT WAS THIS COMET GOAL THAT MATCHED OUR GOALS AT W AND RAISED OUR ANTENNA. SINCE THE EARLY 80'S WE

RECOGNIZED THE NEED TO ACCESS SPACE FOR COMMERCIAL APPLICATIONS. WE SAW AN EMERGING MARKET OF USERS SEEKING TO EXPLOIT THE UNIQUE FEATURES OF THE SPACE ENVIRONMENT WANTING MICROGRAVITY AND ULTRAHIGH VACUUM NOT ACHIEVABLE HERE ON EARTH. THE BIGGEST IMPEDIMENTS THE POTENTIAL USERS FACED WERE ACCESS AND COST.

AT THAT TIME, WE PUT IN PLACE A PLAN TO CREATE THE INFRASTRUCTURE THAT WOULD ULTIMATELY PROVIDE A ONE-STOP-SHOP FROM PAYLOAD ENGINEERING AND INTEGRATION THROUGH LAUNCH, OPERATIONS IN SPACE PLATFORMS AND, FINALLY, RETURN OF THE PAYLOAD PRODUCT TO THE USER. OUR BY-WORD FOR THE PLAN IS "LOW-COST SPACE-IN-SPACE". OUR PLAN LED US TO

- ISF
- ASTROTECH

AND CONTINUES WITH OUR PARTICIPATION IN THE COMET PROGRAM.

WE, AT WESTINGHOUSE, ARE PARTICIPATING AS A TEAM PLAYER WORKING IN CLOSE COLLABORATION WITH SPACE INDUSTRIES AND EER SPACE SYSTEMS AND THE CCDS'S ASSIGNED TO THE PROJECT. THE BUDGET IS TIGHT AND, SINCE WE AND OUR INDUSTRIAL TEAM MEMBERS RECOGNIZE THE TRUE COMMERCIAL POTENTIAL OF THE COMET CONCEPT, WE HAVE TAKEN A TRUE COMMERCIAL APPROACH TO MEET THE BUDGET PROFILE -- WE HAVE ASSUMED FINANCIAL RISK FOR FUTURE PROFIT.

IN ACCORDANCE WITH NASA AND THE CCDS'S WISHES AND OUR DESIRE, WESTINGHOUSE WILL BEGIN MARKETING AT HOME AND ABROAD, THE UNITED STATES' FIRST COMPLETE COMMERCIAL SPACE LAUNCH, OPERATIONS AND RECOVERY SERVICE.

JIM ROSE TESTIFIED, ON THE 5TH OF APRIL THIS YEAR, BEFORE THE HOUSE SUBCOMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY. IN THAT TESTIMONY, JIM DESCRIBED PART OF OCP'S MISSION IS TO "MAKE COMMERCE IN SPACE A REALITY BY

ENCOURAGING PRIVATE INVESTMENT IN COMMERCIAL SPACE VENTURES --- "THE COMET PROGRAM IS A GREAT EXAMPLE OF THE FULFILLMENT OF THIS MISSION. THROUGH THIS INITIATIVE, INDUSTRY --- SPACE INDUSTRIES, EER, AND WE AT WESTINGHOUSE --- ARE INVESTING IN BUILDING THE INFRASTRUCTURE SYSTEMS FOR COMMERCIAL RESEARCH AND MANUFACTURING IN SPACE. WE ARE USING THIS PROGRAM TO DEVELOP AN INTEGRATED COMMERCIAL SPACE SERVICE INFRASTRUCTURE GIVING THE UNITED STATES A LEADING ROLE IN THIS NEW INDUSTRY.

PARAMETER	
MISSION DURATION	30 TO 100 DAYS OR LONGER
NOMINAL ORBIT	300 NMI $\pm$50 AT 40° $\pm$2° INCL.
MICROGRAVITY LEVEL	< 10^{-5}G; DISTURBANCES HELD TO ABSOLUTE MINIMUM
ATTITUDE POINTING	SOLAR INERTIAL $\pm$5°
ATTITUDE CONTROL	3 AXIS ACTIVE CONTROL USING REACTION WHEELS AND MAG TORQUERS
POWER	
- HOUSEKEEPING	115 W
- PAYLOAD	400 W

PAYLOAD ACCOMMODATION PARAMETERS

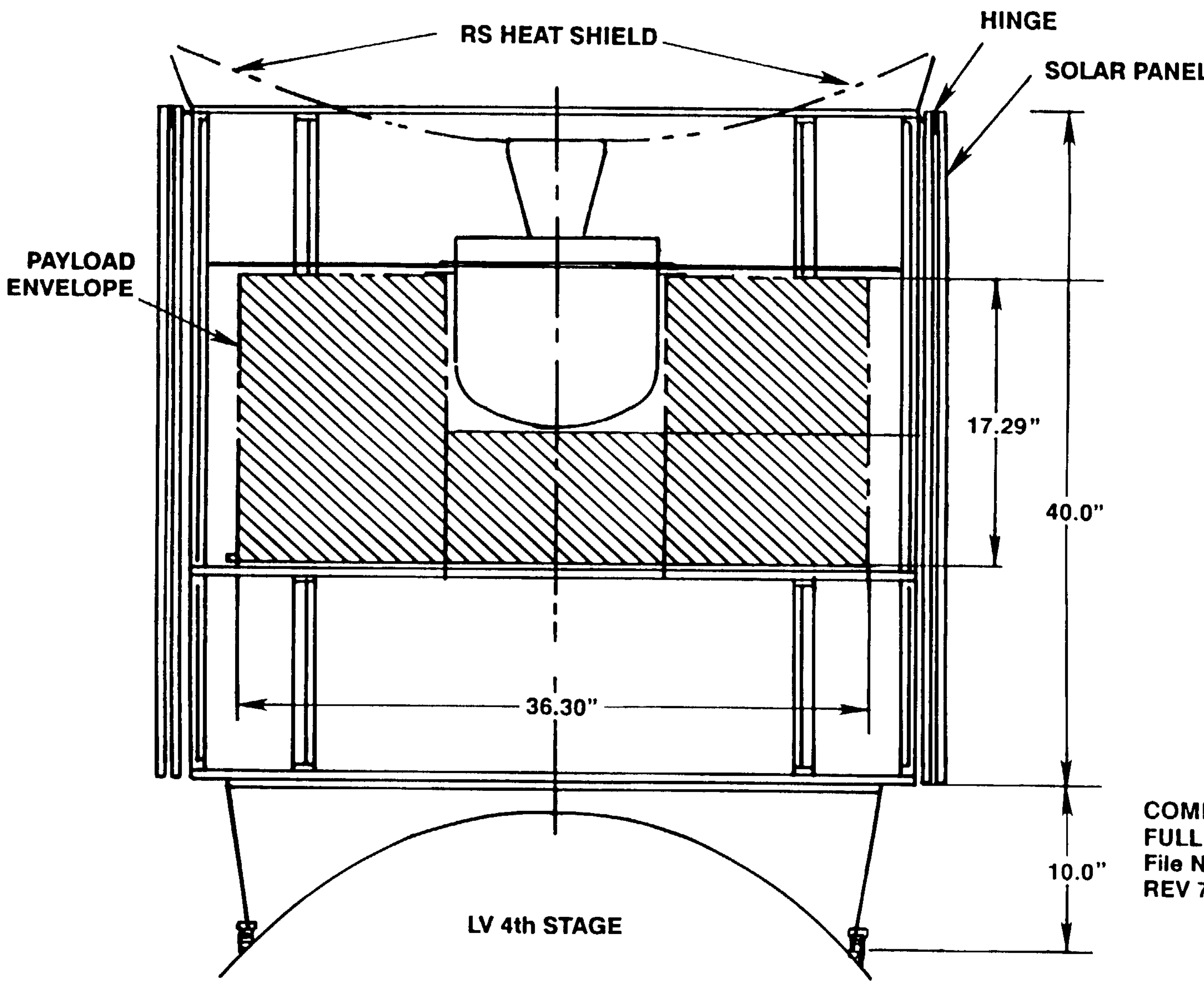
Space Division

PARAMETER	SERVICE MODULE	RECOVERY SYSTEM
Total Payload Weight	150 lb. minimum	300 lb minimum
Total Payload Volume	3 cubic feet	6 cubic feet
Power Available to Payloads*		
- Continuous	200 W	200W
- Peak	400W for 200 hrs.	400W for 200 hrs.
- Voltage	28V ± 4V dc	28V ± 4V dc
Heat Rejection	400 W	400W
Internal Environment		
- Pressure	Vacuum	1 ATM
- Atmosphere	0 ATM	Dry Air
- Temperature	72 ±5°F at Baseplate	72 ± 5°F at Baseplate
Telemetry*		
- Command Uplink	4Kb/sec	4Kb/sec
- Real-time Data Downlink	32Kb/sec	32Kb/sec
- Video Downlink	Compressed NTSC - 256Kb/sec	Compressed NTSC - 256Kb/sec
- Freq. of Transmissions	5 passes/day, 40 minutes contact time per day	5 Passes/day, 40 minutes contact time per day
Loads of Payloads		
- Powered Flight Loads	< Less than 12g	<12g
- Reentry Loads	NA	<10g
Late Access	NA	Within 6 hrs. of launch

* Free-Flyer

COMET Service Module

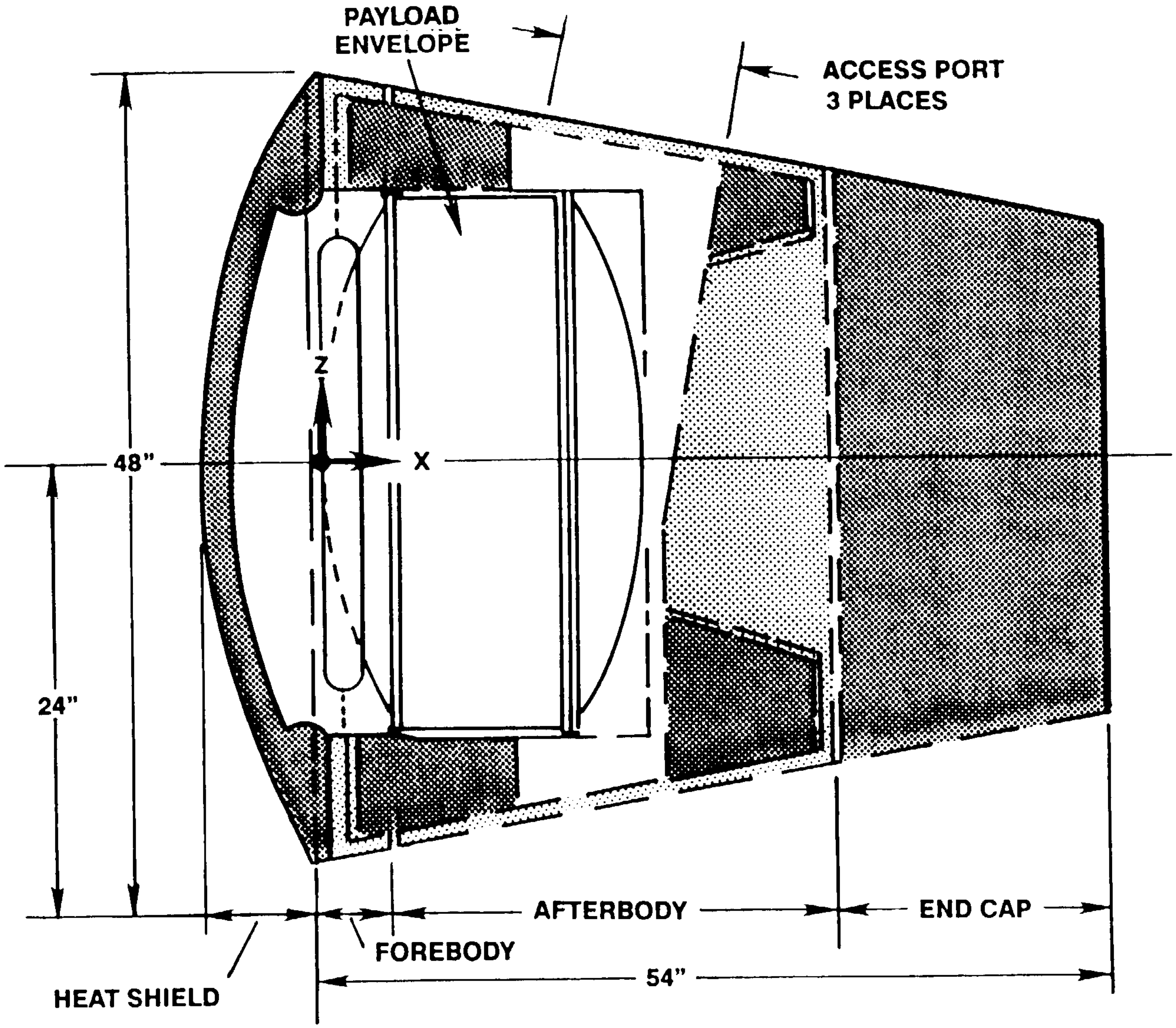
Space Division



COMET
FULL ELEVATION
File Name: COMET 1
REV 7 MAY 1991 SAS

COMET Re-entry Vehicle

Space Division



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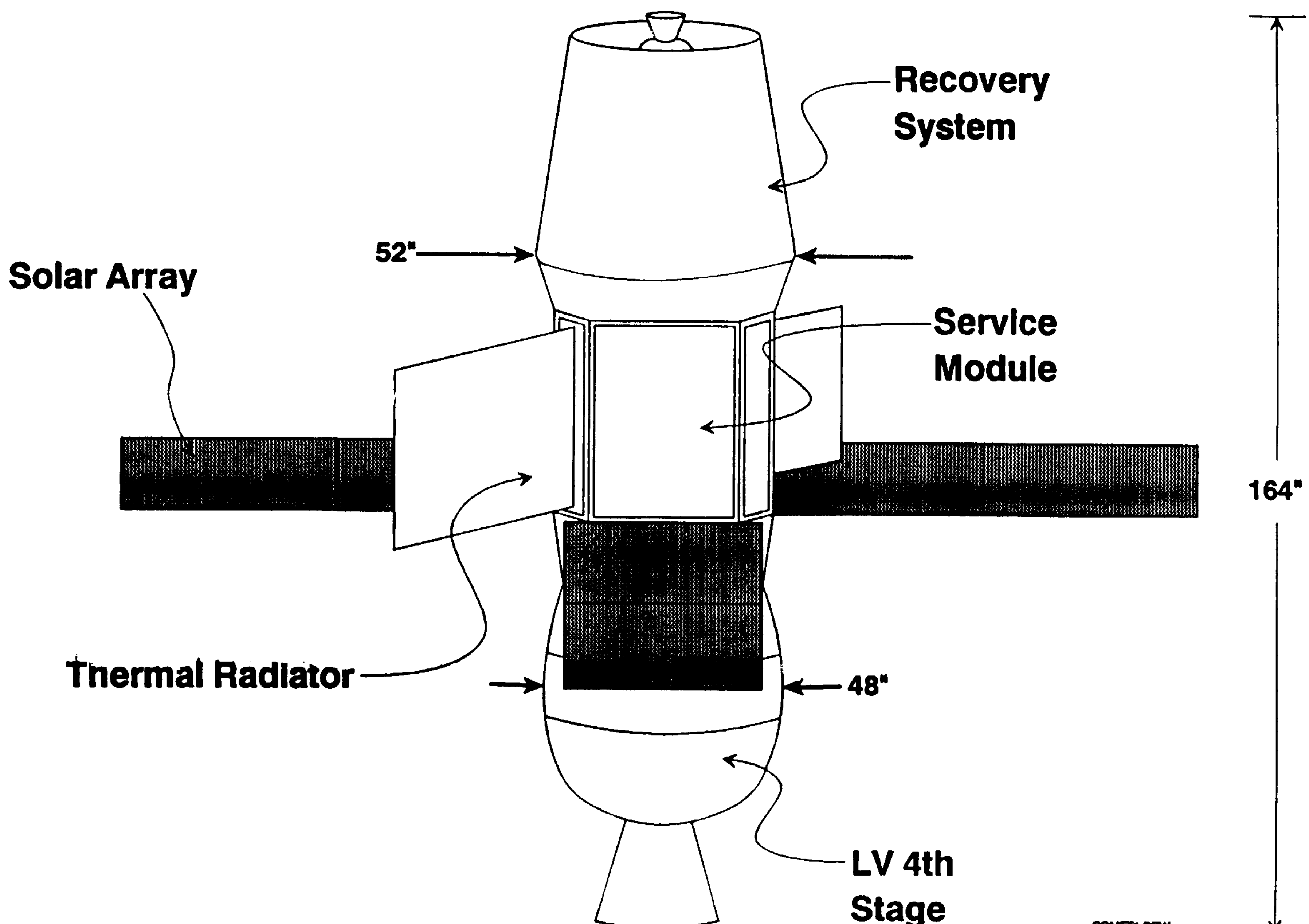
COMET Free Flyer

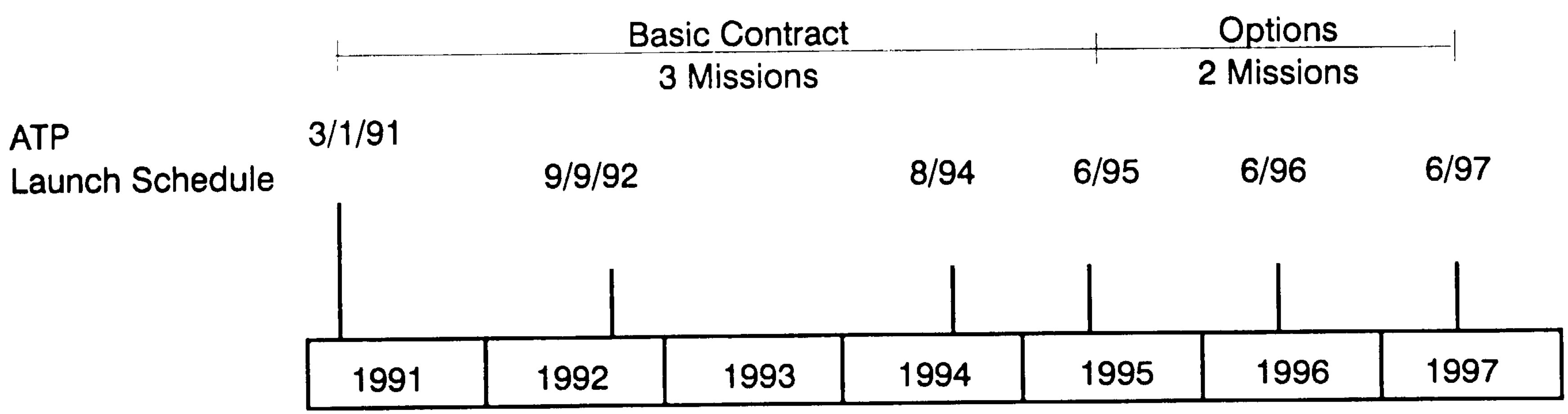
6

Space Division



COMET SCHEDULE

Space Division



N92-23647

SPACEHAB

Mr. David Rossi
Vice President
Spacehab, Inc.

- SPACEHAB, Inc. Is Developing a Pressurized Module to Be Carried Aboard the Space Shuttle which Augments the Shuttle's Capability to Support Man-Tended Microgravity Experiments
- SPACEHAB Augmentation Modules Are Designed to Duplicate the Resources, Such as Power, Environmental Control, and Data Management, That Are Available in the Shuttle's Middeck
- Supported by a Highly Experienced Industry Team, SPACEHAB Is Dedicated to Providing Frequent, Affordable, and Streamlined Access to the Microgravity Environment

COMPANY OVERVIEW

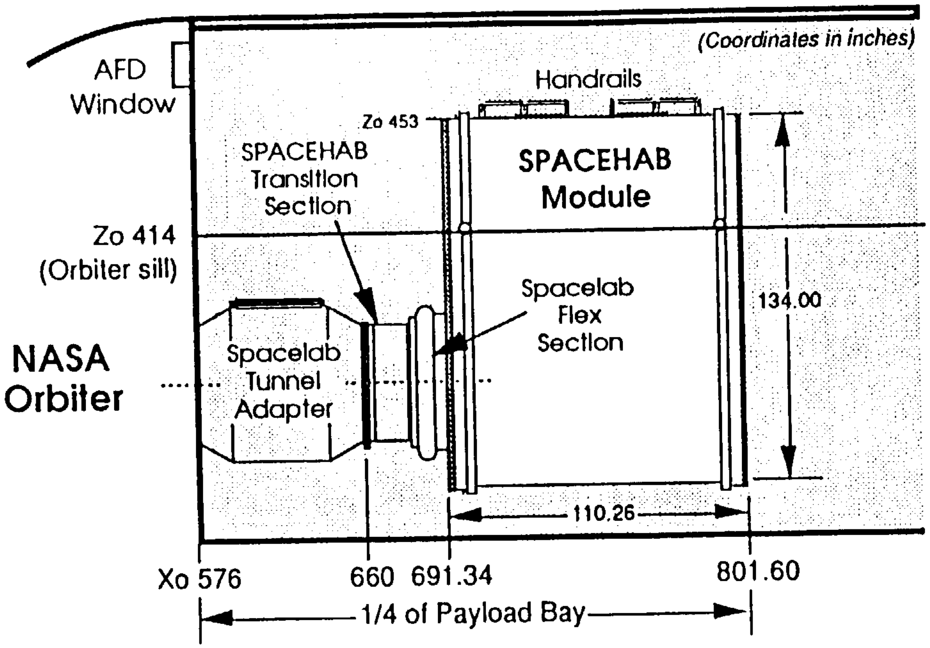
- SPACEHAB Is a Program Management, Marketing, and Financing Company That Was Formed in 1984
- Headquartered in Washington, D.C., SPACEHAB Is Managed by an Experienced Group of Space Industry Executives
- Responsible for Marketing Augmentation Module Services in the U.S., SPACEHAB also Directs a Team of International Marketing Organizations
- SPACEHAB Recently Completed a Financing Package Which Assures That Development and Production of the Augmentation Modules Will Be Completed by Late-1991

COMPANY FINANCING

- SPACEHAB Is a Privately Held Company Funded by Equity and Long-Term Debt
  - U.S. Shareholders and Investors in Japan, Taiwan, and Europe Contributed More Than $30 Million in Equity to Date
  - Major Subcontractors Have Provided Over $12 Million of Subordinated Debt and Equity
  - Chase Manhattan Bank Recently Provided a $64 Million Credit Facility

- SPACEHAB Middeck Augmentation Modules provide:
  - Approximately 31.1 cubic meters of additional man-tended pressurized payload accommodations
  - Up to 1360 Kg of combined payload mass allocated between 50 Middeck Locker Volume Equivalent (MLVE) payloads
  - Standard payload interfaces compatible with Orbiter middeck lockers and Spacelab and Space Station racks
  - Power, thermal control, and command/data functions to payloads on a pro rata basis
  - Simplified integration procedures and documentation and minimal lead time commitment of hardware and personnel

MODULE DESCRIPTION



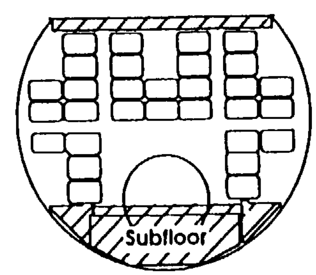
Side View

Module:

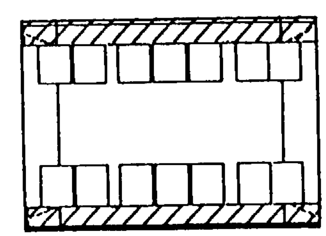
- Characteristics:

	English	Metric
- Length	9.2 ft	28.0 m
- Height	11.2 ft	34.1 m
- Diameter (truncated)	13.5 ft	41.1 m
- Total weight	10,584.0 lb	4800.8 kg

- Allows clearance for EVA with Orbiter payload bay doors closed
- Other features:
  - Flat bulkheads
  - Subsystems mounted in subfloor
  - Volume for two crew operations



Cross Section



Top View

The SPACEHAB truncated module configuration was patented in 1989.

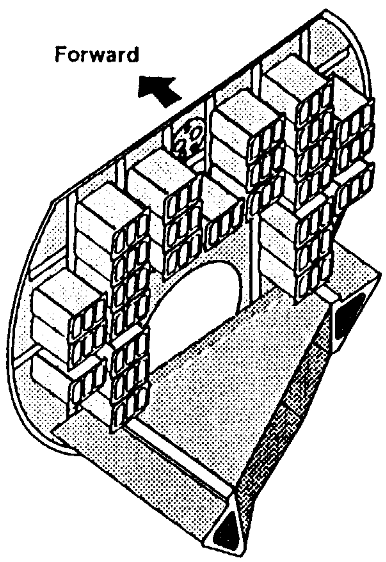
CONFIGURATIONS

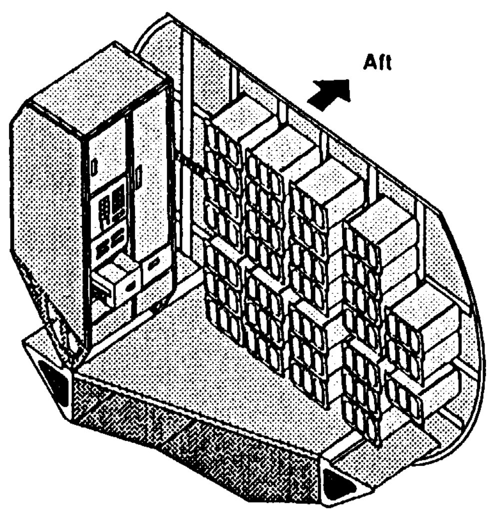
All Locker Configuration

61 lockers (max)

Rack & Locker Configurations

1 rack / 51 lockers (max)
2 racks / 41 lockers (max)





TOTAL PAYLOAD RESOURCES

	English	Metric
Mass:	3000 lb	1360 kg
Volume:	1100 ft3	31.1 m3

Power:
- DC*: 1400 or 3150 W
  - Asc/Des: 300 - 625 W
- AC: 690 VA

Cooling:
- Total: 4000 W
  - *Air:* 1400 - 2000 W
  - *Water***: 4000 W (if all cooling is water)

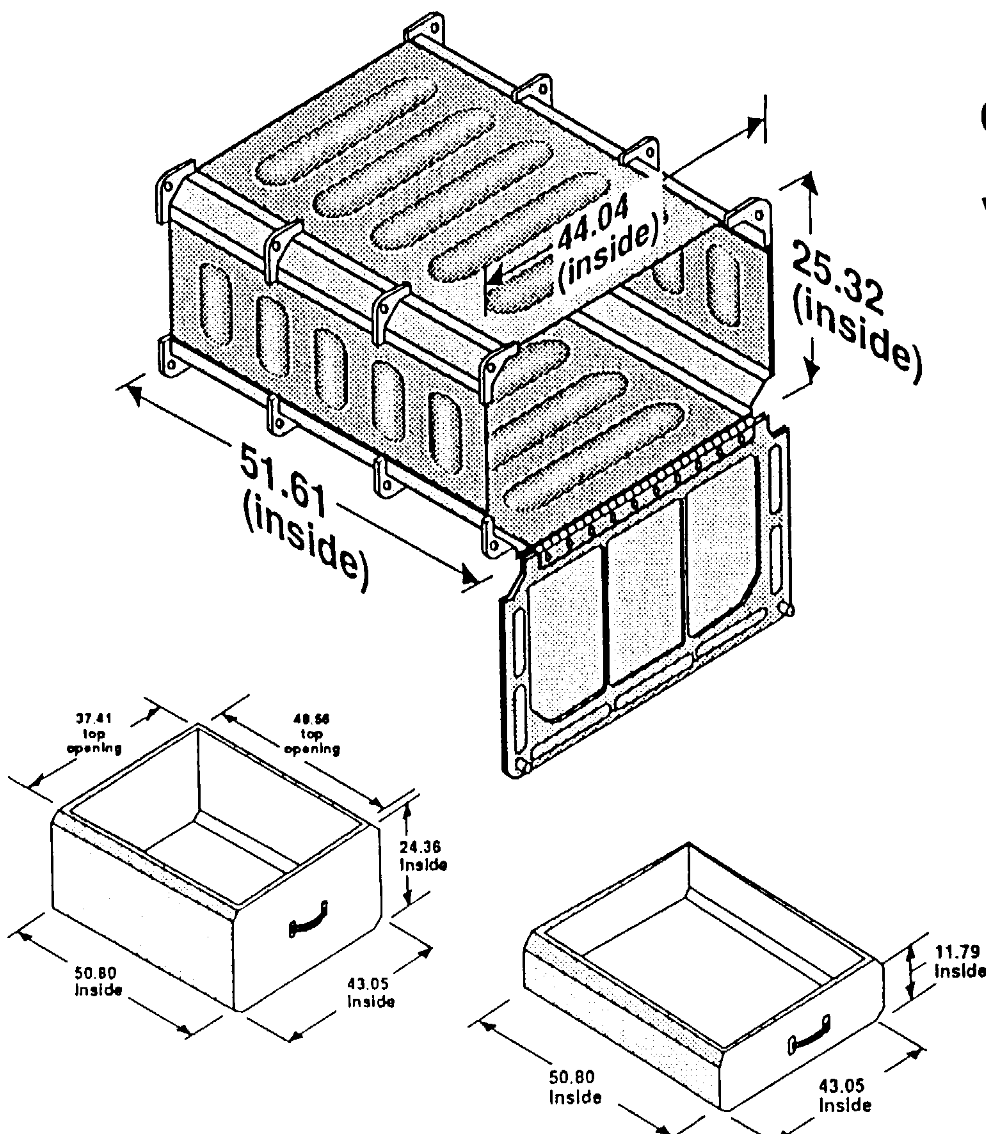
Crew: 2

Other:
- Command/data subsystems
- Fire detection/suppression
- Vacuum venting

* Power dependent on number of Orbiter SMCHs provided.
** Maximum water cooling level includes 2 kW plus whatever air capability is not used.

Mission planning will assess the compatibility of payloads in order to maximize the resources provided to each.

LOCKER ACCOMMODATIONS



	English	Metric
Mass:		
Standard Accom.	42 lbs	20.9 kg
Design Limit	60 lbs	27.2 kg
C.G.:	14 in*	35.6 cm*
Volume:		
Entire Locker	2.0 ft3	0.057 m3
Small tray	0.9 ft3	0.025 m3
Large tray	1.9 ft3	0.054 m3

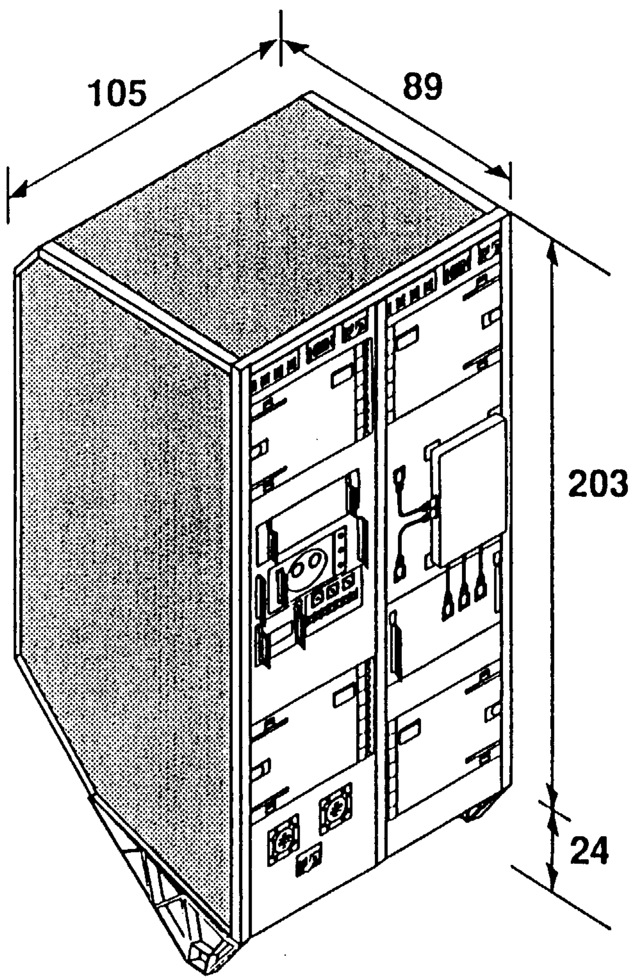
Data: Accommodated through manifesting of compatible payloads.

DC Power:
On-orbit: 115 W (Continuous)
180 W (Peak) for TBD min
@ 28 +/- 4 VDC
*Ascent / Descent**:* available

Cooling: Payload heat generation above 60 W requires forced air cooling.

* From locker rear panel
** Optional resource

RACK ACCOMMODATIONS



Mass:

	English	Metric
Standard Accom.	800 lbs	362.9 kg
Design Limit	1250 lbs	567.0 kg

Volume: 45.0 ft3 1.27 m3

Data: Accommodated through manifesting of compatible payloads.

DC Power:
On-orbit: 1000 W (Continuous)
2000 W (Peak) for 15 min
@ 28 +/- 4 VDC
Ascent / Descent:* available

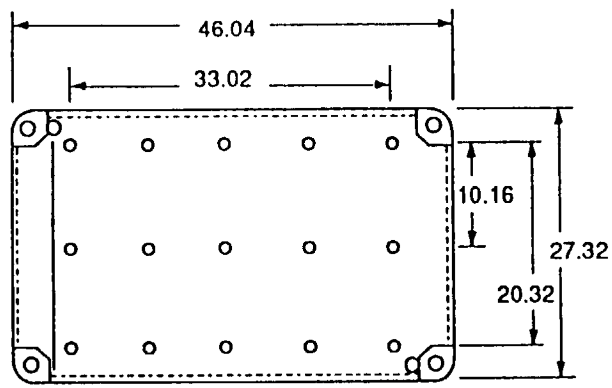
AC Power*: available

Cooling:
Forced Air: 2000 W (all payloads)
Water:* 1000 W (per rack)

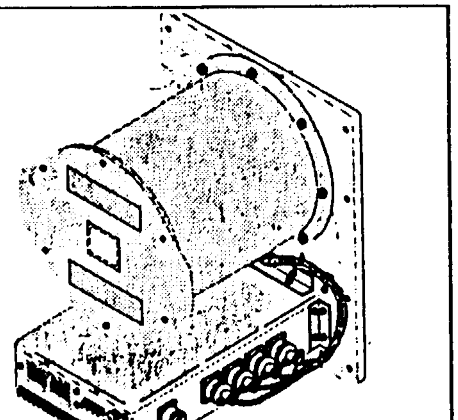
Vacuum Vent*: available**

* Optional resource
** Venting level is dependent on Orbiter altitude and mission-dependent line routing

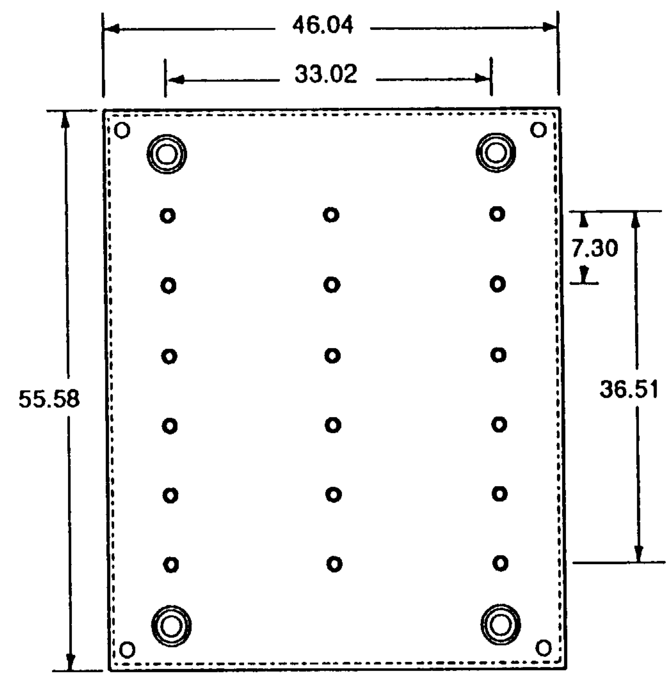
ADAPTER PLATE MOUNTING



Single Adapter Plate



Example Payload



Double Adapter Plate

- Payloads can mount directly to optional adapter plate, replacing locker(s).
- Resource allocation would be the same as for standard locker(s).
- Payload must not violate mass, C.G. and envelope of locker(s) replaced.
- Adapter plate included in total mass accommodation.

ACCOMMODATIONS SUMMARY

ACCOMMODATION	SPACEHAB Total	SPACEHAB Locker	SPACEHAB Rack	REMARKS
WEIGHT [lbm (kg) payload]	3000 (1360)	60 (27.2)	1250 (567)	Maximum weight per unit
VOLUME [cu. ft. (cu. m)]	1100 (31.1)	2 (0.057)	45 (1.27)	Usable interior volume per unit
POWER				
DC (W)	1400 or 3150	115	1000	Total power dependent on number
Ascent / Descent (W)	300 - 625	available	available	(1 or 2) NSTS SMCHs available
AC (VA)	690	available	available	Derived from DC power
HEAT REJECTION (W)	4000 (total)			
Passive Air		60		Nominal locker capability
Forced Air	1400 - 2000	user-provided	2000*	Rack experiments are air surface-cooled.
Water	4000 (if all water)		1000	
Ascent / Descent	300 - 400**			Cooling constrained by Orbiter
VACUUM VENTING	1 Vent & Line	available	interface at each rack	Capability dependent on system
DATA				
Serial Input/Output	4	Mission Dependent	1	
Acquisition Channels				
Discrete Input Low (0-5V)	60	Mission Dependent	15	Minimum rack level based on locker
Discrete Input High (0-28V)	60	Mission Dependent	15	rqmts; 2 rack level available to 1
Analog Input High (0-5V)	75	Mission Dependent	25	rack on mission- unique basis.
Telemetry Downlink Rate via PDI (kbps)	8, 16	8*, 16*	8*, 16*	Includes subsystem data
Closed Circuit Television	Ch. - user video	Mission Dependent	1	Orbiter CCTV; Camcorder
Timing				Orbiter Payload Timing Buffer
Orbiter GMT Signal	1	Mission Dependent	1	Interface, additional signals
Orbiter MET Signal	1	Mission Dependent	1	mission-dependent
Ku-band Signal Processor	1	Mission Dependent	1	48 Mbps
MICROGRAVITY LEVEL	Mission Dependent			

* Total module capability

** A level of 625 W is mission dependent

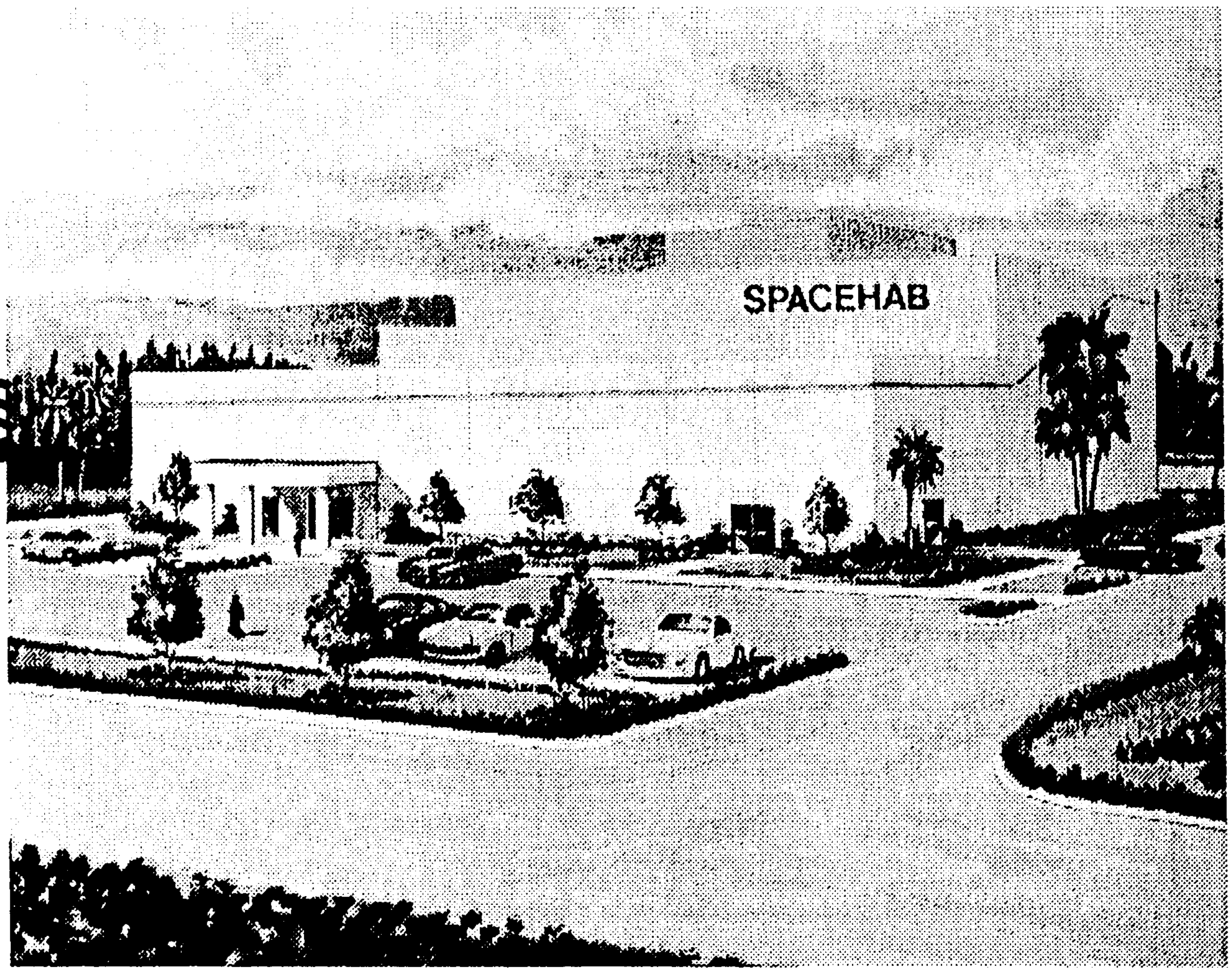
Some of the accommodations above are optional services.

- SPACEHAB Has Successfully Achieved All Initial Programmatic Milestones
  - Two Flight Modules and One Structural Test Module Are Currently in Production
  - Eight SPACEHAB Missions Are Manifested on Shuttle Flights Through 1996
  - Generic Interface Control Documentation (ICD), Payload Integration Plan (PIP), and Phase O and Phase 1 Safety Reviews Completed
  - SPACEHAB's Assembly and Integration Facility (Located Near NASA-KSC) Due for Completion in Late 1991

SYSTEM ADVANTAGES

- Streamlined Payload Integration Process
  - Reservation Required 24 Months Prior to Launch
  - Payload Definition Required 18 Months Prior to Launch
  - Minimal Documentation Requirements
- Limited Dedication of Experiment Hardware & Personnel
  - Hardware Delivery Required 12 Months Prior to Launch
- Frequent Manifested Flight Opportunities
  - Six-Month Experiment Re-Flight Possibilities
  - Additional Missions Will Be Added to Meet Demand
- Dedicated Mission Cost of $77 Million (1991 Dollars) for 3,000 Pounds of Payload

SPACEHAB Payload Processing Facility (SPPF)

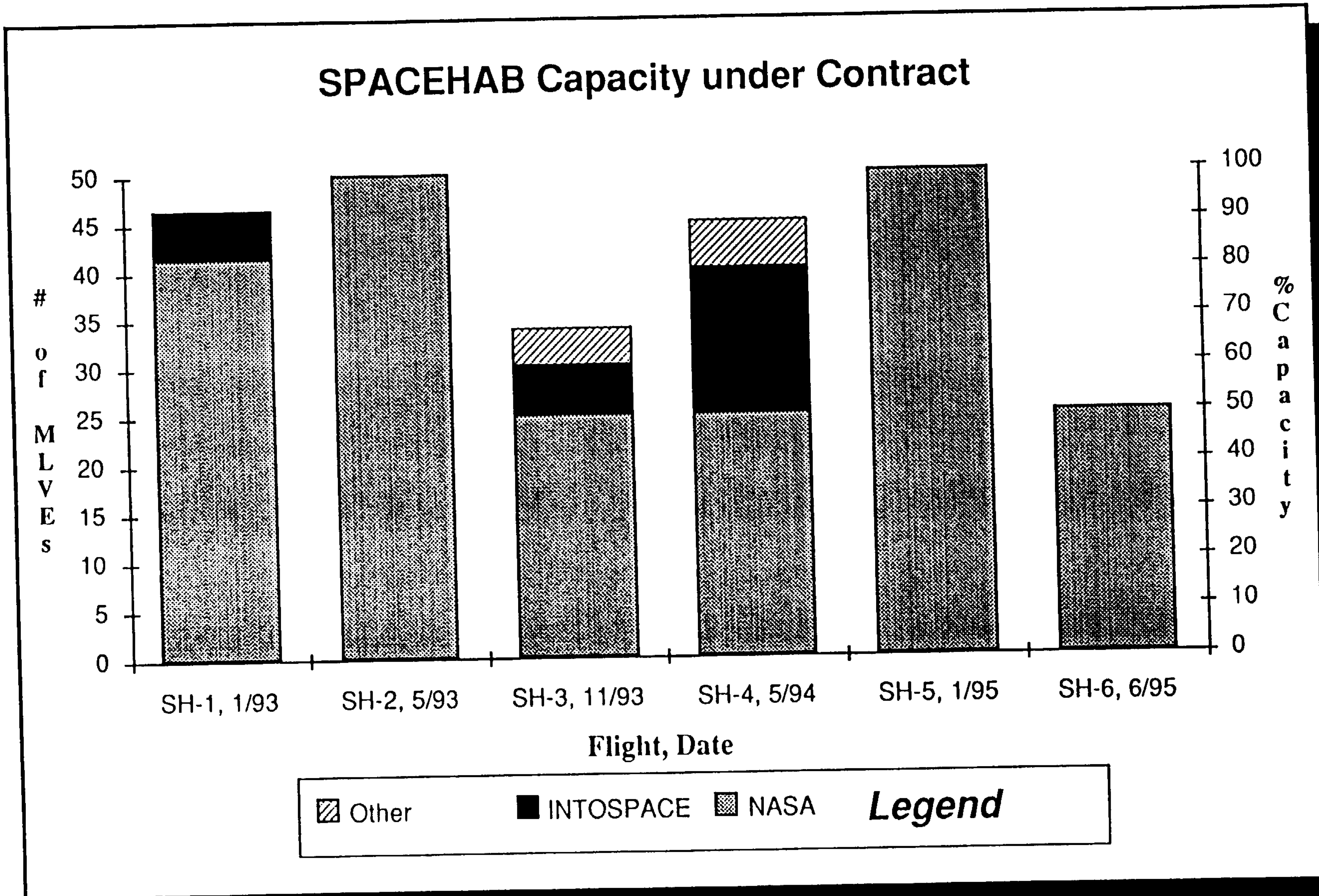


- **35,000** square feet of payload integration, test, training & support facilities
- **6,000** square feet of Customer Work Area (CWA), subdivided into industrial secure rooms
- **Shipping / Receiving** provided for receipt of hardware.
- **Clean Room** - 100K class conditions in shipping / receiving, CWAs, & integration hall
- **General** - classrooms, conference rooms, copiers, and fax machine available for use on shared basis.
- **Availability** date: mid 1991
- **Located** on commercial site near KSC.

USE CONTRACTS

- NASA Code C Selected SPACEHAB as the Commercial Middeck Augmentation Module (CMAM) Service Provider
  - $184 Million, Five-Year Contract Is for Lease and Integration Services for 200 Middeck Locker Volume Equivalent (MLVE) Payloads
  - Services to Be Provided Over the First Six Missions
- Use Contracts Have Been Signed with INTOSPACE, state-affiliated Organizations in Virginia and Florida, and the Government of Canada
- Use Proposals Being Evaluated by Several European and Asian Space Organizations

MISSION RESERVATION STATUS



MISSION ONE STATUS

- SPACEHAB Mission One Currently Manifested for a Late-1992 Launch
- Mission One-Specific ICD and PIP Signed
- Phase 1 Safety Reviews Scheduled for June
- Ascent/Descent Power Allocation Provided by NASA
- NASA Code C Candidate Payloads Identified and Mission Assessment Process Initiated

CODE C CANDIDATE PAYLOADS

Sponsor	Acronym	Payload Name	Mass (lb)	Volume (MLVE)	Ascent Power (W)	Late Access (min)	Average On-orbit DC (W)
3M	GOSAMR	Gelation of Solids: Advanced Microgravity	67.5	1.0	0	0	0
	PM	Polymer Morphology	200.0	3.3	0	0	267
Battelle	IPMP	Investigations into Polymer Membranes Processing	60.0	1.0	0	10	0
	SCG	Solution Crystal Growth	20.0	1.0	0	5	0
	ZCG	Zeolite Crystal Growth	120.0	3.0	0	30	91
Bioserve	BMDA	Bioserve Materials Dispersion Apparatus	70.0	1.0	45	45	45
	CGBA	Commercial Generic Bioprocessing Apparatus	120.5	2.0	50	45	110
Boeing	CVTE	Crystals by Vapor Transport Experiment	453.0	8.3	0	0	830
Clarkson	LEMZ-1	Liquid Encapsulated Melt Zone of Indium	140.0	2.0	0	0	80
LeRC	SAMS	Space Acceleration Measurement System	65.0	1.0	0	0	0
Penn State	PSE	Physiological Systems Experiment	156.0	2.0	34	70	46.5
	PSB	Penn State Biomodule	70.0	1.0	0	5	0
UAB	PCFB	Protein Crystal Growth - Batch	69.0	2.0	110	45	110
	FDB	Protein Crystal Growth - FDB	46.0	0.6	0	5	0
	TES	Thermal Enclosure System	122.0	2.0	110	45	110
UAH	OS	Organic Seperation	55.0	1.0	60	70	60
	SEF	Space Experiment Facility	500.0	8.3	0	30	885
Wisconsin	ASC-2	Astroculture	70.0	1.0	0	20	100
		Totals	2404.0	41.5	409	425	2734.5
		MARGIN	596.0				

SPACE STATION TRANSITION

- Up to 50% of Space Station Payloads May Be Provided by NASA Code C
- SPACEHAB's Short Payload Integration Schedule and Frequently Manifested Missions May Provide an Economical Means to Develop and Transition Code C Payloads to the Space Station
- NASA Requested CMDS to Conduct Evaluation of SPACEHAB Capabilities
  - Interface Control
  - Payload Packaging and Transfer
  - Docking and Berthing
- CMDS Subcommittee Formed and Final Plan to Be Presented at June Annual Meeting

N92-23648

Wakeshield: A Space Experiment Platform

Dr. Joseph Allen
President and Chief Executive Officer
Space Industries, Inc.

Space
Vacuum
Epitaxy
Center

The Wake Shield Facility:

A Space Experiment Platform

May 14, 1991
J. P. Allen
Space Industries, Inc.

SPACE
INDUSTRIES
INC.

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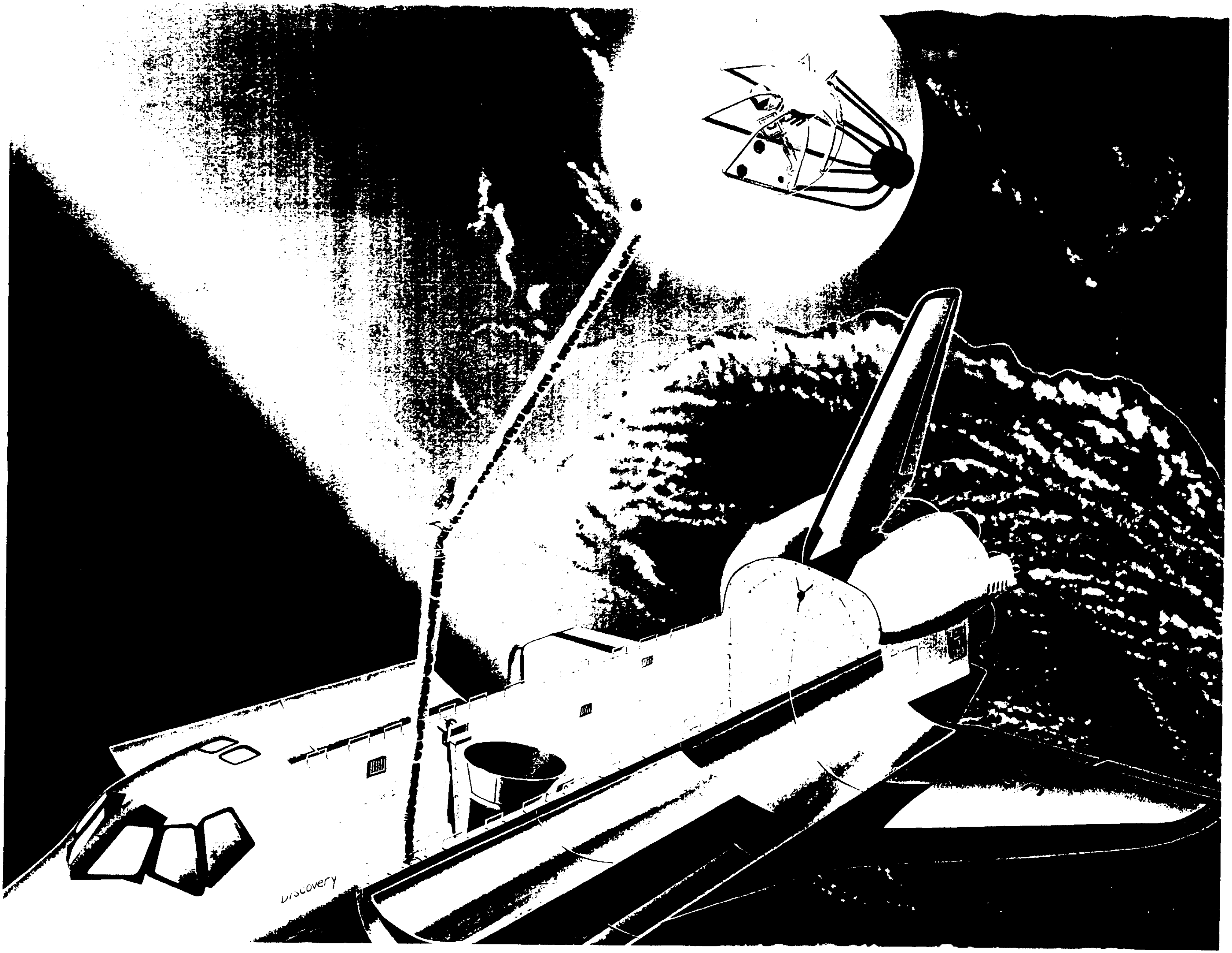
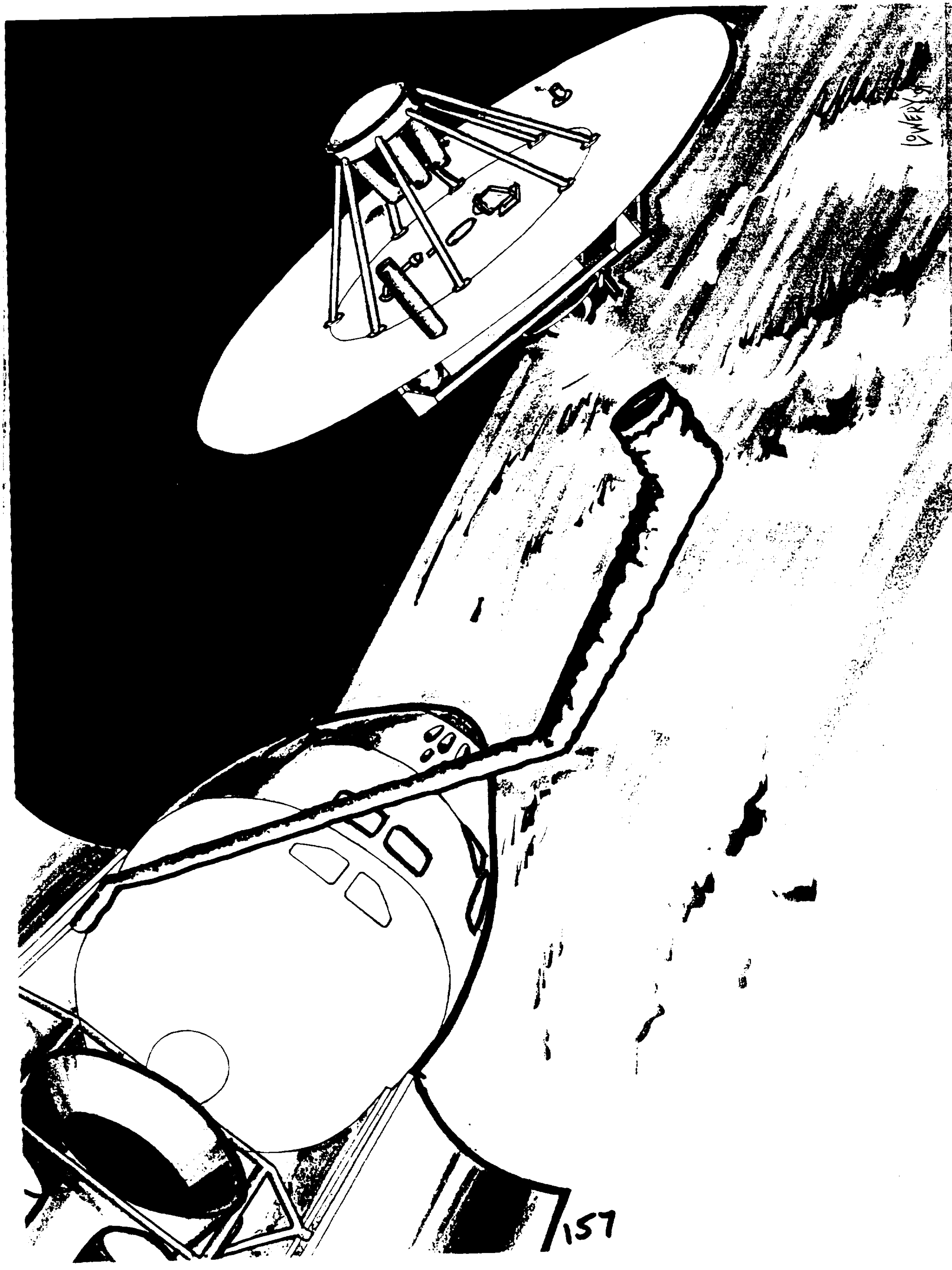
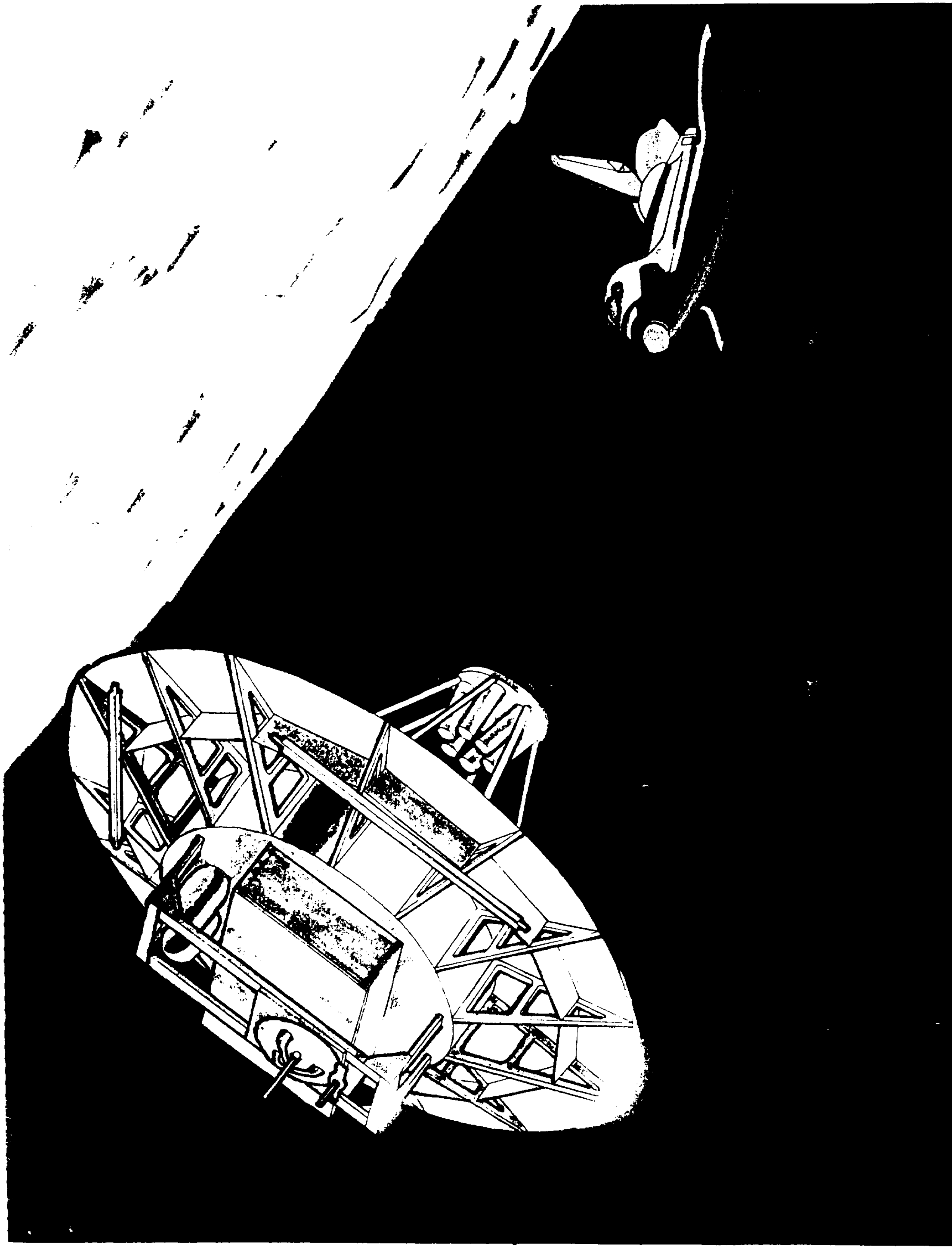


Discovery





Space Vacuum Epitaxy Center

Wake Shield Facility (WSF) Flight Program

CCDS Objectives:

- Produce new industry-driven electronic, magnetic, and super-conducting thin-film materials and devices both in terrestrial laboratories and in space
- Utilize the ultra-vacuum of space for thin-film epitaxial growth and materials processing
- Explore commercial possibilities of space for:
  - epitaxial thin-film growth
  - materials purification
- Develop commercial space hardware for research and development and enhanced access to space

The SVEC - WSF Team:

NASA	Space Industries, Inc.
U of H	AT&T Bell Laboratories
University of Illinois (Urbana)	Schmidt Industries, Inc.
Univ. of Colorado (Col. Springs)	Perkin-Elmer
University of Toronto	Instruments S. A., Inc.
Case Western Reserve Univ.	Ionworks
U.S. Army - AMTL	
U.S. Army - CERL	
Battelle Laboratories	

University of Houston

CCDS

Space Vacuum Epitaxy Center

Importance of WSF Flight Program:

- Access to space ultra-vacuum which will allow for advanced technologies in materials processing
  - ultra-vacuum feature of space has never been used
  - vacuum 10,000 times better than on earth systems
- Provides future national resource with a unique capability to produce advanced semi-conducting and super-conducting materials leading to future computer, communications and sensor systems

Product Applications:

- High-quality, thin-film semiconductor materials used in computer and other microelectronic applications; superconducting thin-film development for device applications
- Epitaxial thin-film products for fiber-optic communication applications
- Epitaxial thin-film products used in infrared surveillance devices
- Solid-state, thin-film laser diodes used for next generation tuned laser sources

UH Space Vacuum Epitaxy Center

Wake Shield Facility (WSF) Flight Program

Commercial Development Approach:

- Low cost
- Design simplicity
- Proven technology
- Reduced documentation & testing
- Highly coordinated project team
- Safety compliance - highest priority

WSF Utilization Potential:

- Experiments which require:
  - access to ultra vacuum
  - gravity level < 10^{-6}g
  - low power over long durations
  - high power for short durations
  - near-term free flyer opportunity
  - 60 to 90 day missions
  - space environment exposure
- Test platform for space power, space propulsion and space robotics

Wake Shield Facility Free Flyer

Importance of WSF Free Flyer:

- Technical
  - improve vacuum environment/thin-film growth conditions
  - reduce impact on Orbiter operations
- Programmatic
  - reduced overall cost to NASA
  - quick route to commercialization
- National Impact
  - WSF brings NASA the capability of a U.S. Free Flyer for STS

Cooperative Experiments

- Air Force Geophysics Laboratory
  - plasma diagnostics
  - ion capture in wake region
- Case Western Reserve University
  - ram flow diagnostics
  - materials exposure
- Battelle Laboratories
  - zeolite crystal growth
- Army - CERL
  - material coatings - vapor deposition

N92-23649

Space Station Freedom

Mr. Gilbert Keyes
President, Program Manager
Space Exploration Initiative
Boeing Commercial Space Development Company

ACCESS TO SPACE

SPACE STATION FREEDOM AND COMMERCIALIZATION

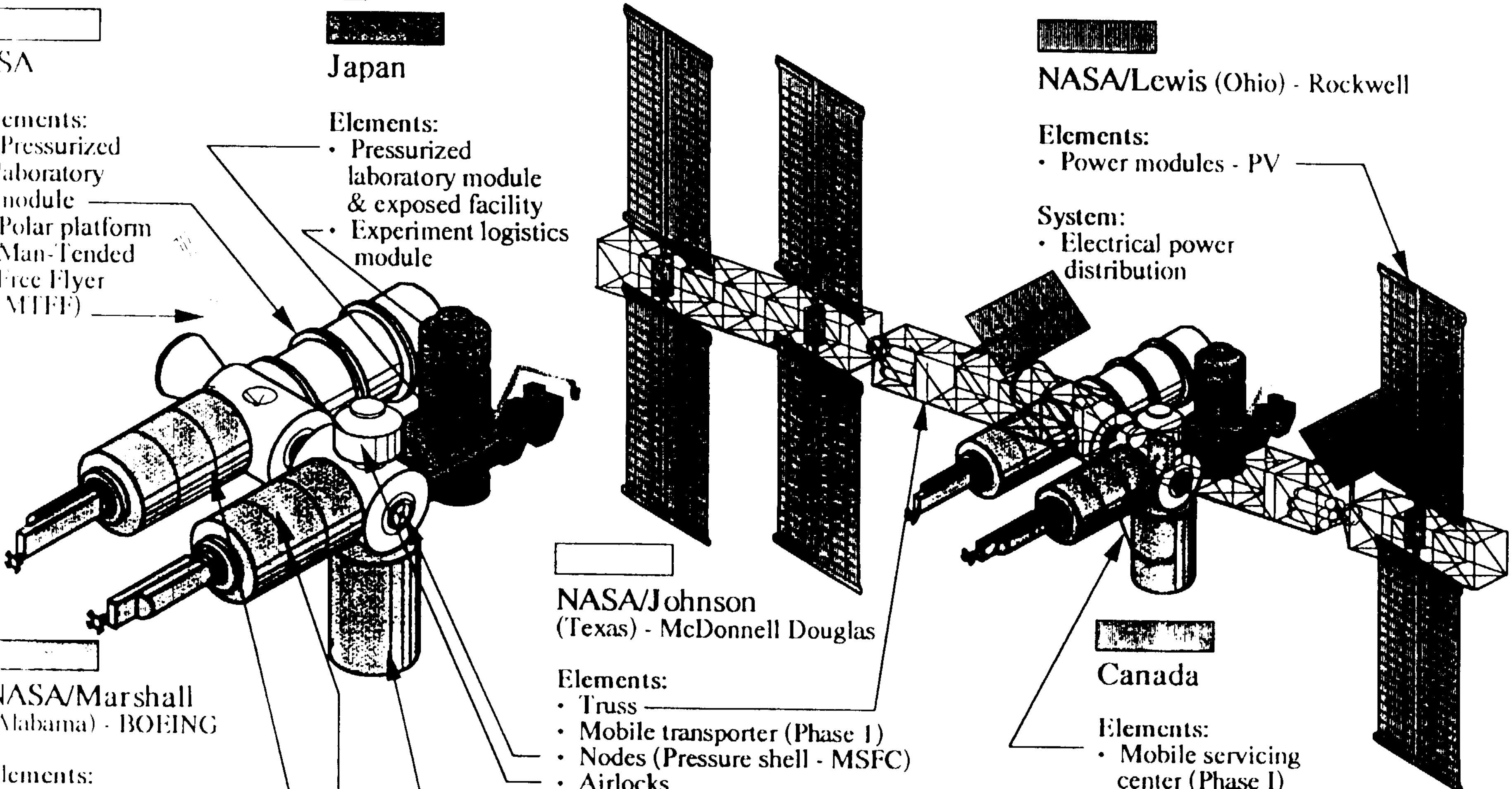
May 14, 1991

SPACE STATION FREEDOM

BALANCED COMMERCIAL ACCESS TO SPACE
EVOLUTIONARY APPROACH

- Drop Tubes/Towers (MSFC, LeRC)
- Microgravity Aircraft (KC 135)
- Suborbital Sounding Rockets (Joust, Consort)
- Orbital Rockets (COMET)
- Shuttle - Based Facilities (Middeck, SPACEHAB, Wakeshield)
- Space Station Freedom

Space Station Freedom



ESA

Elements:
- Pressurized laboratory module
- Polar platform
- Man-Tended Free Flyer (MTFF)

Japan

Elements:
- Pressurized laboratory module & exposed facility
- Experiment logistics module

NASA/Lewis (Ohio) - Rockwell

Elements:
- Power modules - PV

System:
- Electrical power distribution

NASA/Marshall
(Alabama) - BOEING

Elements:
- Pressure shells for nodes
- U.S. Laboratory module
- Habitation module (outfitting TD by JSC)
- Logistics module (press & unpress)

Systems:
- ECLSS
- Internal thermal control
- Internal audio/video

NASA/Johnson
(Texas) - McDonnell Douglas

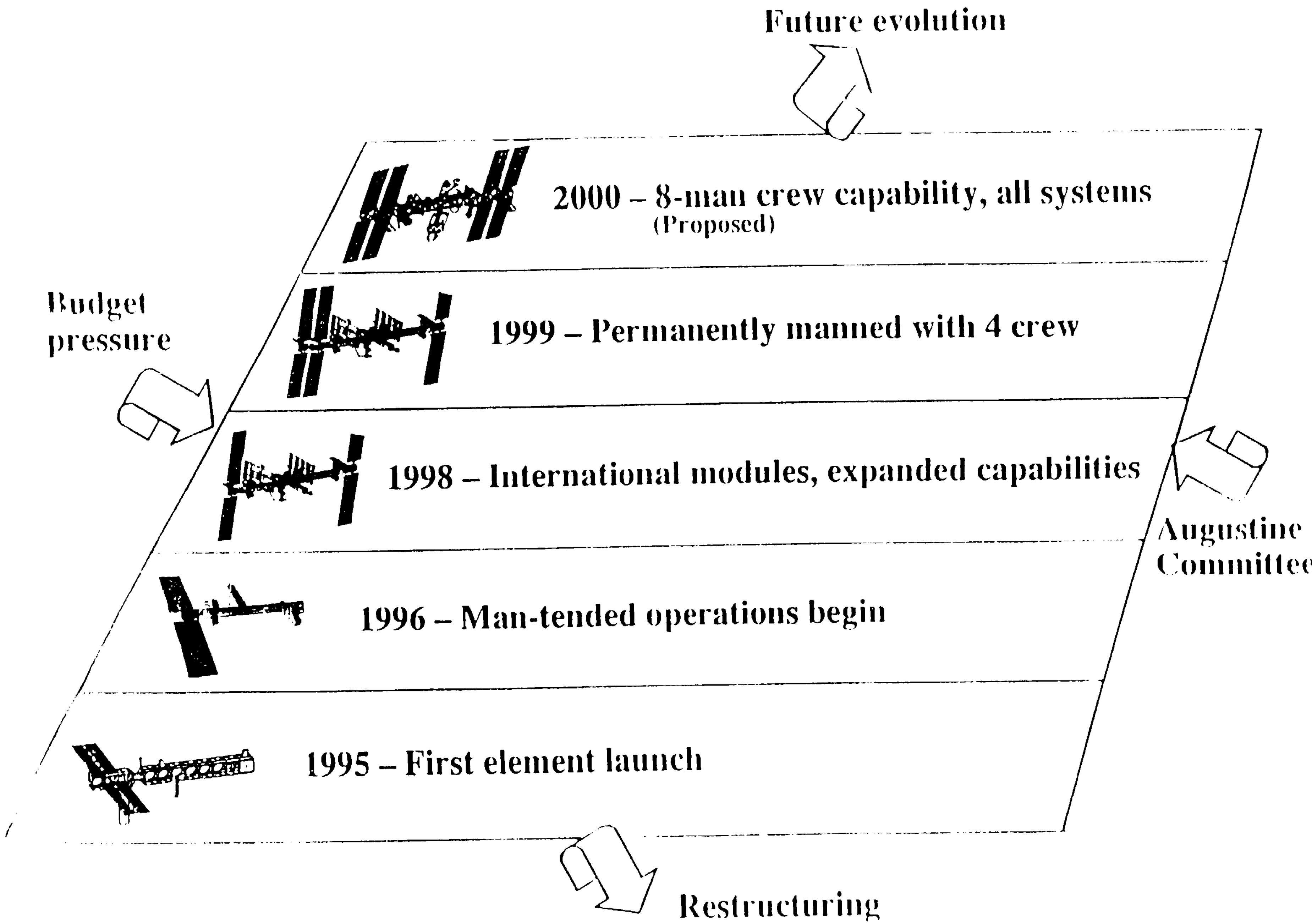
Elements:
- Truss
- Mobile transporter (Phase I)
- Nodes (Pressure shell - MSFC)
- Airlocks

Systems:
- External thermal control
- EVA
- Data management
- Communications & tracking
- Guidance, navigation & control
- Propulsion (Thruster TD by MSFC)
- NSTS/SS attachment systems

Canada

Elements:
- Mobile servicing center (Phase I)

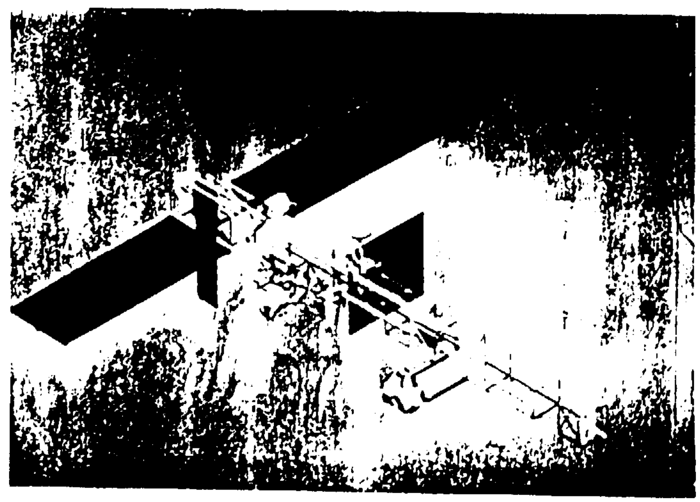
Phased Space Station Freedom Program



Man-Tended Capability

Science mode like Spacelab with equipment on orbit all year

Shuttle-based crew operates experiments during two 2-week visits per year



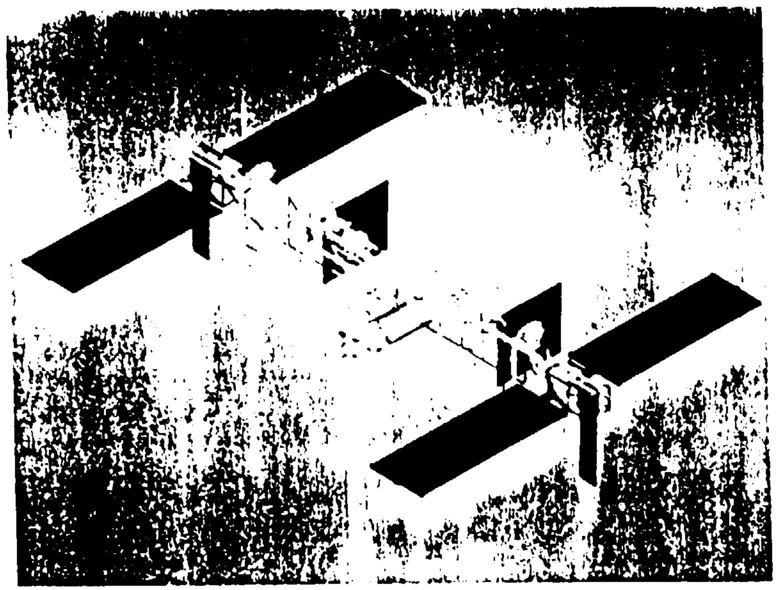
	Spacelab	Man-Tended Capability Station
User racks on orbit	6	15
Days/year of operation	39	365
Available crew	6	6
Average user power (kW)	2.5-3.5	12-45

Add power, truss, logistics, and international modules during this phase

Permanently Manned Capability

Science mode like Skylab or Mir with more power, international laboratories, and logistics

4-person crew rotates every 2 to 3 months



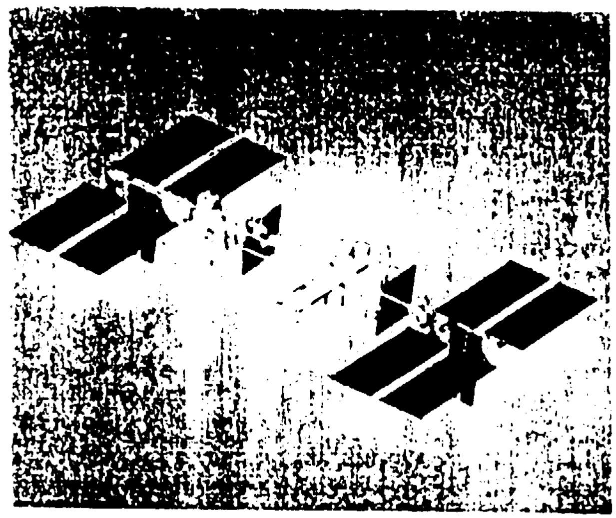
	Skylab	Mir* (estimated)	Permanently Manned Capability Station
User racks on orbit	295 m^3 workshop	10-25	14-45
Available crew	2-3	2-3	2-3
Average user power (kW)	7.5	5-10	31-54

Add habitation modules, environmental control systems, and user systems during this phase

Eight-Man Crew Capability

Full power and three laboratories with 8-person international crew

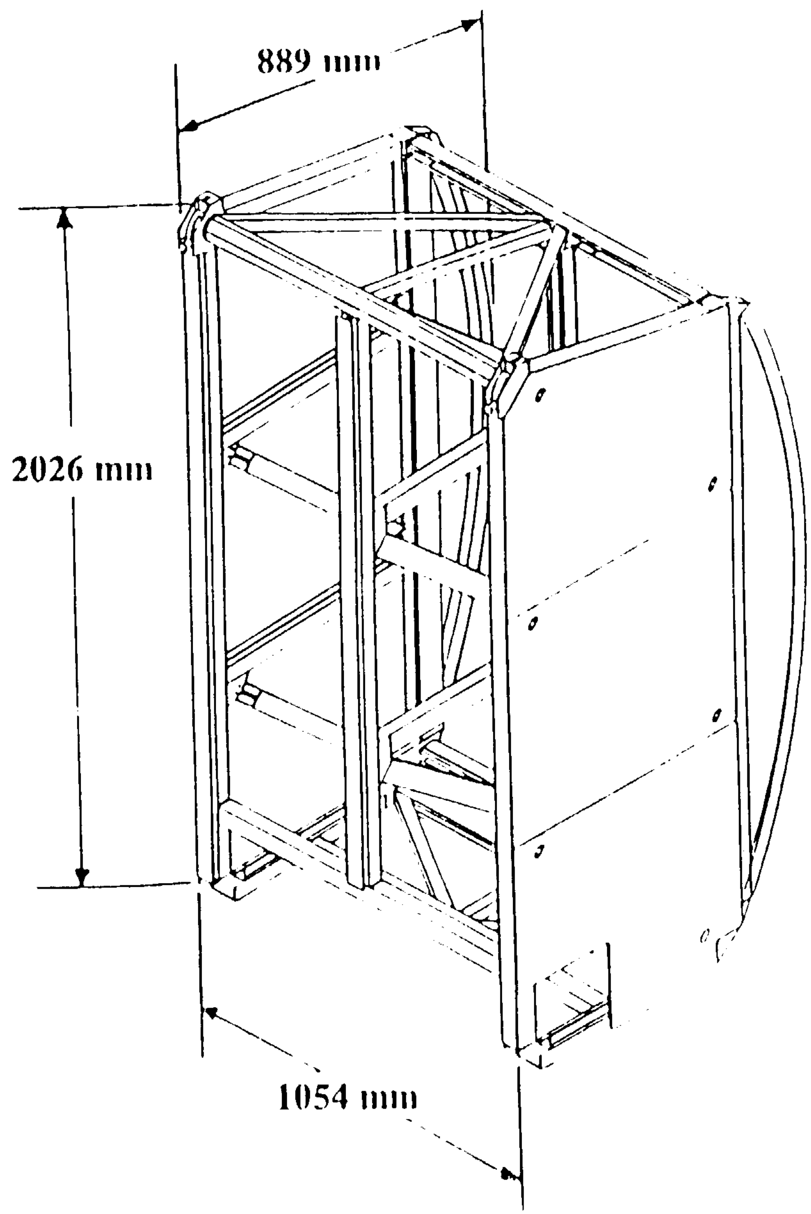
8-person crew rotates every 2 to 3 months



	Mir* (estimated)	Freedom Station
User racks	10-25	60
Available crew	2-3	6
Average user power (kW)	5-10	30

- Ready for growth missions
  - Commercial processing
  - Life sciences
  - Missions from planet Earth

Standard Payload Rack Dimensions



Resource Capabilities

	Man Tended	Permanently Manned	Eight-Man Crew
Crew Size	7 with Orbiter docked	4	8
Power, kW	18.75	56.25	75
Pressurized Volume, m^3	100	600	800
User Racks	15	46	60
Thermal Control	3°C	3°C and 17°C	3°C and 17°C
Process Fluids	Vacuum vent	Vacuum vent	Vacuum + Ultrapure water
Pressurized Logistics Modules	8-rack	8-rack + 20-rack	8-rack + 20-rack

BOEING COMMERCIAL PROJECT

(JOINT ENDEAVOR AGREEMENT)

CRYSTALS BY VAPOR TRANSPORT EXPERIMENT (CVTE)

- Joint Endeavor Agreement signed with NASA - May 1986
  - Entitles Boeing to three Shuttle experiment flights and options for two more
  - Quid pro quo entitles NASA to samples in CVTE furnaces
- Purpose of CVTE is to investigate materials processing technologies in microgravity
  - Build and integrate hardware
  - Initial investigations focus on vapor transport processing of electro-optic matierials
  - Assess commercial viability of materials processing
- First flight scheduled for STS-49 - April 1992
- Program challenges
  - Integration to a manned flight system
  - Interface requirements and schedule changes

SD2-2840A

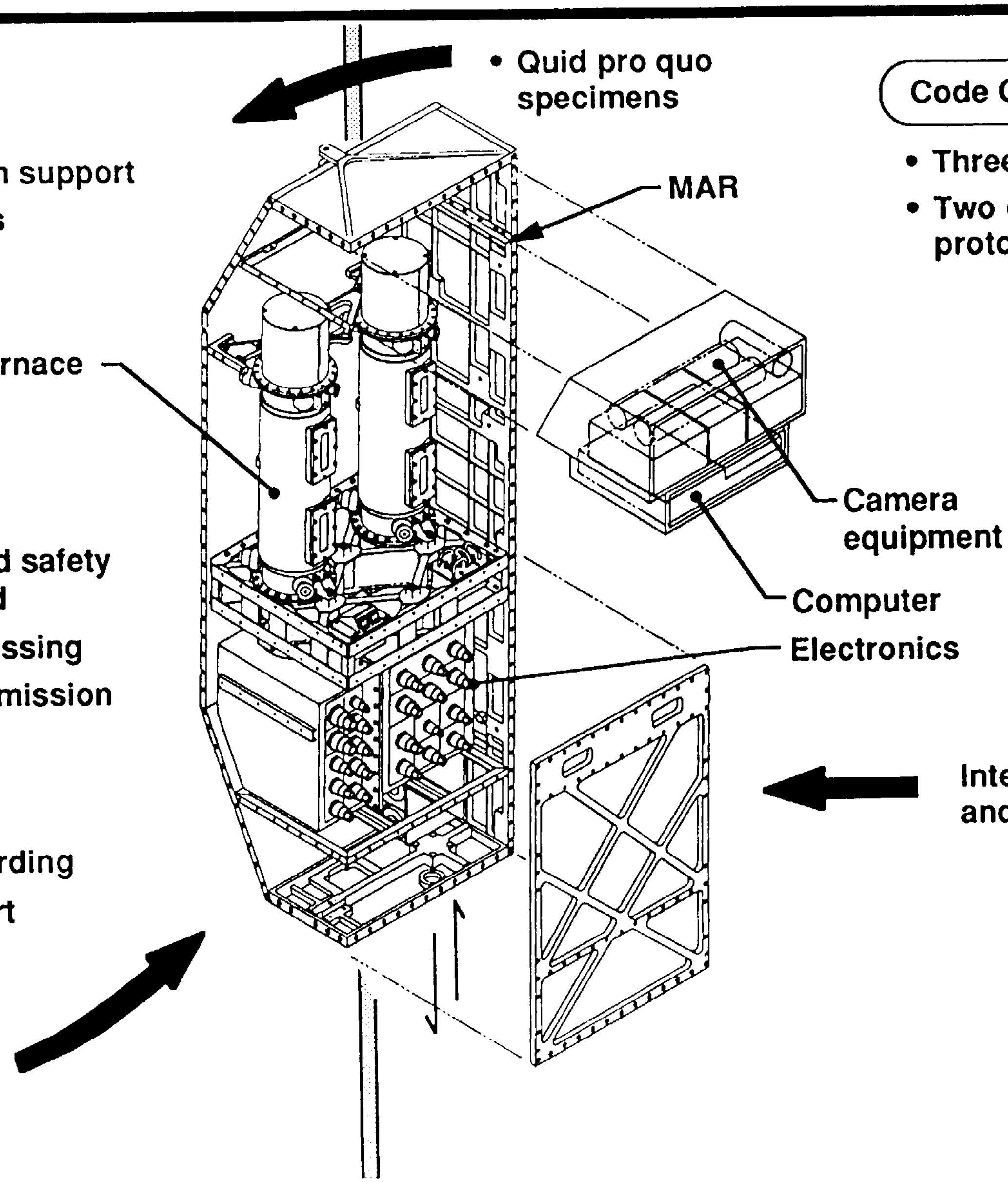
CVTE – A Cooperative Venture

CCDSs

- Science/research support
- Material samples

Boeing

- Design, test, performance and safety of CVTE payload
- Specimen processing
- Integration and mission support
- MAR/CVTE ICD certification
- Flight data recording
- Post flight report



Code C – JEA

- Three experimentation flights
- Two optional commercial prototype flights

JSC

- Integration and mission management
- Crew support

MSFC

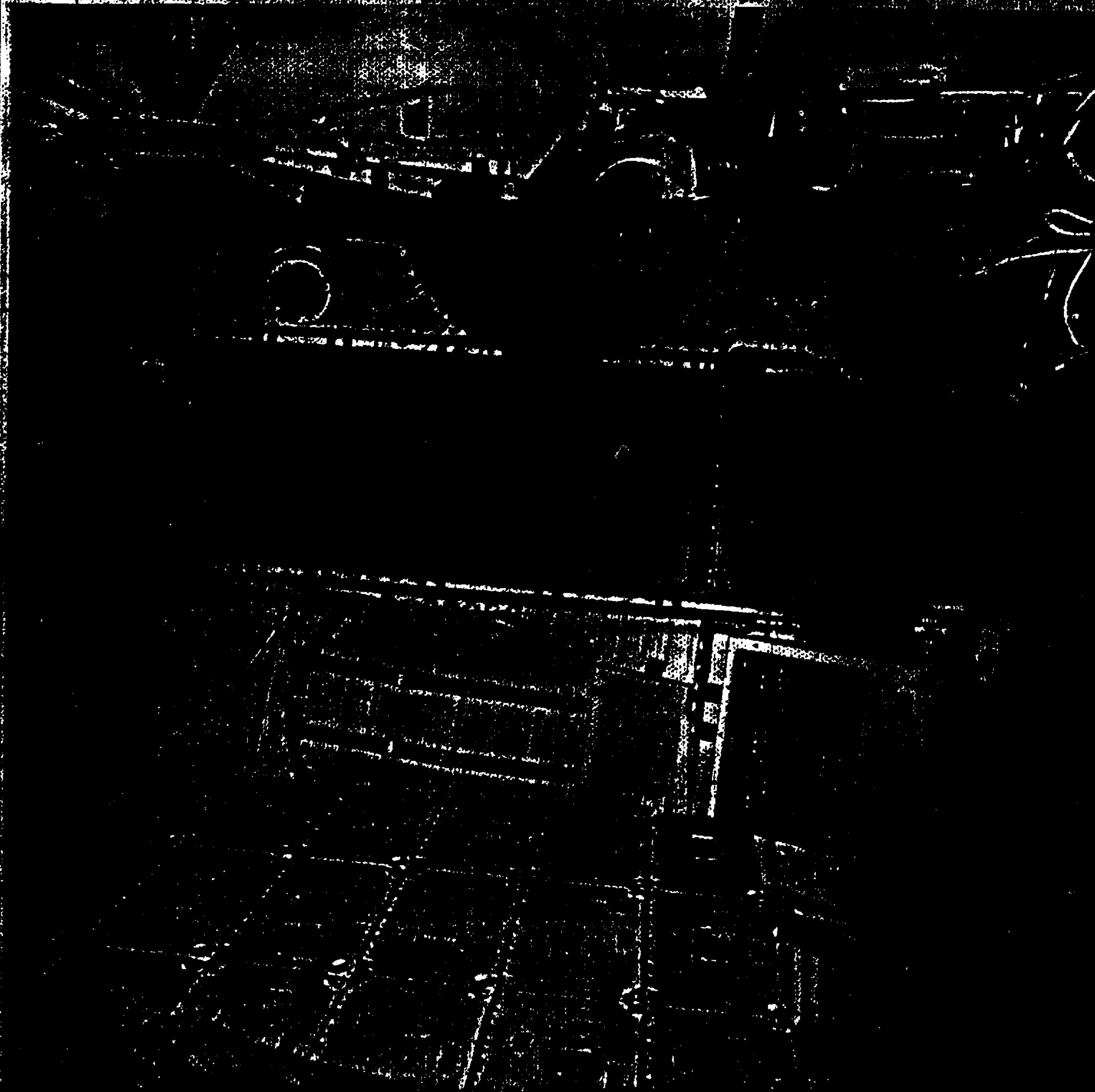
- JEA management
- Science support

KSC

- Final assembly, installation, and checkout

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058



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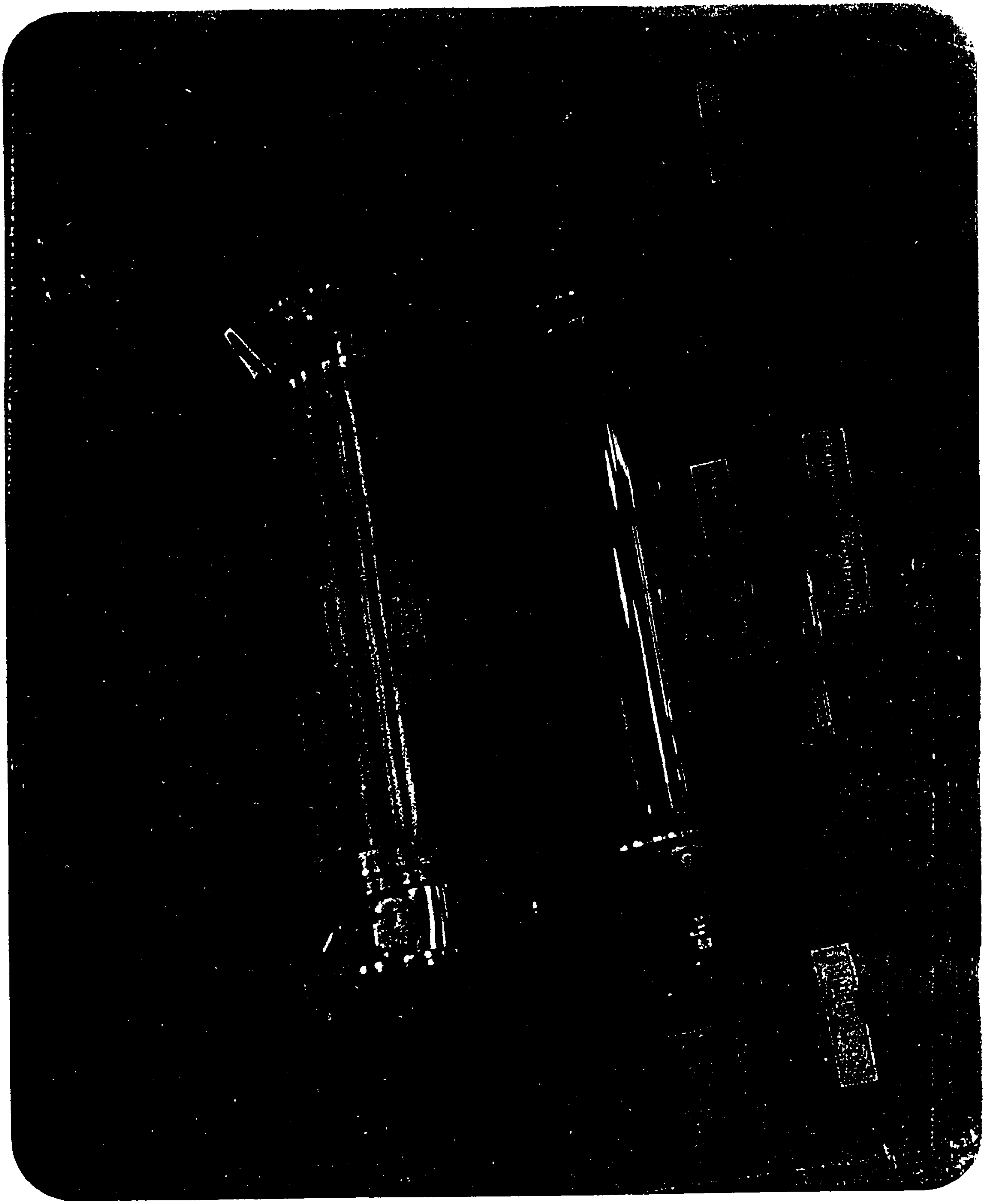

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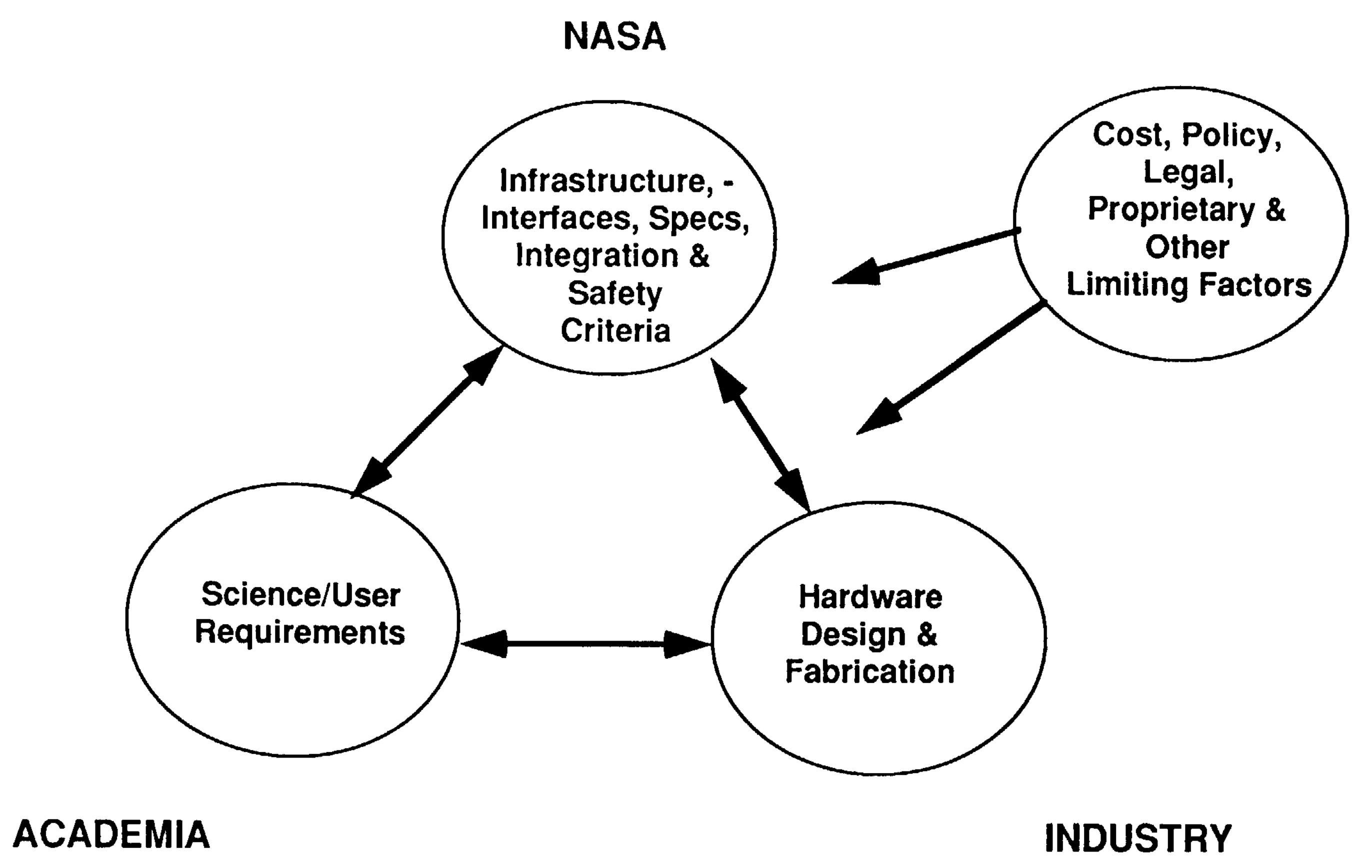
COMMERCIAL SPACE PROJECTS INTERFACES



LESSONS LEARNED

LESSONS LEARNED

ESSENTIAL ELEMENTS FOR SPACE STATION COMMERCIALIZATION

- Stable and Encouraging Pricing Policy
- Firm Commitments for Manifesting Payloads and Use of Infrastructure
- Established Requirements and Specifications
- Streamlined Management and Documentation
- Coordinated Interfaces Between NASA, Industry and Academia

STABLE AND ENCOURAGING PRICING POLICY

- Early establishment of pricing policy for SSF needed to permit commercial business analysis (cost/benefit)
- Pricing policy should be encouraging to commercial interests
  - Options may include initial reimbursement for direct services only, deferred payments, payments from revenue, and quid pro quo arrangements (such as used with Joint Endeavor Agreements for the Shuttle)
  - May not be able to provide long term pricing policy today, but NASA should establish "limited period" pricing policy

FIRM COMMITMENTS FOR MANIFESTING PAYLOADS AND USE OF INFRASTRUCTURE

- Important to know that you have guaranteed opportunity to fly within certain time period
  - Investment decisions based on prospective returns and payback periods
  - If opportunity to fly in space is in question, business interests will not support project
- Similarly, guaranteed access to adequate resources (eg - power, volume, time) on orbit is critical to commercialization

ESTABLISHED REQUIREMENTS AND SPECIFICATIONS

- Designers, developers and users of Space Station Freedom based hardware need baselined requirements and specifications early to efficiently take full advantage of its resources
  - Unclear or changing requirements results in inefficient and costly designs and redesigns
- Restructured Space Station Freedom presents opportunity to establish and disseminate user requirements
- Academic and industrial users need to become knowledgeable of the requirements so they scope their projects properly

STREAMLINED MANAGEMENT AND DOCUMENTATION

- Single layer of both management and requirements documents are crucial to efficient, lower cost, and timely development of commercial projects

- Interface, integration and safety documents for users prepared by multiple offices and NASA Centers causes confusion

COORDINATED INTERFACES BETWEEN NASA, INDUSTRY AND ACADEMIA

- Coordinate hardware and programmatic requirements and interfaces to optimize use of Space Station Freedom resources and economize the commercialization project are needed early
- Coordination applies to both government provided hardware projects as well as commercially developed hardware
  - In the case of government procurement programs, input from science and industrial user communities is important to meaningful capability built into hardware
  - Industry funded programs overlook important requirements due to lack of NASA incentive to communicate

RECOMMENDATIONS & SUMMARY

RECOMMENDATIONS

- NASA needs to establish early pricing policies, administrative procedures, and cooperative agreements to encourage commercialization
- System for "guaranteeing "access to Space Station Freedom needs to be developed; otherwise, business risk is too high
- Interface control documentation and payload accommodations books need to be published early to permit designers and users to properly scope their projects
- Integration management and documentation should be out of one office or Center (eg - Space Station Freedom Office) without allowing cross-referencing, duplication or modification by other offices or NASA Centers
- Coordinate and develop interface requirements, pricing policies, procedures, etc. to encourage cooperation between NASA, commercial, and academic communities

SUMMARY

- Space Station Freedom has abundant resources and can serve as important element in commercialization of space
- NASA, Industry and Academia cooperation is key to successful commercial ventures - CCDS's serve as a role model
- Lessons learned to date, by Boeing and others, ought to be incorporated into Space Station Freedom commercialization planning
- NASA can best stimulate commercialization with early pricing and use policy and early documentation of interfaces and requirements for Space Station Freedom use
- Commercial space strategy should include consideration of commercialization of Space Station Freedom systems and services

N92-23650

Center for Macromolecular Crystallography
University of Alabama in Birmingham

Dr. Manuel Navia
Senior Scientist
Vertex Pharmaceuticals,, Inc.

Refinement of Porcine Pancreatic Elastase Using Data from Crystals Grown in Microgravity

Porcine pancreatic elastase (PPE) crystals grown under microgravity conditions on mission STS-26 of the space shuttle "Discovery" have been shown to diffract to considerably higher resolution than the best PPE crystals grown by us on the ground (DeLucas *et. al.* (1989) ***Science* 246**: 651-654). We have now independently refined both the microgravity and ground-based data. Preliminary results of these refinements are summarized below:

D-MIN RES. to...	EARTH GRAVITY # of RFLS	EARTH GRAVITY SHELL R-FACTOR	MICRO-GRAVITY. # of RFLS	MICRO-GRAVITY. SHELL R-FACTOR
3.00Å	3546	19.0%	3624	14.2%
2.50Å	3044	18.8%	322	15.0%
2.00Å	5937	18.7%	6971	14.8%
1.90Å	1751	20.0%	--	--
1.80Å	1873	22.1%	4920	15.7%
1.70Å	1990	26.4%	--	--
1.65Å	944	32.0%	--	--
1.60Å	--	--	6636	17.2%
1.40Å	--	--	8387	20.2%
1.30Å	--	--	2079	26.6%

	EARTH GRAVITY # of RFLS	EARTH GRAVITY SHELL R-FACTOR	MICRO-GRAVITY. # of RFLS	MICRO-GRAVITY. SHELL R-FACTOR
TOTAL	19085	19.9%	35841	15.9%

Note: Deviations from ideal bond lengths for both refinements was appx. 0.020Å.

These results show nearly a doubling of experimental diffraction data for this structure, exceeding 1.3Å resolution. Improved phase information derived from the refined structure of PPE based on this microgravity data has allowed us to interpret previously-uninterpretable electron density obtained from ground-based crystals of a complex of PPE with a chemically-reactive inhibitor. Intermediate stages in the enzyme-inhibitor reaction mechanism in the crystal can now be directly observed. Further refinement of PPE structures is in progress.

Table 2:

PROTEIN	a (Å)	b (Å)	c (Å)	angles (deg.)	Soln.
Anhydro-PPE	50.74	57.94	75.28	90. 90. 90.	SUL
A-PPE + peptide	50.94	57.91	75.33	90. 90. 90.	SUL
PPE (gravity)	51.00	58.08	75.29	90. 90. 90.	SUL
PPE (micro-grav)	50.88	58.02	75.35	90. 90. 90.	SUL

Table 3:

PROTEIN	# reflections	resolution	R-Factor	Bond length deviation (Å)	detector type
Anhydro-PPE	17564	1.65Å	15.7%	0.019Å	diffractometer
A-PPE + peptide	16035	1.80Å	16.8%	0.016Å	diffractometer
PPE (gravity)	19085	1.65Å	19.9%	0.016Å	area detector
PPE (micro-grav)	35841	1.30Å	15.9%	0.016Å	area detector

N92-23651

Center for Space Power
Texas A&M University

Mr. Ken Jones
Manager
Nickel Hydrogen Batteries
Johnson Controls, Inc.

NASA's CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE

Johnson Controls is a 106 year old company employing 42,000 worldwide people with \$4.7 billion annual sales. Though we are new to the aerospace industry we are a world leader in automobile battery manufacturing, automotive seating, plastic bottling and facilities environment controls.

The battery division produces over 24,000,000 batteries annually under private label for the new car manufacturers and the replacement market. We are entering the aerospace market with the nickel hydrogen battery with the help of NASA's Center for Space Power at Texas A&M. Unlike traditional nickel hydrogen battery manufacturers, we are reaching beyond the space applications to the higher volume markets of aircraft starting and utility load leveling. Though space applications alone will not provide sufficient volume to support the economies of scale and opportunities for statistical process control, these additional terrestrial applications will. For example, nickel hydrogen batteries do not have the environmental problems of nickel cadmium or lead acid and may someday start your car or power your electric vehicle.

However you envision the future, keep in mind that no manufacturer moves into a large volume market without fine tuning their processes. The Center for Space Power at Texas A&M is providing indepth technical analysis of all of the materials and fabricated parts of our battery as well as thermal and mechanical design computer modeling.

Several examples of what we are doing with nickel hydrogen chemistry to lead to these production efficiencies can be seen in the following designs.

Our first space qualified design was influenced by a joint effort with Comsat and resulted in a 32 V, 24 Ah, 10" diameter battery that has sustained over 6,000 LEO cycles (16 charge-discharges/day) to 44% DOD at 10° C. This battery is unique in that all of the cells are packaged in a common pressure vessel (CPV) instead of the traditional individual pressure vessel (IPV) for each cell. This is a natural evolution of the technology and results in lower weight, size and cost with equal or higher reliability. The challenges in making what appears to be a simple packaging transistor are significant and a number of aerospace companies have tried and given up.

Through the use of Texas A&M's microcalorimeter, we have obtained excellent thermal transfer data which was then applied to the computer model.

We have moved from the initial 10" diameter battery with its fixed cell housing to a 5" diameter with individual heat fin dishes that permit excellent heat transfer and also ideal manufacturing tolerances for high speed assembly.

With the aid of Sandia National Laboratories we have also made two iterations of stationary batteries. One 7 kWh has operated successfully for over two years and four newer versions of 4 kWh capacity for one year.

Even with the high first cost of nickel hydrogen CPV batteries, their long cycle life over other chemistries allows the true cost to be half that of lead acid over 10 years or more.

FEATURES OF PATENTED

JCI CPV DESIGN

MULTIPLE CELLS IN A SINGLE VESSEL

STANDARD NICKEL HYDROGEN CELL COMPONENTS

BACK-TO-BACK POSITIVE CONFIGURATION

ABSORBER BETWEEN POSITIVE ELECTRODES

CELL ENCLOSED IN ECS

VENTED ECS ALLOWS HYDROGEN ACCESS

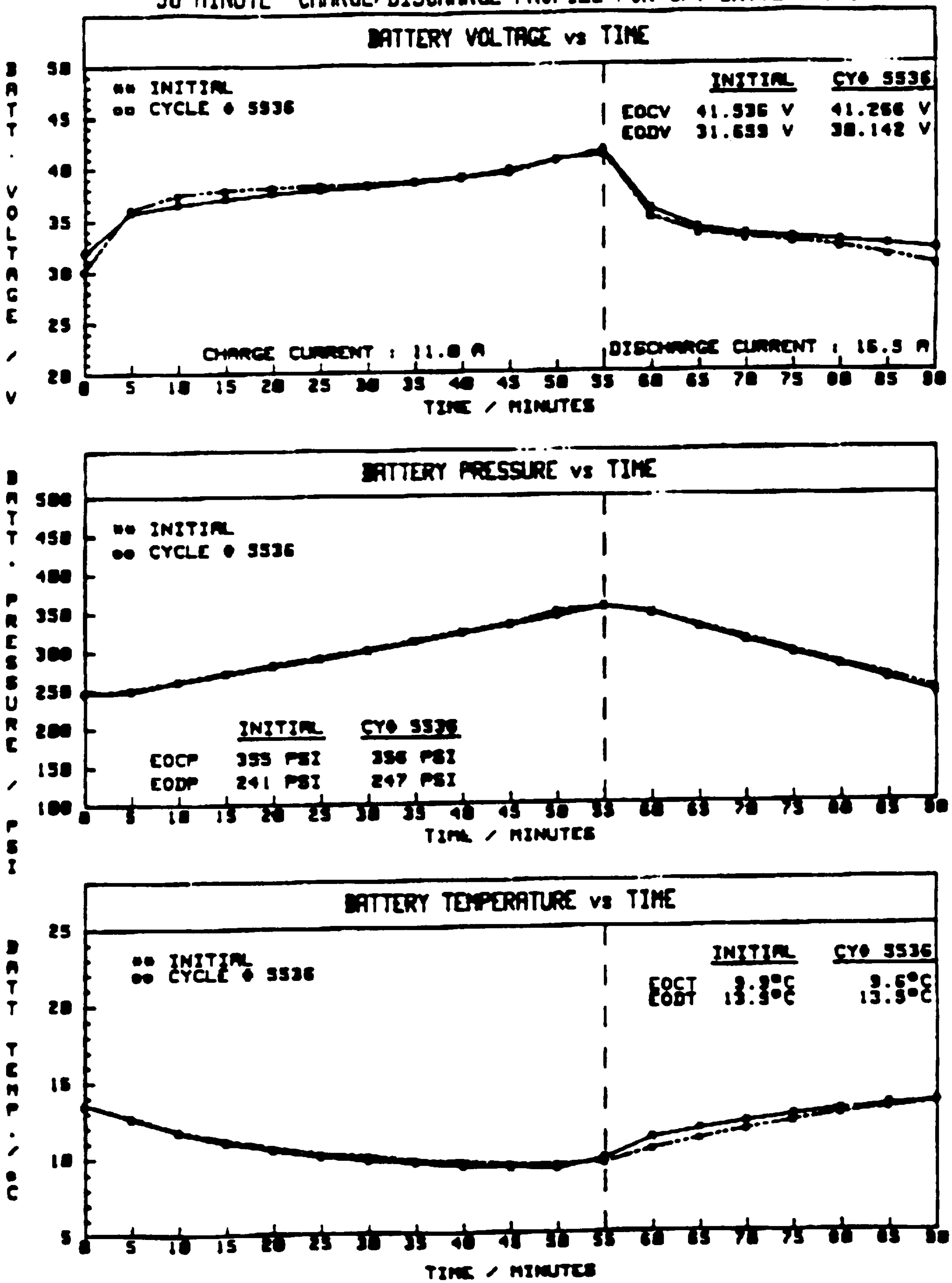
VENT LOCATION ENSURES IN-CELL RECOMBINATION

DOUBLE ECS ENHANCES RELIABILITY

RADIAL HEAT FIN IMPROVES THERMAL TRANSFER

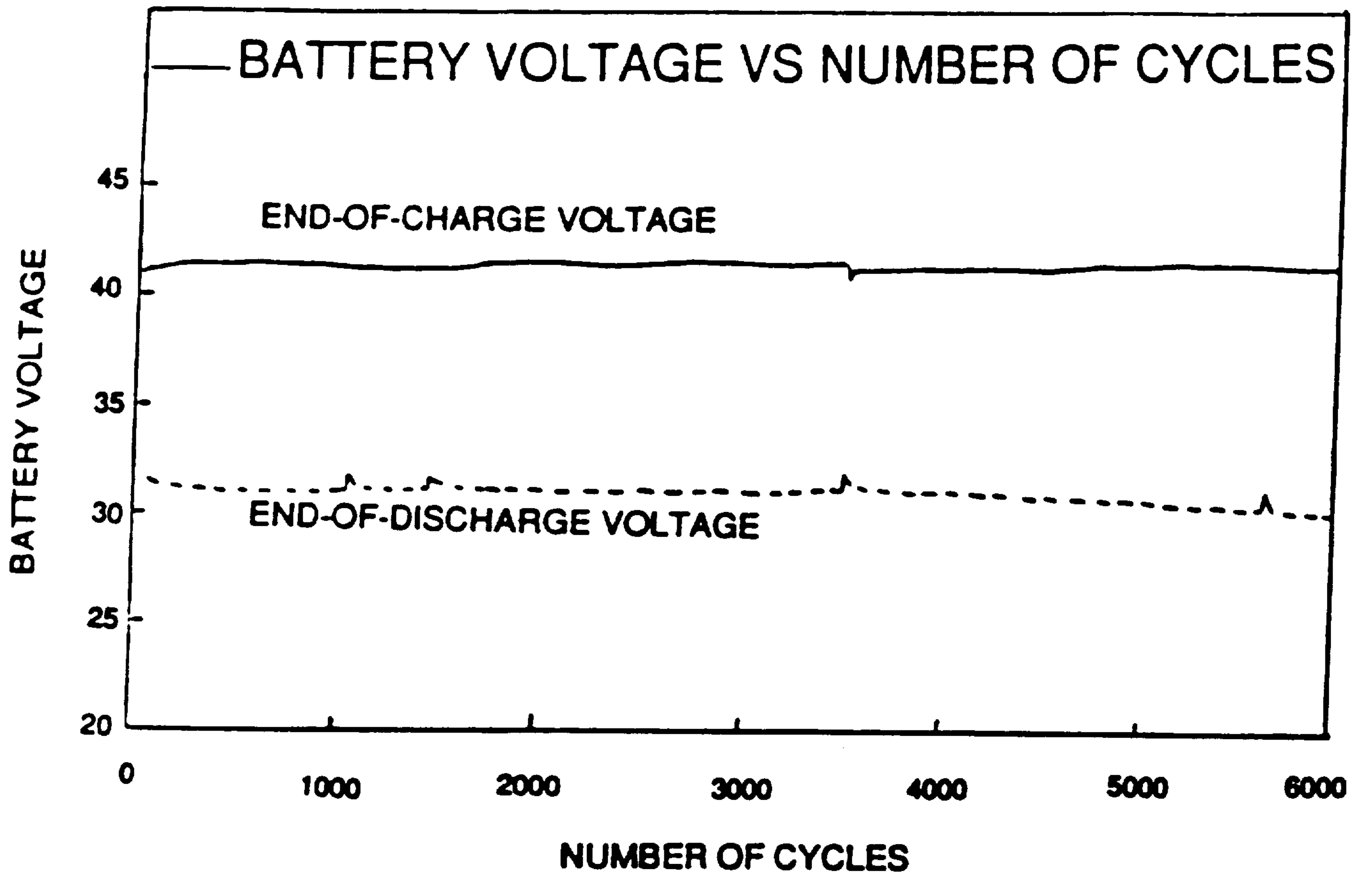
WELDED INCONEL 718 VESSEL

90-MINUTE CHARGE/DISCHARGE PROFILE FOR CPV BATTERY # 1



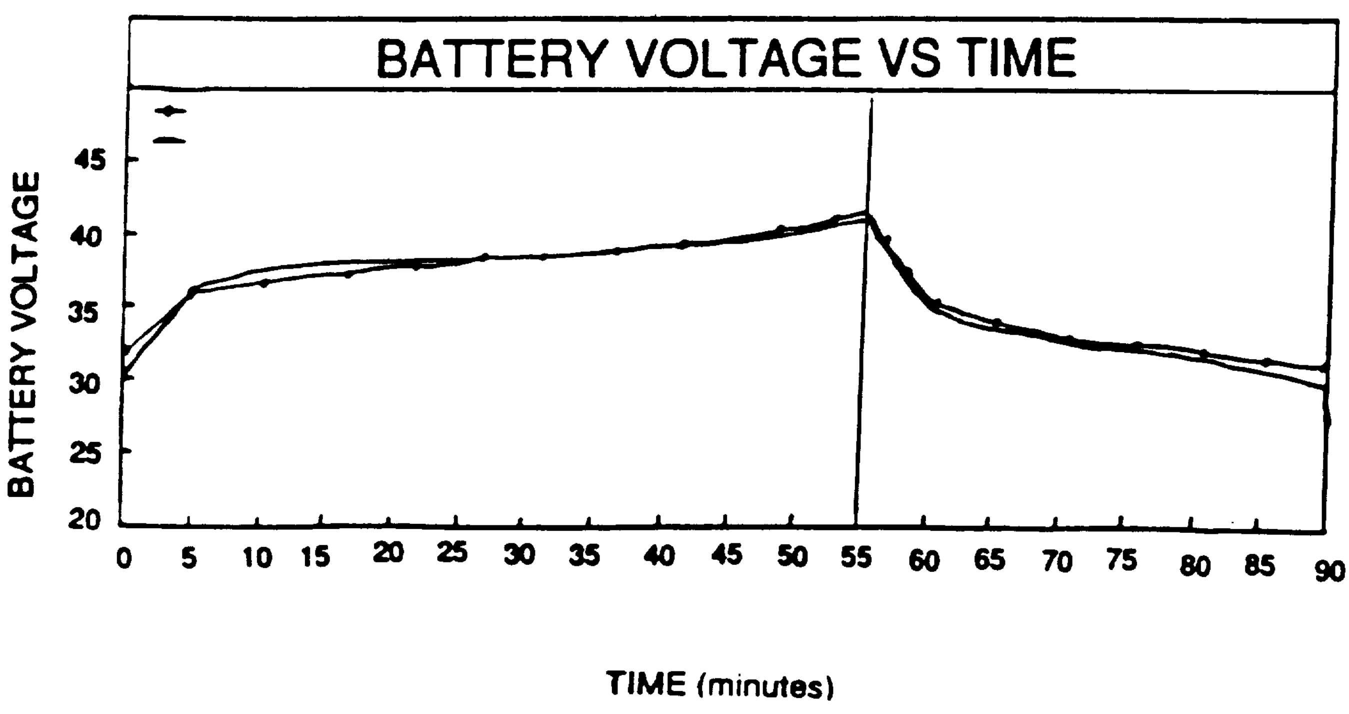
CPV PROTOTYPE BATTERY #1

44% DOD LEO CYCLING TEST



CHARGE DISCHARGE PROFILE

TEMPERATURE = 10°C



N92-23652

Advanced Materials Center, Battelle

Dr. Harold Bellis
Research Fellow
E.I. DuPont De Nemours and Co., Inc.

C-3

ADVANCED MATERIALS CENTER - BATTELLE

DR. HAROLD E. BELLIS
DUPONT CHEMICALS
E. I. DU PONT DE NEMOURS & COMPANY, INC.

MIXED OXIDE - PROGRAM GOAL

- Determine the results obtained by using microgravity processing on commercially significant catalyst - - V-P-O System.

MIXED OXIDE - WHY MICROGRAVITY

- Better control of catalyst synthetic process under microgravity

- Catalyst system selected is sensitive to preparation method used

- May obtain catalyst with improved selectivity

MIXED OXIDE - SYNTHESIS PROCESS

- Formation of droplet of precursor solution (inlet/nozzle)
- Evaporation of water (solvent) (furnace)
- Reaction of the V-P-O precursors (furnace)
- Configuration of droplet flow - - upflow to simulate microgravity.

NOVEL RESULTS OF THE EARTH BASED PROGRAM

HTAD Catalyst Active for Maleic Anhydride

HTAD Process Capability to Alter Vanadium Valency

Synthesis of New P-V-O Metal Oxide Phase

Synthesis of High Surface Area Catalysts

Synthesis of Hollow Spheres with Superior Heat Transfer

Synthesis of Ultrafine Microstructured P-V-O Catalyst

Adjustment in Process Conditions to Alter Vanadium Valency

Synthesis of P-V-O Catalyst with no Micropores

Light Weight Sperical, Fluidizable Particles

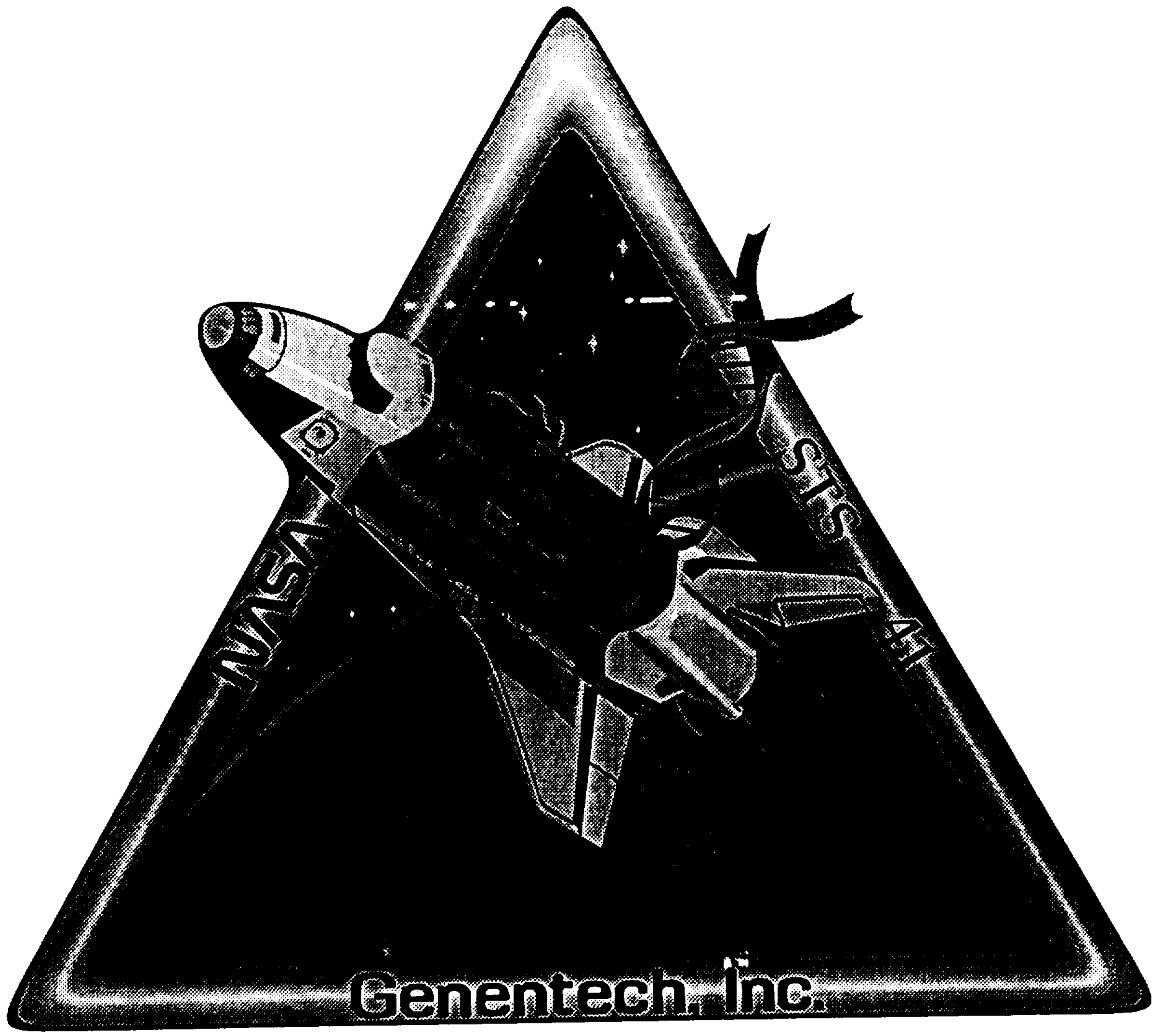
MIXED OXIDE - DUPONT INTERESTS

- Discovery
- Support from Business and Technology Centers
  - THF
  - Catalysis
- Interact with Leaders in Academia/Industry on Common Cause
- Leverage for Participants

N92-23653

Center for Cell Research
Pennsylvania State University

Dr. Mike Cronin
Director of Endocrine Research
Genetech, Inc.


NASA
STS
41
Genentech, Inc.

INTRODUCTION

GENENTECH IS GRATIFIED TO BE THE FIRST BIOTECHNOLOGY COMPANY TO HAVE CONDUCTED A LIFE SCIENCES EXPERIMENT IN MICROGRAVITY.

AMERICANS HAVE DISCOVERED AND APPLIED MOST OF THE PREEMINENT SCIENTIFIC AND TECHNOLOGICAL ACHIEVEMENTS OF THIS CENTURY, INCLUDING THE GENETIC ENGINEERING OF PROTEINS FOR HUMAN HEALTH APPLICATIONS.

WE MUST IMPROVE OUR ABILITY TO RAPIDLY TRANSLATE ADVANCES IN PROCESS AND BIOLOGICAL SCIENCES INTO ECONOMIC AND HEALTH BENEFITS FOR THE AMERICAN PUBLIC.

CRONIN
5-14-91

GENENTECH, INCORPORATED

GENENTECH DISCOVERS AND PRODUCES BY RECOMBINANT DNA TECHNOLOGY PHARMACEUTICALS FOR HUMAN HEALTH.

- 1989 REVENUES OF $476 MILLION

- **GROWTH HORMONE**, **TISSUE PLASMINOGEN ACTIVATOR** AND **GAMMA-INTERFERON** ARE APPROVED BY THE FDA FOR TREATING GROWTH HORMONE INADEQUACY IN CHILDREN, HEART ATTACK AND CHRONIC GRANULOMATOUS DISEASE IN CHILDREN, RESPECTIVELY

- PARTIAL LIST OF PROTEINS IN CLINICAL TRIALS:

    - DNASE FOR CYSTIC FIBROSIS
    - INSULIN-LIKE GROWTH FACTOR FOR DIABETES
    - RELAXIN TO FACILITATE CHILDBIRTH
    - HER-2 FOR BREAST AND OVARIAN CANCER

CRONIN
5-14-91

- ~ 40% OF OUR REVENUES REINVESTED IN R & D, TWICE THAT OF OUR NEXT COMPETITOR

- 2100 EMPLOYEES; 27% HAVE ADVANCED DEGREES

- ~ 1,500 PEER REVIEWED ARTICLES PUBLISHED IN THE PUBLIC LITERATURE BY GENENTECH SCIENTISTS SINCE 1977

- HOLD 88 PATENTS IN U.S. AND 672 ABROAD WITH 1076 PENDING

CRONIN
5-14-91

HISTORY OF PHYSIOLOGICAL SYSTEMS EXPERIMENT (PSE - 01)

1988 PENN STATE CCDS CONTACTS GENENTECH

1989 GENENTECH MEETS WITH NASA - AMES RESEARCH CENTER SCIENTISTS AND ADMINISTRATORS

GENENTECH, AMES AND PENN STATE PRESENT PLAN TO MR. JAMES ROSE

MANIFESTED ON STS-41 IN DECEMBER

1990 FLIGHT CREW TRAINED FOR PSE-01

PSE-01 LAUNCHED ON DISCOVERY OCT 6

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5-14-91

SCIENTIFIC RATIONALE

WE ARE INTERESTED IN THE REPORTS OF BONE AND MUSCLE WAISTING, AS WELL AS IMMUNE CELL DYSFUNCTION, THAT OCCUR IN MICROGRAVITY.

A NUMBER OF HUMAN DISORDERS ARE ASSOCIATED WITH MALADAPTIVE CHANGES IN BONE, MUSCLE AND IMMUNE FUNCTION.

THE ADJUSTMENTS TO SPACE FLIGHT MAY AID IN THE DISCOVERY OF NEW PROTEIN FORMS AND PATTERNS. THIS RESEARCH MAY ALSO PROVIDE STRATEGIES FOR PROTECTING THE HEALTH OF FLIGHT CREWS ENDURING PROLONGED SPACE FLIGHT.

WE MEASURED THE LEVEL OR EFFECT OF A NUMBER OF PROTEINS DURING PSE-01.

CRONIN
5-14-91

WE LEARNED

- PRECIOUS LITTLE IS KNOWN ABOUT PHYSIOLOGIC ADJUSTMENTS TO MICROGRAVITY.

  THUS, OUR ABILITY TO CONTROL SOME IMPORTANT EXPERIMENTAL VARIABLES, AND TO PREDICT THE COMMERCIAL OPPORTUNITY, WAS LIMITED BY LACK OF EXPERIENCE AND KNOWLEDGE.

- NASA IS A COMPLEX AND DEMANDING ORGANISM.

CRONIN
5-14-91

TAKE HOME MESSAGE

PSE-01 FLEW AND LANDED ON TIME !

HEALTHY SPECIMENS WERE RETURNED TO US FOR ANALYSIS.

THE SYSTEM CAN WORK WITH PRIVATE ENTERPRISE.

CRONIN
5-14-91

GENENTECH SPACE SHUTTLE EFFORT 1990
(partial list)

Allen, Judy
Bancroft, Celeste*
Booker, Chris
Bowman, Terri*
Clark, Ross*
Crase, Dietrich*
Daugherty, Ann
Frankel, Lalaine*
Gantzox, Robin
Hancock, Bill*
Hansen, Stan*
Hollenbach, Cathy
Lai, Corazon*
Lyon, Becky*
Mauldin, Rita*
Moffat, Barbara*
Morita, Carol*
Mortensen, Debbie*
Nellen, Carol
Oeswein, J.Q.*
Powers, Don
Reyes, Joey
Rogers, Susan*
Runner, Mary*
Salud, Joe
Siegel, Mark
Tatum, Jane*
Terrell, Tim*
Trainor, Jim
Vega, Kathy*
Wenzel, Pat
Zamora, Sam
Peter Gribling

Andow, Kerrie*
Beck, Steve
Booth, Richard
Briggs, Jonathan
Cook, Jennifer
Cronin, Mikie
DeGuzman, Leo
Fuchs, Hank*
God
Hotchkiss, Adair
Harris, Angela
Keller, Gilbert
Lee, Dave
Macario, Robin*
McCracken, Joe*
Mohler, Margie
Morita, again
Muphy, Jack
Niall, Hugh*
Osborne, Dave
Raygoza, Tino
Richards, Jim*
Roos, Filip
Rusher, Tamara
Schwall, Ralph*
Strasser, Joe*
Taylor, Robin
Tetlow, Sharon*
Vandlen, Dick
Webb, Dale
Woods, Kathryn*
Bill Lagrimas

CRONIN
5-14-91

THANKS

- NASA HEADQUARTERS, ARC, KSC AND JSC
- PENN STATE CCDS
- KIRK RAAB AND THE EXECUTIVE MANAGEMENT OF GENENTECH

DEDICATION

PSE-01 IS DEDICATED TO THE MEMORY OF MATTHEW MATLOCK, WHO DIED AT BIRTH DURING THE FLIGHT OF DISCOVERY.

N92-23654

Center for Space Power and Advanced Electronics
Auburn University

Dr. Dan Deis
Manager of Engineering Science

Dr. Richard Hopkins
Manager of Electro-Optical Materials

Westinghouse Science and Technology Center

VALUE OF PARTICIPATION IN A CCDS TO AN INDUSTRIAL PARTNER

Dr. D. W. Deis

Dr. R. H. Hopkins

Westinghouse Science & Technology Center

Member of
NASA/Auburn University CCDS;
Center for Space Power and Advanced Electronics

NASA Office of Commercial Projects
Washington, DC
May 14, 1991

Westinghouse
Science & Technology Center

Westinghouse Is Involved In Space Activities: Its Commercial Activities Are Expanding As A Result Of Its CCDS Participation

- Space Division
- Commercial & Civil Space Dept.
- Science & Technology Center
- NASA CCDS's

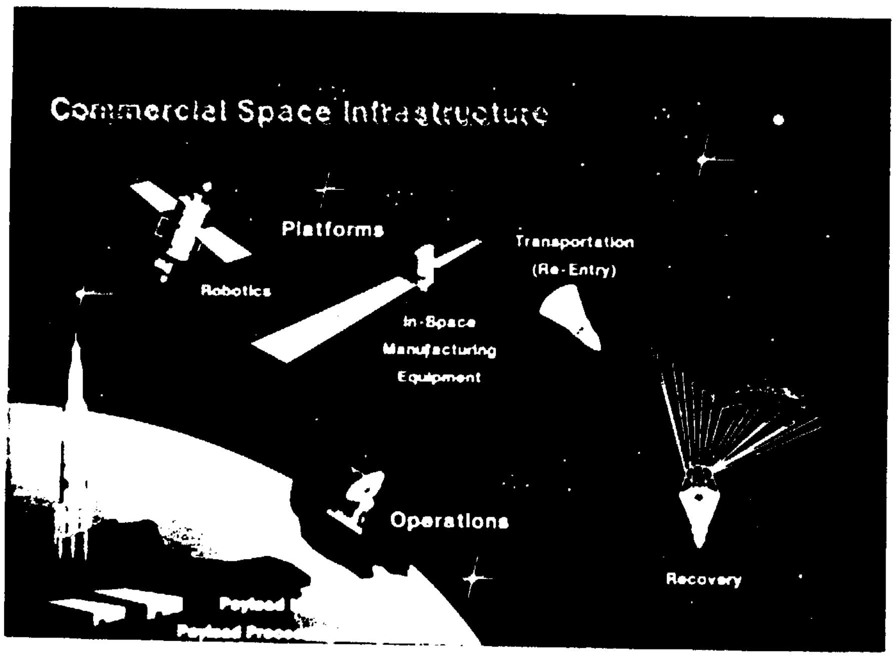
The Westinghouse Space Division Applies Its Advanced Electronic Capability to the Analysis, Design, Development Production and Support of Space Related Missions

DMSP (Block V) Operational Line Scan (OLS) systems combine sensors, on-board data processing and broad-band digital recording to provide wide dynamic range imagery. Block V sensors have successfully demonstrated many years of on-orbit continuous operation

- Earth Observation Sensors
- Control and Data Management
- Signal Processing
- Space Defense

Westinghouse
Science & Technology Center

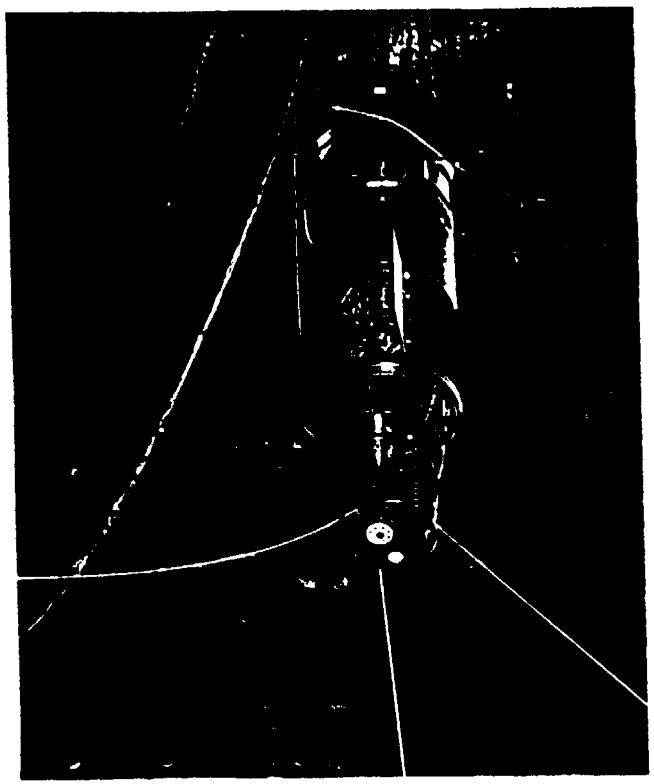
The Westinghouse Commercial & Civil Space Department Is Committed to Development the Infrastructure for Low Cost Access to Space



- Responsible for the Systems Engineering and Service Module for the COMET project.
- Operates Astro Tech for payload processing.
- Will actively pursue all aspects of commercial launch, on-orbit services, and recovery.
- Maintains active interactions with several CCDS's.

Westinghouse
Science & Technology Center

The Westinghouse Science & Technology Center Develops Products & Technologies for Westinghouse Divisions



<u>Major Space Activities</u>

- SPEAR Program
- Hyper-Conductor Generator
- TEM-Pump for SP-100
- Space Furnaces
- SMES Program
- Participation in CCDS's
  - Auburn
  - Clarkson

Westinghouse
Science & Technology Center

Westinghouse, In Conjunction With The Auburn CCDS, Is Developing Space Related Products and Technologies

Products: Intelligent fault protection system based on neural network technology

- Critical element of adaptive (autonomous) controls for electrical power systems and components.
- Terrestrial applications can expedite commercialization.

Technologies: High temperature, radiation-hard electronics based on SiC

- Enabling technology for highly reliable and long-lived space based electronics.
- Extensive commercial and military applications.

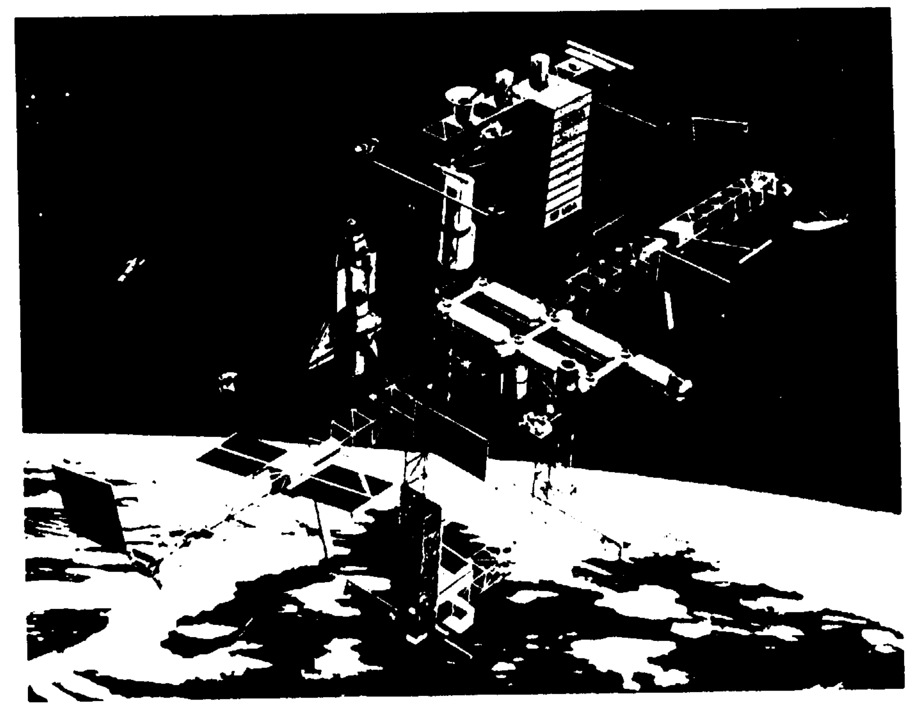
Intelligent Adaptive Controls Can Improve The Reliability of Space Power Systems

- Minimizing human response time and errors in correcting faults, and properly interpreting fuzzy sensor signals.

- High level autonomous operation

- Detecting incipient faults

- Impact
  - Improved availability
  - Reduced fault severity
  - Reduced maintenance time



The Development of the Product Need, Concept and Implementation Has Utilized Significant University Participation

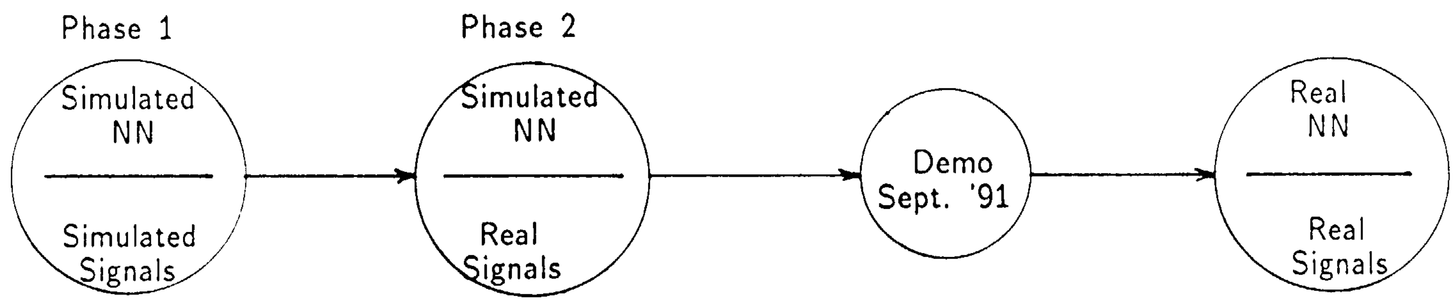
W - STC

- Selection of neural network applications
- Integration of neural network with hardware
- Training of neural network with data
- Laboratory set-up and demonstration
- Commercialization

Auburn U

- Consultation on neural network techniques
- Development of user-friendly neural network software
- Development of parallel processor computer system on card
- Awareness of current developments in neural network hardware and paradigms

Intelligent Fault Protection Development Accompishments and Status



	Phase 1	Phase 2	Demo Sept. '91	
Applied To:	Power System	Power Component (Motor Controller)	Power Source Motor Controller Motor	• (W) Commercialization Maritime Industry • Space Applications • Central Control Systems
Features:	• Proof of concept NN fault classification	• Real-world interface • C-language program (fast) • Realistic input signals • Flexible design choices	• Fault Detector/ Classifier Plug In Board • Real-time response	

Westinghouse
Science & Technology Center

Silicon Carbide (SiC) - The Semiconductor With the Right Stuff

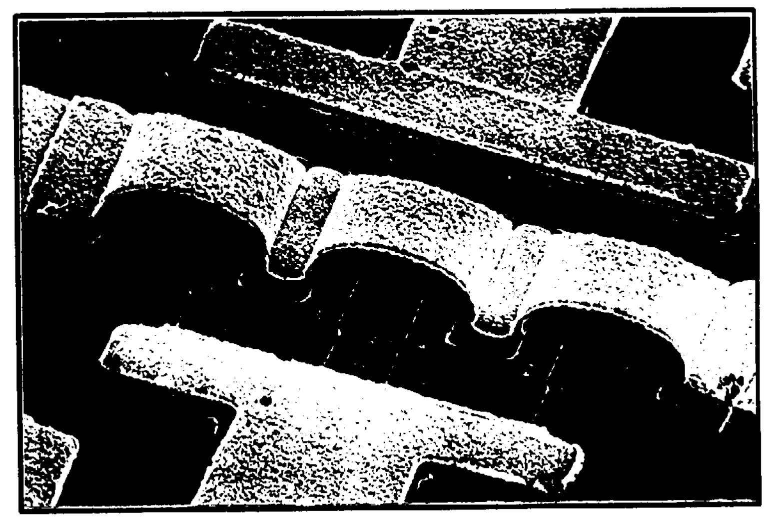
Rectification in a Hot, Chemically Active Environment

STC

1A617.BW

SILICON CARBIDE ELECTRONICS

- High Temperature, RAD Hard Devices are an Enabling Technology for Advanced Ultrareliable Space Electronics
  - Secure, Uninterrupted Satellite Communications
  - Significant Reduction in Satellite Payload Cooling and Weight
  - Compact Reactor Diagnostics and Thrust Controls for SEI Missions



- Silicon Carbide is a Pervasive Technology with Many Commercial Applications

2T500 / VS2561

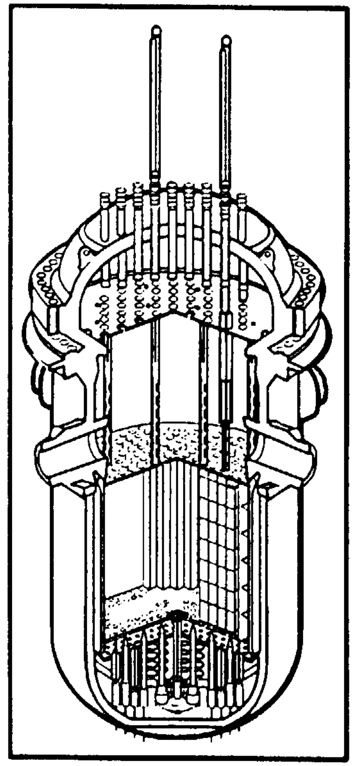
Silicon Carbide Beats Nearest Competitor

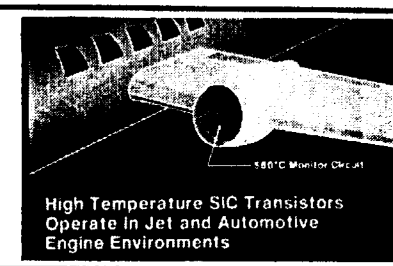
High Power
- 10X Power Density
  - Reduced Parts, Size, Cost
  - New Capabilities: Stealth Detection

High Temperature
- 650° Operation vs. 150°
  - Less Cooling, Weight, System Cost
  - 1,000X Reliability

Radiation Hard
- 20X Gamma, 50X Neutron Resistance
  - First In-Core Electronics for Protection and Control
  - Reduced Cabling, Penetrations and Cost
  - New Services

Transistors for Long-Range Surveillance





Electronics in Severe Environments: All-Electric Vehicles

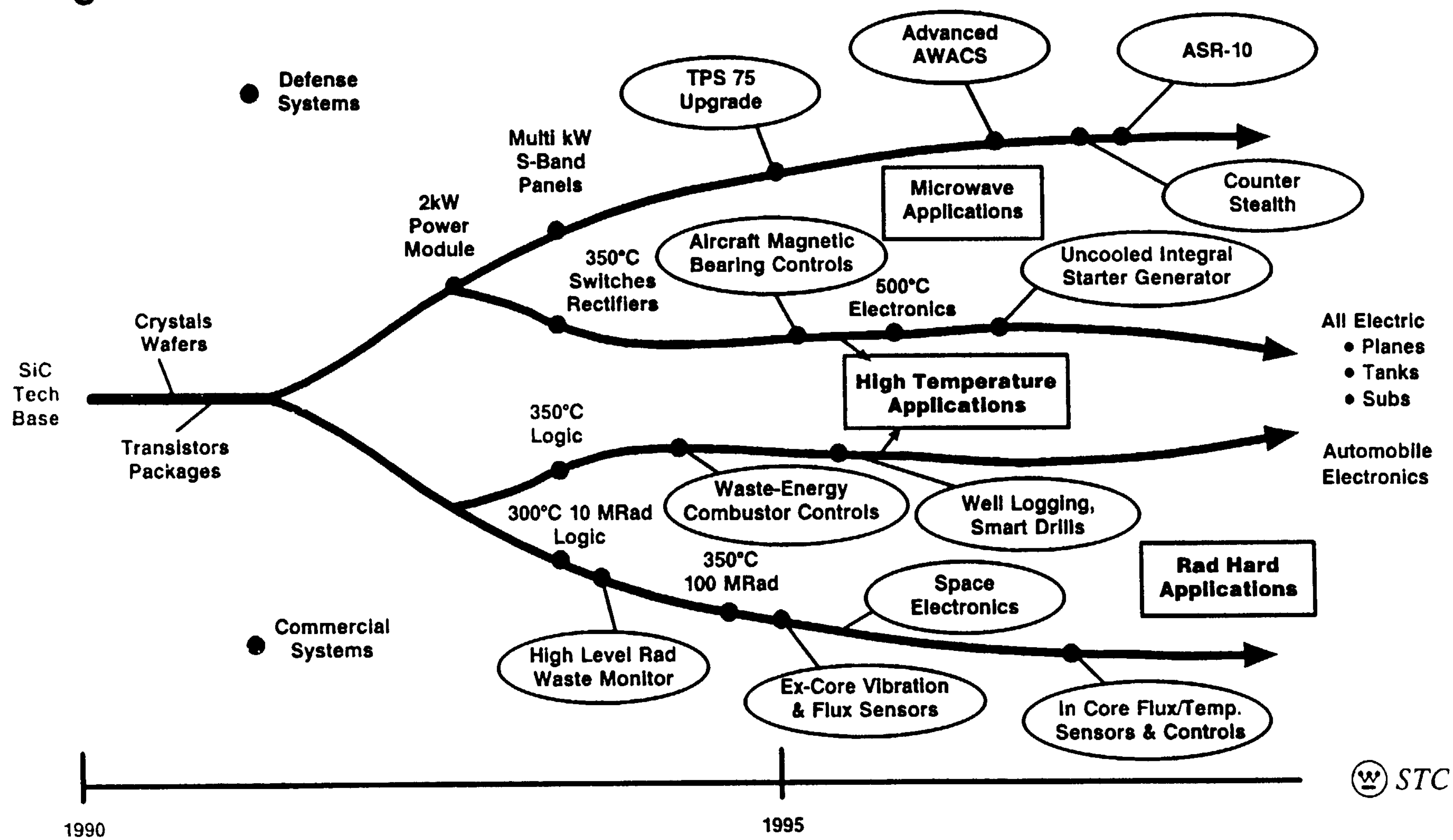
In-Core Flux and Temperature Measurements at 100 MRad 350°

STC

1A620.BW

Silicon Carbide Payoff

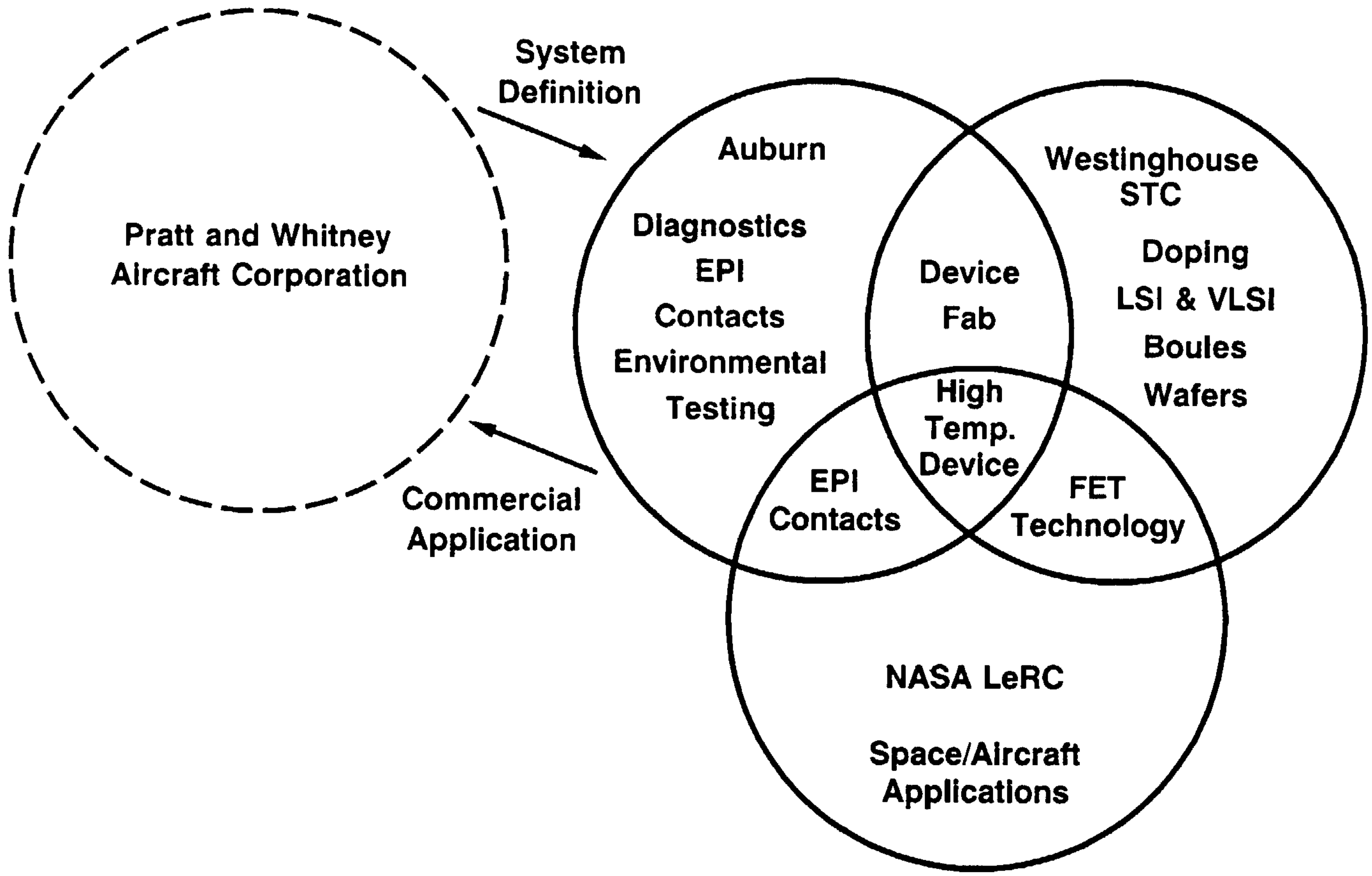
Significant New Business



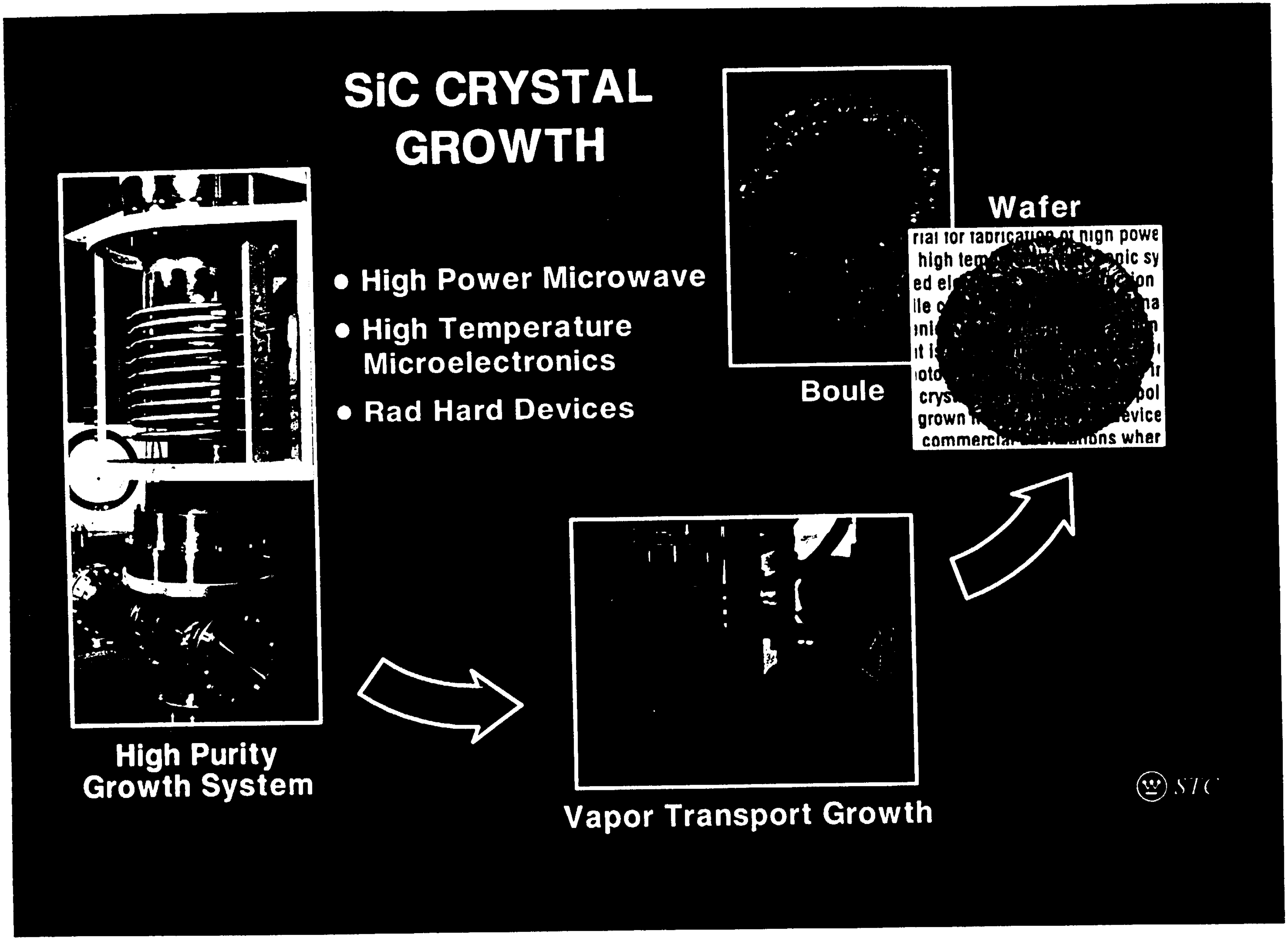
1a618.bw

THE AUBURN CCDS PARTNERSHIP

Complementary Skills Linked to Accelerate Silicon Carbide Electronics to Commercialization

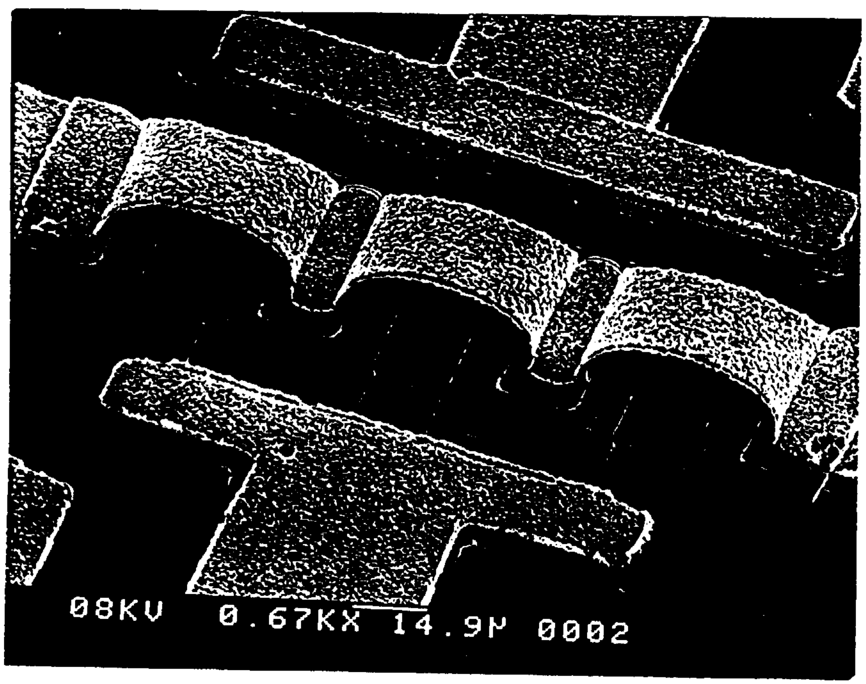


2T501 / VS2561

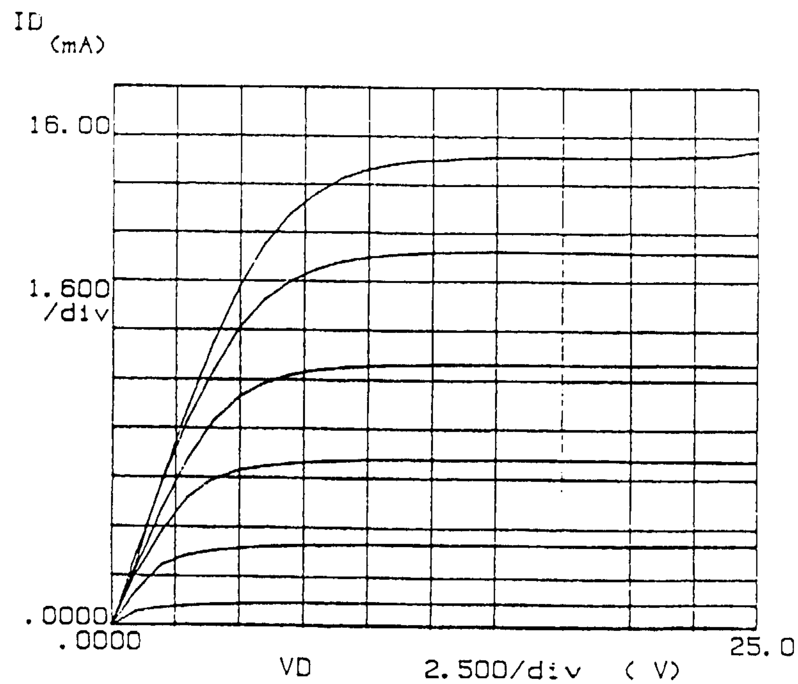

SiC CRYSTAL GROWTH
• High Power Microwave
• High Temperature Microelectronics
• Rad Hard Devices
High Purity Growth System
Vapor Transport Growth
Boule
Wafer
STC

SiC Device Development At STC For Microwave Power Transistors

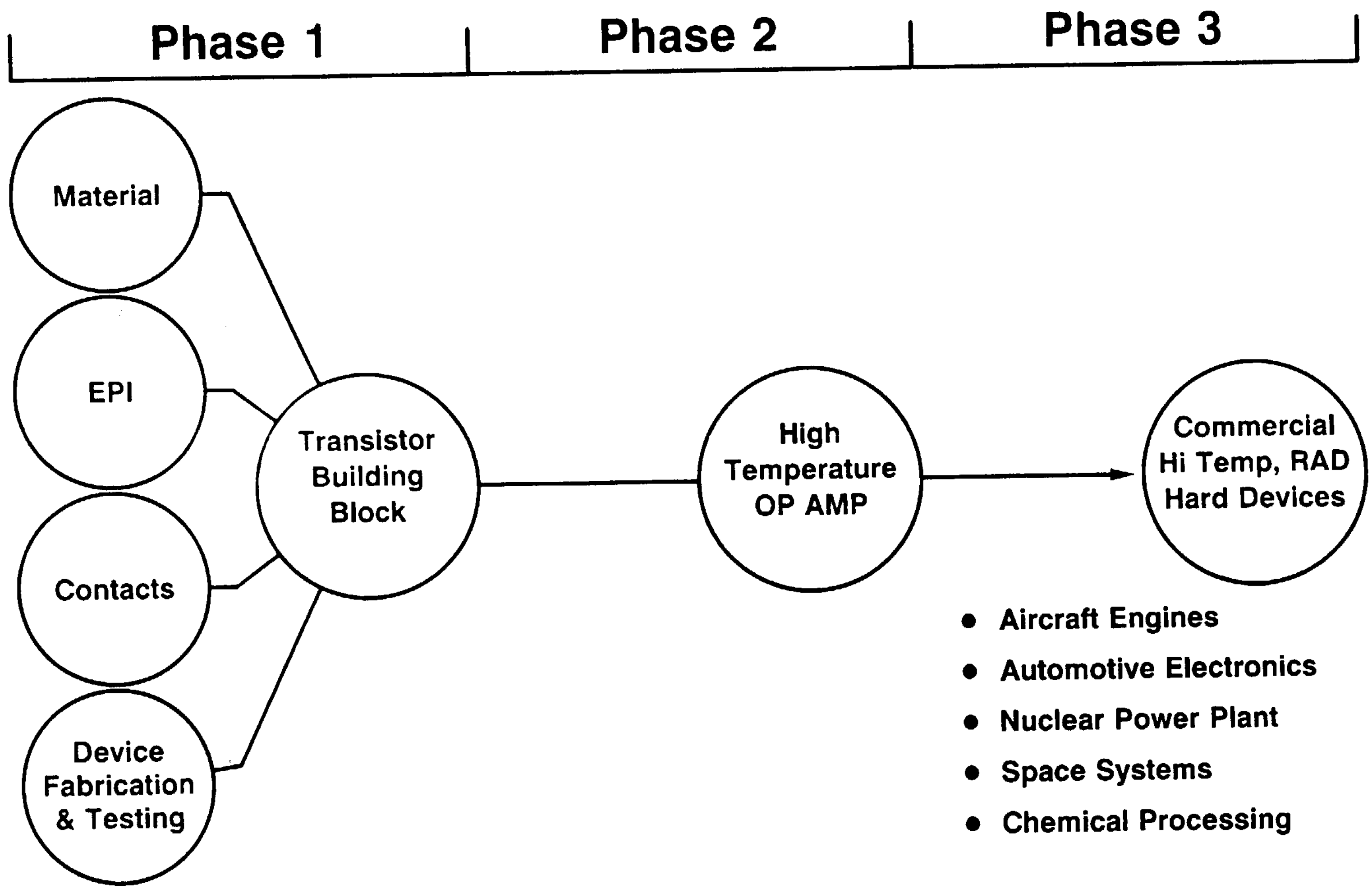
6-Gate μ-Wave Transistor



dc Characteristics



A SILICON CARBIDE MICROELECTRONIC DEVICE DEVELOPMENT PATH HAS BEEN DEFINED

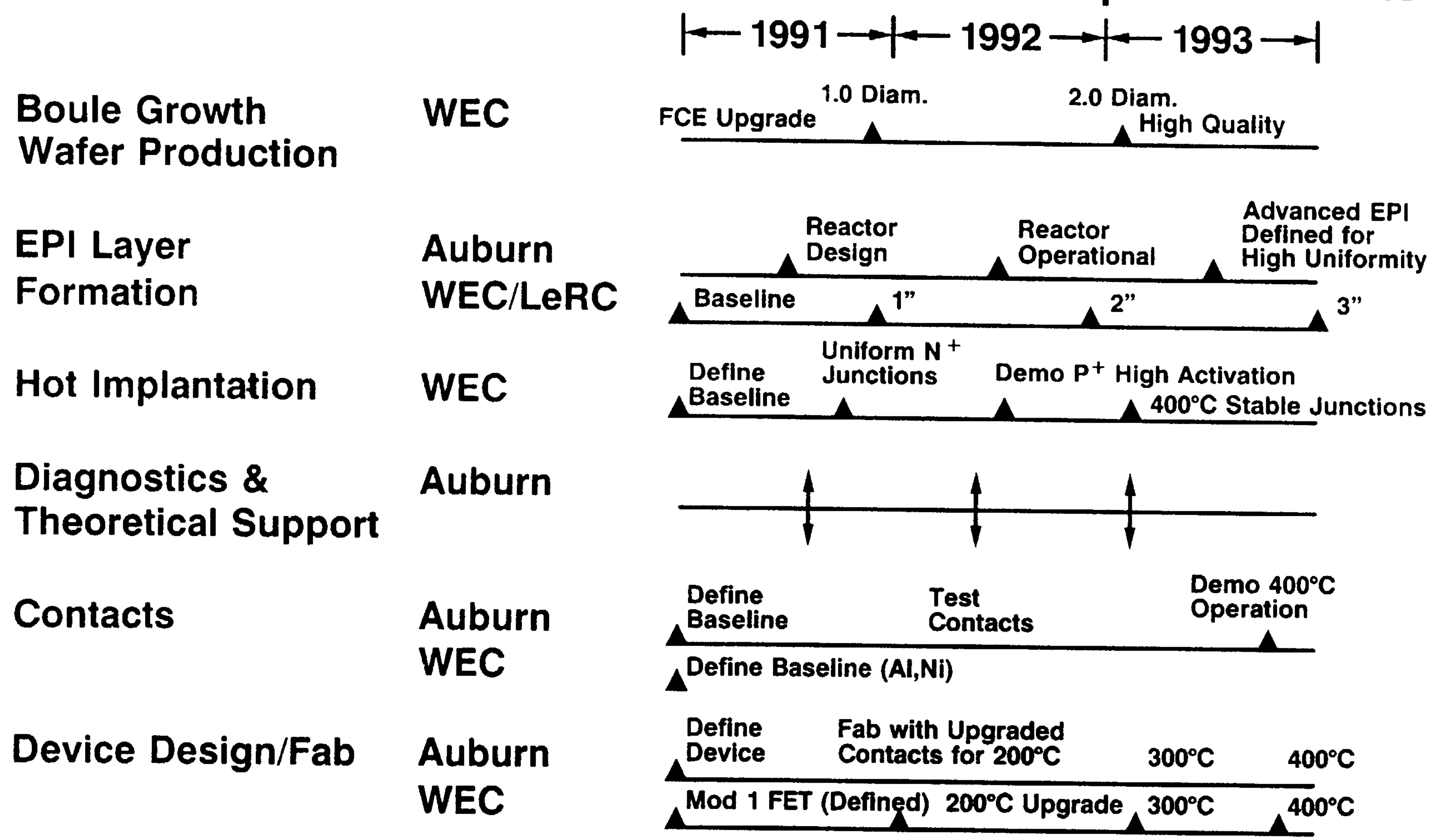


- Aircraft Engines
- Automotive Electronics
- Nuclear Power Plant
- Space Systems
- Chemical Processing

2T502 / VS2561

THE CCDS PROGRAM WAS INITIATED IN 1991

Goal: Devices that Operate at 200-500°C with Acceptable Lifetime



THE CCDS SILICON CARBIDE EFFORT IS ON SCHEDULE

- Working Relationships Established
  - First Exchange of Devices and Test Data Accomplished

	Auburn	Westinghouse
Staff Committed	5 Faculty, 4 Students	6 Scientists, 4 Technical Support
Topics	Structure Modeling Contact Metalization Systems Advanced Epitaxy Techniques SiC Growth Kinetics Surface Chemistry Structural Diagnostics	• Boule Growth Scale-Up • Low Defect Wafer Production • Hot Ion Implantation Junction Formation • Device Design / Fabrication
Status	• RBS Analysis of Initial WEC Contact System • Design of New EPI Reactor Initiated • Polytype Stability Calculations Made	• Furnace Scale-Up Design Complete • Furnace Fabrication Initiated • Sucessful 1.5" Diameter Boule Growth

STC

2T504

The NASA-CCDS at Auburn University Has Met All of Westinghouse's Expectations

- Excellent leadership.
- Impressive R&D programs.
- Stimulation of University environment - participation of students.
- Full cooperation of industrial partners.
- Cooperative participation by government labs.
- Opportunity to develop, in partnership with Auburn University, technologies and components for space.

N92-23655

Center for Mapping
Ohio State University

Mr. Lowell Starr
Technical Advisor for International Marketing
Intergraph Corporation

INTERGRAPH CORPORATION

IN COOPERATION WITH

THE OHIO STATE UNIVERSITY
CENTER FOR MAPPING

CENTER FOR THE COMMERCIAL DEVELOPMENT OF SPACE

1990-91 PROJECTS

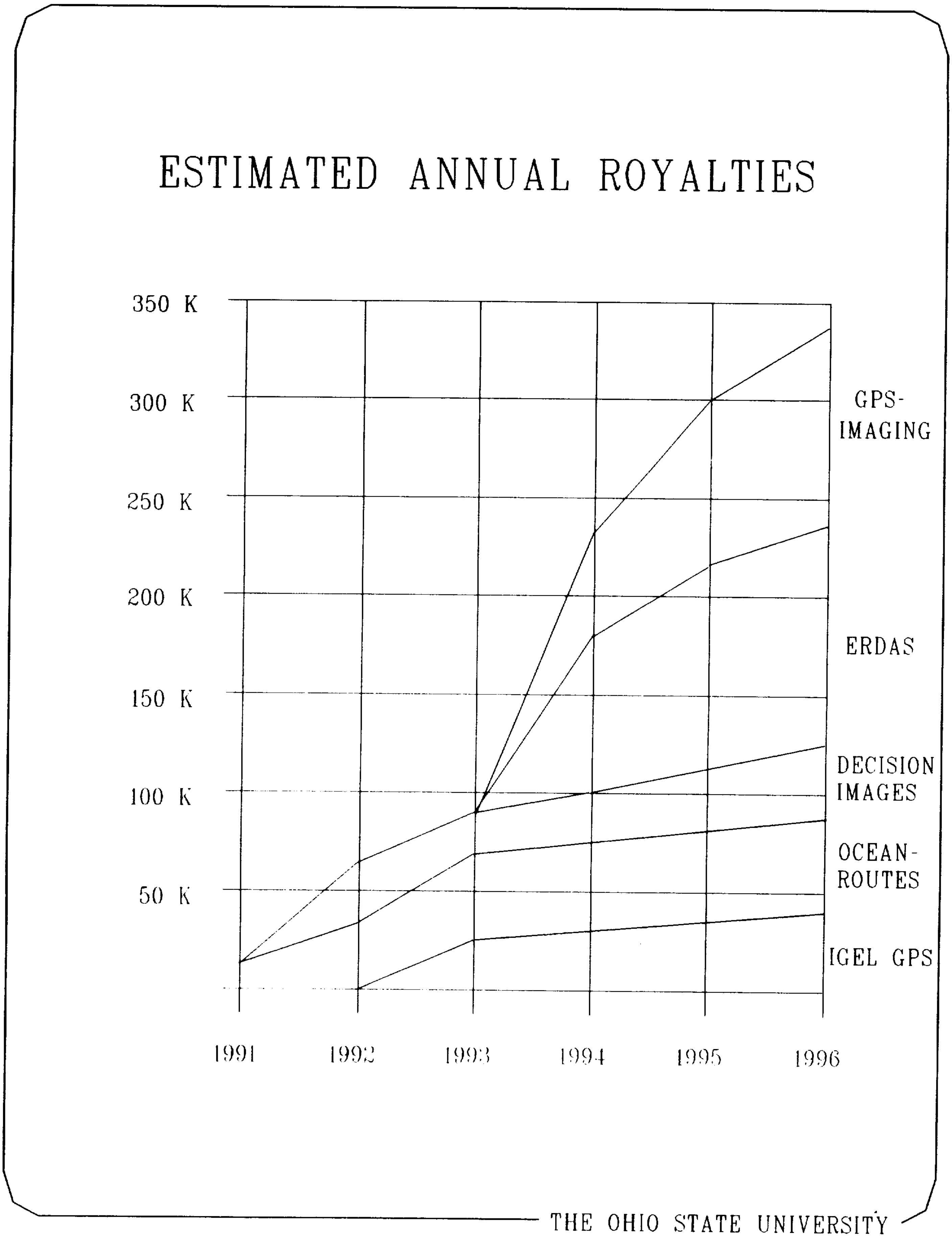
P.I.	DEPT.	PRODUCT NAME	FUNDING
BOYER	ELECTRICAL ENGINEERING	FEATURE EXTRACTION & DETERMINATION OF DIGITAL ELEVATION MODELS FROM AERIAL & SATELLITE IMAGERY	$ 70,000
GOAD	GEODETIC SCIENCE	REAL-TIME GPS SYSTEM FOR EARTH MOVING EQUIPMENT APPLICATIONS	$ 75,000
BARNES	GEODETIC SCIENCE	DEVELOPMENT OF A GIS CAPABILITY TO SUPPORT "ONE-CALL" UTILITIES PROTECTION SERVICES	$ 49,500

P.I.	DEPT.	PROJECT NAME	FUNDING
MCCORD	CIVIL ENGINEERING	IMPROVED OCEAN ROUTING USING REMOTE SENSING	$ 75,000
VON FRESE	GEOLOGY & MINERALOGY	INTEGRATING SATELLITE, AIRBORNE, AND SURFACE GEOPHYSICS FOR GLOBAL HYDROCARBON EXPLORATION	$ 49,500
NOVAK	GEODETIC SCIENCE	AUTOMATIC DERIVATION OF DIGITAL ELEVATION MODELS AND SIMULTANEOUS RECTIFICATION USING DIGITAL AERIAL PHOTOGRAPHY AND SPOT IMAGERY	$ 93,698
PRIDE	GEOLOGY & MINERALOGY	INTEGRATING THEMATIC MAPPER AND HIGH-RESOLUTION SURFACE DATA TO HIGHLIGHT GOLD MINERALIZATION IN NORTHERN NEVADA	ON-GOING NO NEW FUNDS AWARDED
SCHENK	GEODETIC SCIENCE	FEATURE EXTRACTION & DETERMINATION OF DIGITAL ELEVATION MODELS FROM AERIAL & SATELLITE IMAGERY	$ 86,000

P.I.	DEPT.	PROJECT NAME	FUNDING
TOMLIN	NATURAL RESOURCES	A MAPBOX/SYSTEM 9 INTERFACE	$ 108,000
BOSSLER, GOAD, AND NOVAK	CENTER FOR MAPPING AND GEODETIC SCIENCE	COMMERCIAL APPLICATION OF A GPS SYSTEM FOR TRANSPORTATION PLANNING	$ 140,000
MERRY	CIVIL ENGINEERING	STUDY OF EOS COMMERCIALIZATION POTENTIAL	$ 40,000
WU	CIVIL ENGINEERING	LANDSLIDE HAZARD FROM SNOW-MELT	$ 35,000
ANDERSON, BOSSLER, BOYER, SCHENK	CENTER FOR MAPPING/EE/GSS	SPACE CAM	$ 250,000

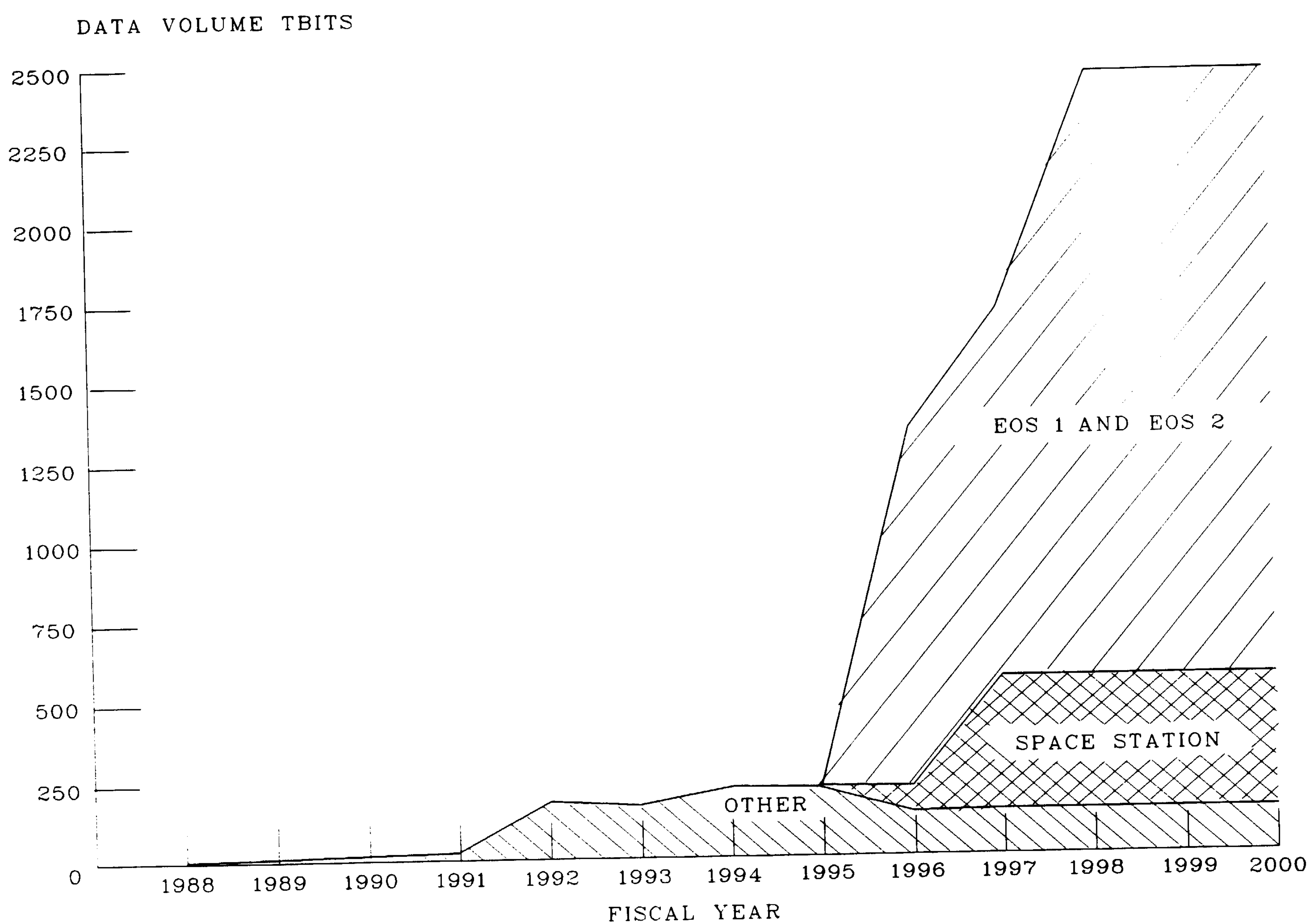
OHIO STATE UNIVERSITY CCDS CORPORATE PARTNERS AND AFFILIATES

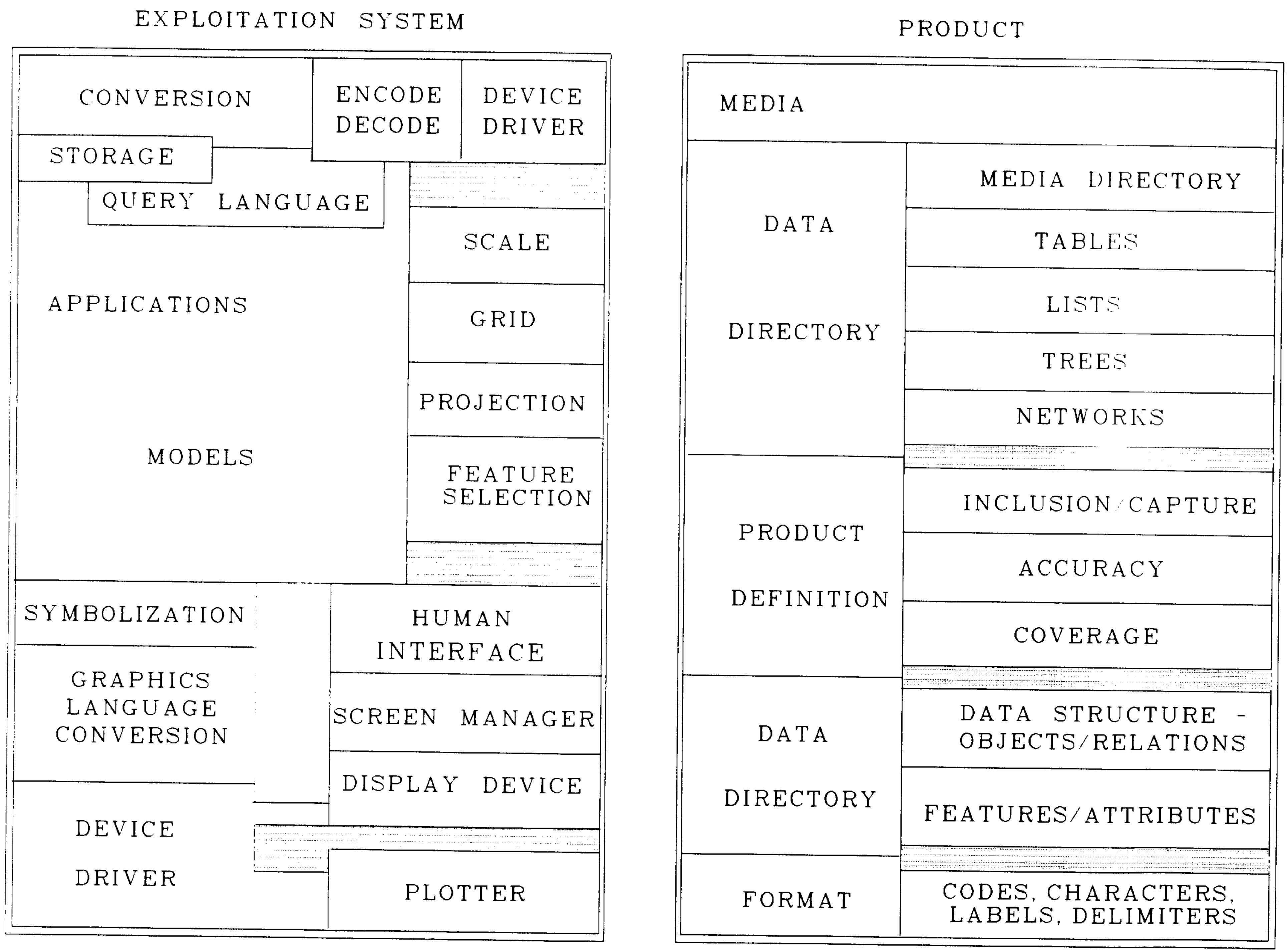
AMOCO (HOUSTON, TX)
ARCO (PLANO, TX)
DECISION IMAGES (PRINCTON, NJ)
ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (REDLANDS, CA)
ERDAS, INC. (ATLANTA, GA)
EXXON (HOUSTON, TX)
GAS RESEARCH INSTITUTE (CHICAGO, IL)
INTERGRAPH CORPORATION (HUNTSVILLE, AL)
GEORGE J. IGEL AND COMPANY (COLUMBUS, OH)
KRIG RESEARCH (BEAVERTON, OR)
QUEST VENTURES (SAN FRANCISCO, CA)
SANTE FE MINING (ALBUQUERQUE, NM)
TEXACO (HOUSTON, TX)
TRIMBLE NAVIGATION (SUNNYVALE, CA)
TYDAC TECHNOLOGIES (ARLINGTON, VA)
ULTIMAP CORPORATION (MINNEAPOLIS, MN)
UNOCAL (BRIA, CA)
DEPARTMENT OF TRANSPORTATION (38 STATES)
DOT/FEDERAL HIGHWAY ADMINISTRATION (WASHINGTON, DC)
NASA/GODDARD SPACE FLIGHT CENTER (GREENBELT, MD)
NASA/STENNIS SPACE CENTER (SSC, MS)
NOAA/NATIONAL OCEAN SURVEY (WASHINGTON, DC)
USGS/NATIONAL MAPPING DIVISION (RESTON, VA)
WASHINGTON DEPARTMENT OF NATURAL RESOURCES (OLYMPIA, WA)
OHIO STATE UNIVERSITY SCHOOL OF BUSINESS (COLUMBUS, OH)

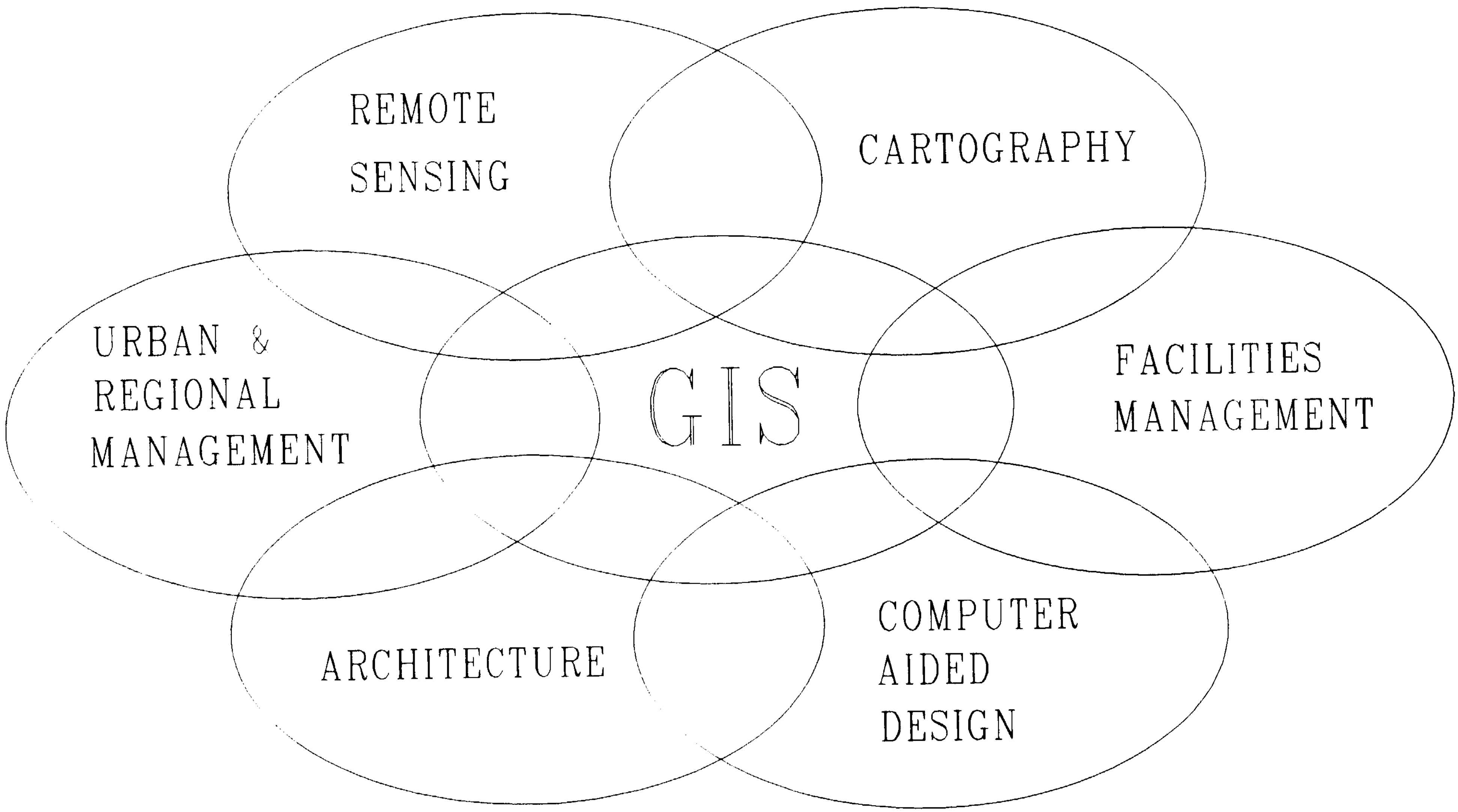


ESTIMATED ANNUAL ROYALTIES
350 K
300 K
250 K
200 K
150 K
100 K
50 K
1991
1992
1993
1994
1995
1996
GPS-IMAGING
ERDAS
DECISION IMAGES
OCEAN-ROUTES
IGEL GPS
THE OHIO STATE UNIVERSITY

ANNUAL DATA VOLUME BY LOCATION OF MISSION




EXPLOITATION SYSTEM
CONVERSION
ENCODE DECODE
DEVICE DRIVER
STORAGE
QUERY LANGUAGE
APPLICATIONS
MODELS
SCALE
GRID
PROJECTION
FEATURE SELECTION
SYMBOLIZATION
GRAPHICS LANGUAGE CONVERSION
DEVICE DRIVER
HUMAN INTERFACE
SCREEN MANAGER
DISPLAY DEVICE
PLOTTER
PRODUCT
MEDIA
DATA DIRECTORY
MEDIA DIRECTORY
TABLES
LISTS
TREES
NETWORKS
PRODUCT DEFINITION
INCLUSION/CAPTURE
ACCURACY
COVERAGE
DATA DIRECTORY
DATA STRUCTURE - OBJECTS/RELATIONS
FEATURES/ATTRIBUTES
FORMAT
CODES, CHARACTERS, LABELS, DELIMITERS



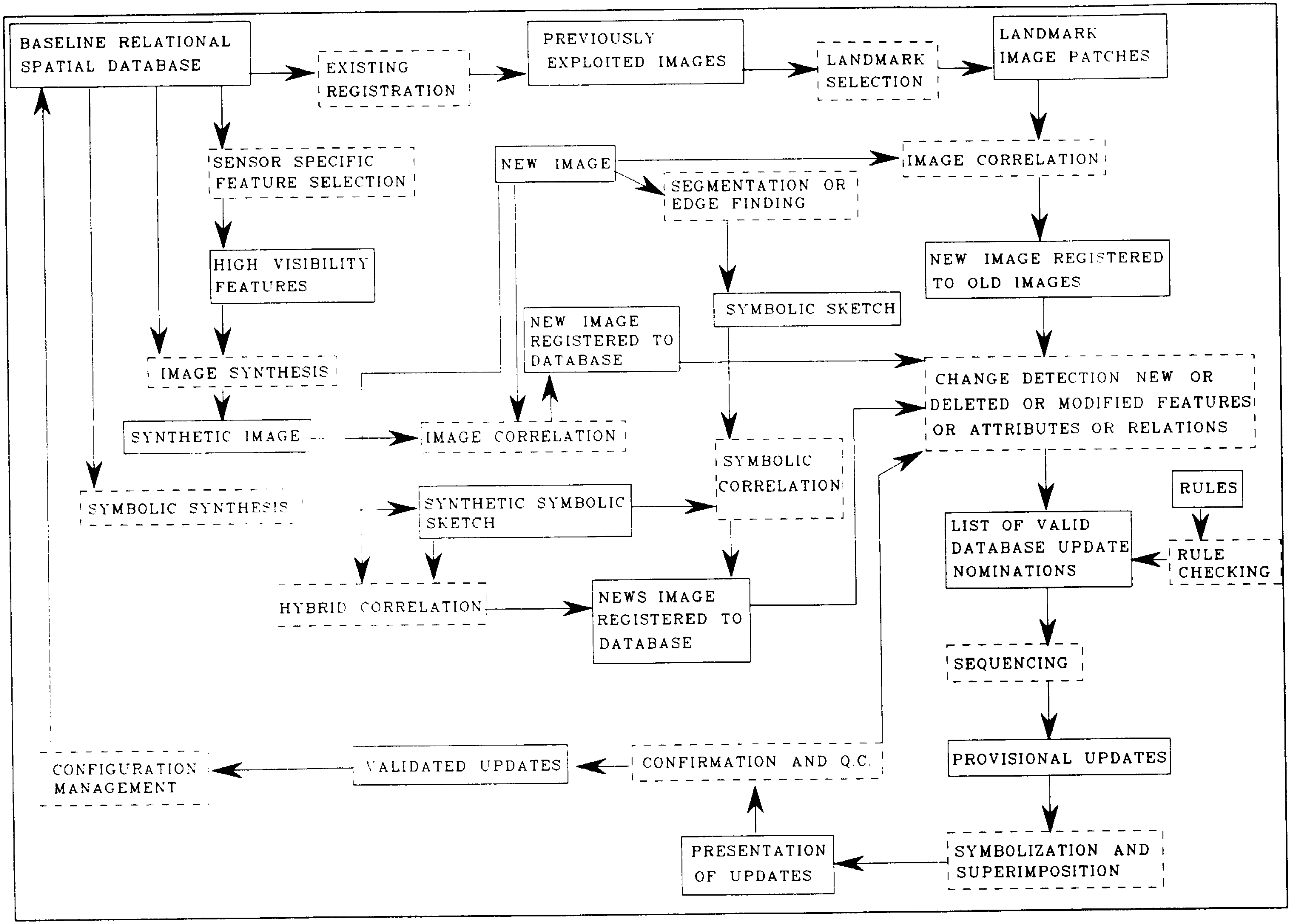
THE OVERLAPPING SPATIAL DATA DISCIPLINES

SOME SPATIAL THEMES

TOPOGRAPHY (CONTOURS)
TOPOGRAPHY (SHADED RELIEF)
TOPOGRAPHY (FORM LINES,...)
ROADS (MAJOR, MINOR,...)
RAILROADS (NO. OF TRACKS)
PRIMARY POLITICAL B'ND'RIES (CITY, COUNTY, COUNTRY,...)
ADMINISTRATIVE BOUNDARIES (SCHOOL, FIRE, POLICE, ZIP,...)
LAND OWNERSHIP
GEOLOGY: SURFACE AND SUBSURFACE, FAULTS, ...
VEGETATION (TYPE, SIZE, CONDITION, ...)
SOIL
FLIGHT CONTROL ZONES
BUILDINGS
WATER BODIES (LAKES, RIVERS, OCEANS,...)
AIRPORTS, RUNWAYS,...
POPULATION & DENSITY
POPULATION ATTRIBUTES (INCOME, FAMILY SIZE,...)
CLIMATE
WEATHER, RAINFALL, TEMPERATURE, WIND, ...
MILITARY ZONES
OPERATIONAL PLANS
FORCE DEPLOYMENT

NAVIGATION AIDS (BUOYS, BEACONS, ...)
SHIPPING CHANNELS
ANCHORAGES
POPULATED PLACE NAMES
NATURAL FEATURE NAMES
HIGHWAY NAMES AND NUMBERS
REFERENCE GRID
MAP GRID
ADDRESSES OR SCHEME
BATHYMETRY (SOUNDINGS)
BOTTOM CONTOURS
OTHER MAN-MADE FEATURES: DAMS, MINES, PARKING LOTS, MONUMENTS, ...
LINES OF COMMUNICATION
ANTENNAE
WETLANDS
FLOOD PLAINS
SURVEY BENCHMARKS
CITY/COUNTY INFRASTRUCTURE WATER SERVICES, GAS, ELECTRIC, TELEPHONE, CABLE, ...
MILITARY AND SPECIAL INTELLIGENCE
BRIDGES, TUNNELS, MINES, ...

MODIFIED IMAGE UNDERSTANDING PROGRAM



KEY ISSUES

1. LEVEL OF INFORMATION VS. PRESENTATION

2. DATA BASES,
   - SPATIAL: OBJECTS, QUERY SUPPORT, LINKAGE, SCHEMA: CELLS, LAYERS
   - RELATIONAL: OBJECTS, ATTRIBUTES

3. PRESENTATION
   - SYMBOLIZATION AND RENDERING

4. MODELING

5. INITIALIZATION
   - DATA CAPTURE

6. MAINTENANCE
   - UPDATE AND INTERACTION

PRESENTATION ISSUES

1. SYMBOLIZATION
2. GENERALIZATION
3. DISPLACEMENT
4. TEXT PLACEMENT
5. DEVICE DRIVER
6. ZOOM AND ROAM
7. AGGREGATION
8. RESYMBOLIZATION
9. THEMATIC LAYERING
10. TRANSPARENCY
11. SUPERIMPOSITION
12. COMBINATION OF RASTER AND VECTOR
13. PROJECTION
14. ACCURACY AND PRECISION
15. RESOLUTION
16. MARGINALIA: LEGEND, SCALE, SERIES, TITLE, NOTES,
17. GRIDS, TICS, GRADUICULES, HATCHURES
18. COLOR, COLOR SEPARATION,
19. CONTOUR LABELS
20. BATHYMETRY
21. . . . . .

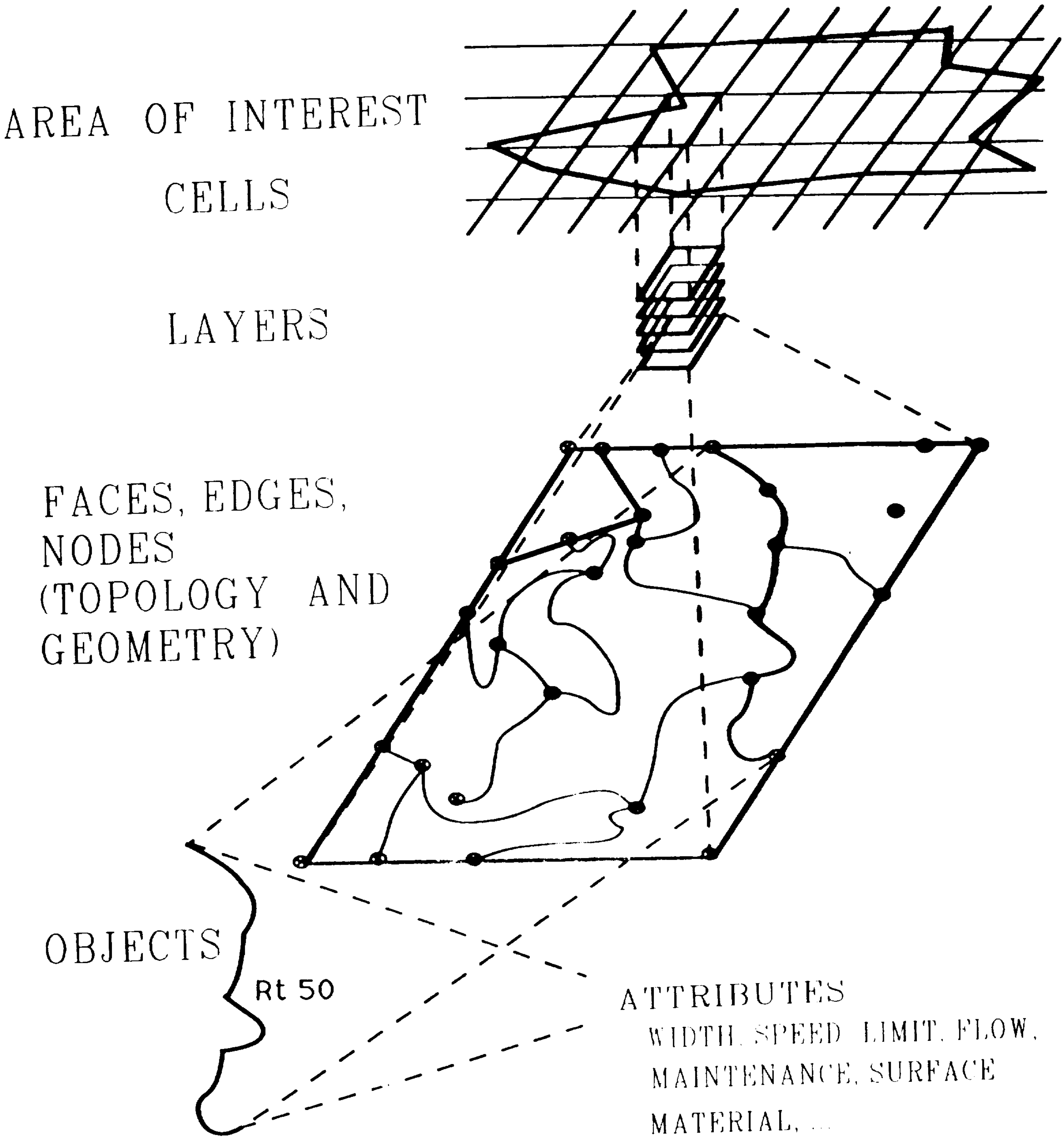
PRESENTATION:

- DATA IS PIXELS OR STROKES
- INTENDED FOR HUMAN EYE
- PRE-SYMBOLIZED, FIXED SCALE
- REQUIRES NEARLY STATIC DATA
- OFTEN LACKS DATA STRUCTURE
- MOST ANALYSIS PERFORMED BY HUMAN VISUAL CORTEX
- STRAIGHTFORWARD INDICES

INFORMATION:

- DATA HIGHLY STRUCTURED AND ENCODED
- COMPUTER ANALYSIS INTENDED
- SCALE INDEPENDENT
- ALLOWS DYNAMIC DATA
- REQUIRES SYMBOLIZATION FOR VISUALIZATION
- COMPLEX RETRIEVAL INDICES

TYPICAL GIS DATA STRUCTURE



SUMMARY

In closing I would like to impart the message that there are many future opportunities for CCDS activities that are directly linked to industry strategic objectives. In the field of mapping, remote sensing and GIS the near term opportunities may exceed all that have occurred in the past 10 years. I strongly believe that a national spatial data infrastructure must be established in this country if we are to remain a national leader in the information age. I am sure, the centers can have a profound impact on this mammoth task.

Special Presentation: Remote Sensing

Dr. Jacqueline Michel
Director of Environmental Technology Division
Research Planning, Inc.

Dr. Bruce Davis
Project Manager of Technology Utilization and Application Division
NASA Stennis Space Center

Oil Spill Environmental Sensitivity Index (ESI) Mapping Using Remote Sensing and Geographic Information System Technology

PROJECT SPONSORED BY

NASA OFFICE OF COMMERCIAL PROGRAMS

Jacqueline Michel, Ph.D.
Research Planning, Inc.

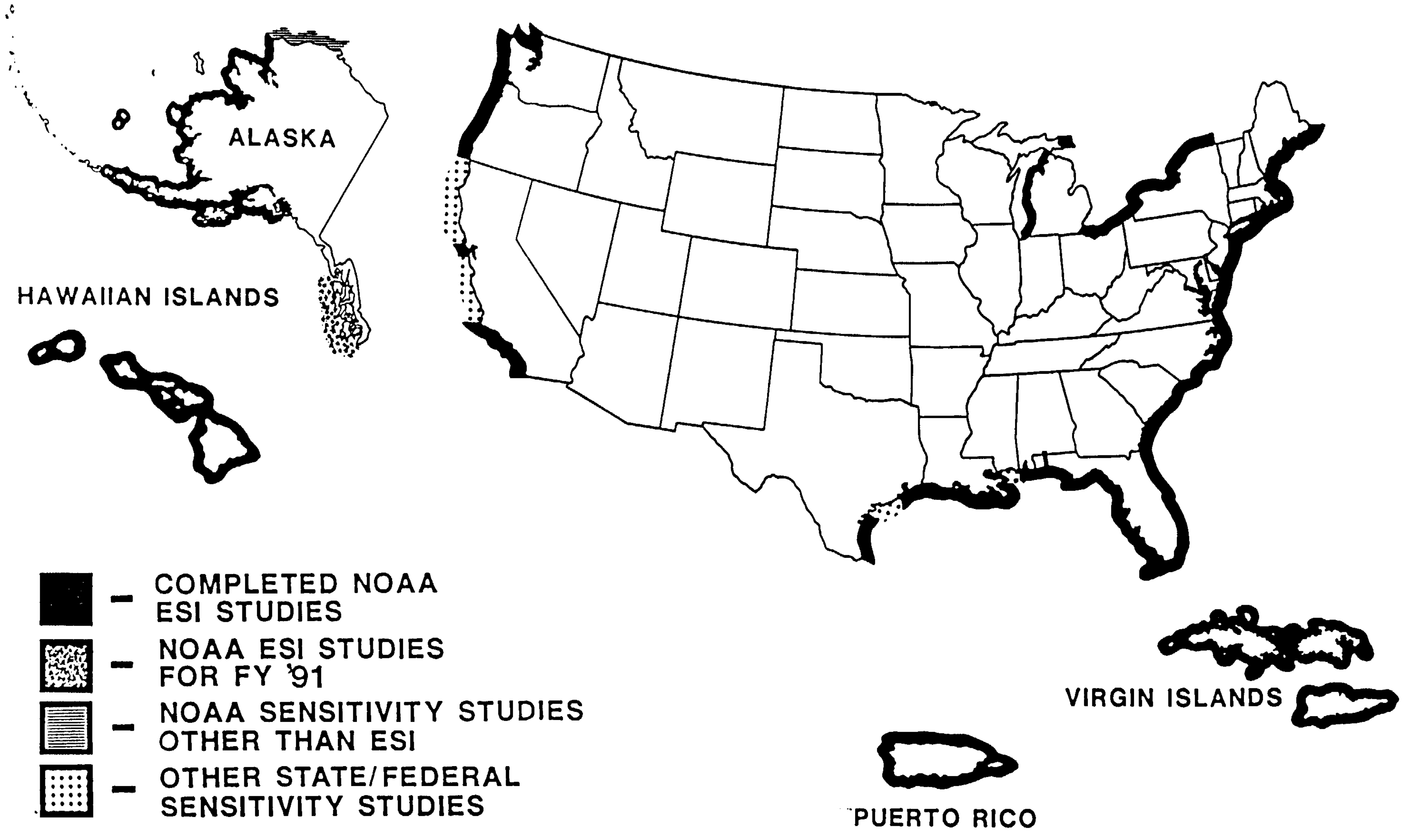
John R. Jensen, Ph.D.
University of South Carolina

Bruce A. Davis
NASA

RESEARCH PLANNING, INC.

- **Specialized environmental science company.**
- **Business Objective:** Develop a DIGITAL Environmental Sensitivity Index (ESI) database product which focuses on oil spill response, coastal zone development, and conflict management using remote sensing and geographic information system (GIS) technology.
- **Market Strategy:** Build on RPI's original ESI map client base to market the DIGITAL ESI database and expand the market for this product into other environmental applications.

STATUS OF ENVIRONMENTAL SENSITIVITY INDEX MAPPING



RESEARCH PLANNING, INC. IS WELL POSITIONED TO TAKE THE LEAD IN OIL SPILL PLANNING & RESPONSE USING THE DIGITAL ESI ATLAS PRODUCT

- Produced 41 of 45 ESI atlases totaling > $1.6 million
- Doing first full DIGITAL ESI of Southeast Alaska
- Most actual oil spill response experience

RESEARCH PLANNING, INC.
DIGITAL ENVIRONMENTAL SENSITIVITY INDEX (ESI)
MARKETING PLAN

- As a result of the *EXXON VALDEZ* (1989), *WORLD PRODIGY* (1990), and *MEGA BORG* (1990) oil spills, state and federal governments as well as private industry are demanding improved database products for planning and response. RPI's DIGITAL ESI atlases are poised to meet this demand. RPI is in a very strong position to capture at least 35% of the U.S. and 10% of the international market.

- The U.S. market is projected to be $7.5 million dollars by 1995.

- The international market is projected to be $5.0 million dollars by 1995.

- Research Planning, Inc. is attacking this market at both the national and international levels.

NATIONAL MARKETING PLAN

Existing Market:

- Automate existing ESI maps for NOAA and State governments.

Potential Market:

- Marine Spill Response Corporation (MSRC)
  - $750M for oil spill response
  - $33M for R&D
- Oil Pollution Act of 1990
  - Mandates sensitivity mapping for U.S.
- Major Oil Companies
  - All revising their contingency plans (which includes sensitivity mapping)

PERSIAN GULF SPILL

- Participated in response and analysis for the Persian Gulf Spill.
- NASA EOCAP Project was key in positioning RPI to participate more fully.
- Used remote sensing for oil spill tracking and mapping of sensitive resources.

SIGNIFICANCE OF NASA SPONSORSHIP

- **Able to demonstrate future sensor resolutions to potential clients:**

  NASA CAMS digital data (5 x 5 and 10 x 10m) and CIR aerial photography were *invaluable* for demonstrating ESI digital mapping technology using current and simulated future sensor systems.

- **High quality marketing products:**

  NASA provided high quality display of remote sensing and ESI mapping output products which were *indispensible* for marketing the technology.

- **Leverage for developing a relationship with MSRC (Marine Spill Response Corporation):**

  Using this NASA EOCAP to obtain a significant market share of the research by the MSRC.