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Space
Administration

(NASA-TM-79446) OAST SPACE SYSTEMS STUDIES REVIEW MEETING (National Aeronautics and Space Administration) 415 p HC A18/MF A01 CSCL 22A

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OAST SPACE SYSTEMS STUDIES REVIEW MEETING

Held at
NASA Headquarters
Washington, D. C. 20546

11 — 12 January 1978

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C.

FOREWORD

This report summarizes the working papers from the OAST Space Systems Studies Review Meeting held at NASA Headquarters , 11-12 January 1978. This material is intended for further use by the participants of the meeting and in structuring the FY 1979 Space Studies Program. The material in this document is presented in an unedited format to enable distribution in a timely matter. It should be understood that the data contained in this report do not represent official plans or positions but are part of the process of evolving such plans and positions.

Stanley R. Sadin
Study, Analysis, and Planning Office (Code RX)
Office of Aeronautics and Space Technology
NASA Headquarters

CONTENTS

SECTION 1

INTRODUCTION AND SUMMARY

The objectives of this OAST Space Systems Studies Review Meeting were:

- Brief the participants on the space systems study (RX) program
- Inform program offices, study investigators, and OAST discipline divisions on the status of the OAST space systems studies
- Initiate planning for the studies for FY 79
- Review with the participants the OAST space technology model and the space technology forecasts handbook

This meeting brought together the principal investigators of the OAST space systems studies and provided a forum by which OAST, the Headquarters' program offices, and the Centers became mutually aware of the progress of the space systems studies. This review meeting also provided an opportunity to participate in the development of the FY 79 studies program. Prior to the meeting, a detailed study description package was distributed (Appendix A).

The meeting consisted primarily of the principal investigators presenting the objectives and status of the studies to the OAST division directors, representatives from other offices, and the other principal investigators and Center program managers. Time was allocated for each active study (including those just completed and those just starting). Approximately a third of this time was reserved for questions and answers and pertinent discussion. These discussions were valuable for helping to suggest possible future studies and program emphasis.

The meeting consisted of several sessions. Table 1 gives the agenda of the meeting. Table 2 lists the individuals who attended one or more of the sessions. At the end of Secs. 2-8 of this document, each of which corresponds to a separate session, there is a condensation of some of the discussions which occurred during that session.

TABLE 1

SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

NASA Headquarters (FOB 10B), Room 625

FIRST DAY

8:30 am	OVERVIEW OF OAST SPACE STUDIES PROGRAM	S. Sadin (HQ)

8:45 am SESSION 'U' - SPACE UTILIZATION

Space Utilization Studies	S. Sadin (HQ)
Lunar Resources Utilization Studies	E. Crum (JSC)
Extraterrestrial Processing and Manufacturing of Large Space Systems	G. von Tiesenhausen (MSFC)

10:30 am SESSION 'T' - SPACE TRANSPORTATION

Advanced Space Transportation Technology Studies	B. Z. Henry (LaRC)
Space Transportation Studies	J. Pelouch, Jr. (LeRC)

1:30 pm SESSION 'M' - MULTIPROGRAM TECHNOLOGY

Advanced Automation Needs Analysis	E. Heer (JPL)
Technology Enablement-Multiple Requirements for Pointing and Control	W. Bachman (JPL)
Payload Software Technology	P. Rose (M&S Computing)
Payload Data Systems Technology Requirements	L. Krchnak (JSC)

TABLE 1 (Cont.)

1:30 pm SESSION 'M' - MULTIPROGRAM TECHNOLOGY (Cont.)	
Superconducting Sensors in Space	J. Murphy (ARC)
Technology Enablement-Space Power Systems	J. Stearns (JPL)

SECOND DAY

8:45 am SESSION 'A' - APPLICATIONS	
SEASAT Follow-On Technology Readiness Study	J. West (JPL)
Technology Readiness for a Global Services Mission	W. R. Hook (LaRC)
Public Service Platform	T. Durham (GSFC)
Penetrator Concepts	J. Murphy (ARC)
Post-LANDSAT D Advanced Concept Evaluation	F. Flatow (GSFC)
Enabling Technology for Global Services Missions	W. R. Hook (LaRC)
Public Information Management Services System	R. Nagler (JPL)
Global Services	T. Durham (GSFC)
Global Services	D. Aviv (Aerospace)
Geostationary Platform	S. Sadin (HQ)

TABLE 1 (Cont.)

1:30 pm SESSION 'S' - SCIENCE AND EXPLORATION

Spaceborne Antenna and Microwave Systems Technology Study	R. Edelson (JPL)
Extrasolar Planetary Detection	J. Murphy (ARC)
VOIR Technology Readiness Study	J. West (JPL)
Mars Sample Return Technology Readiness Study	J. West (JPL)
Technology Needs for Sample Return Missions	J. West (JPL)
Surface Exploration, Prospecting, and Assaying	P. Meeks (JPL)

4:00 pm SESSION 'X' - ANALYSIS

OAST Space Systems Technology Model and OAST Technology Forecast Handbook	T. Zakrzewski (GRC)

TABLE 2

OAST SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

NAME	CENTER	CODE	PHONE NUMBER
James P. Murphy	ARC	SPT	415/965-6520
David H. Suddeth	GSFC	402	301/982-2697
Tony Durham	GSFC		
Fred Flatow	GSFC		
W. E. Bachman	JPL	198-104	FTS 720-4420
J. W. Stearns	JPL		FTS 792-6156
E. Heer	JPL	180-701	FTS 792-3060
R. Edelson	JPL	264-801	FTS 792-3394
John L. West	JPL	233-307	213/354-3338
Paul Meeks	JPL	180-703	213/354-2546
Hal Alsberg	JPL		213/354-2969
A. R. Hibbs	JPL	180-703	213/354-2430
R. Nagler	JPL		
Marta Chelesky	JSC	AT-2	FTS 525-2703
Earle Crum	JSC		
L. C. Krchnak	JSC	AT-2	
W. R. Hook	LaRC	MS364	804/827-3666
B. Z. Henry	LaRC	MS365	804/827-3911
William R. Jones	LaRC		804/827-3951
Richard E. Snyder	LaRC	MS158	804/827-4606

OAST SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

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NAME	CENTER	CODE	PHONE NUMBER
J. J. Pelouch, Jr.	LeRC	6141	216/433-4000
Fred Billingsley	HQ	ERB-1	755-8596
Jan Heuser	HQ	EI-7	755-3777
Paul Tarver	HQ	SL-4	755-3770
J. W. Haughey	HQ	MTG-3	755-3024
Les Fero	HQ	MTE-3	755-3740
Tom Hagler	HQ	MTE-3	755-3233
Jules Lehmann	HQ	ERB-2	755-8623
Don Dement	HQ	ECT-4	755-3591
B. B. Schardt	HQ	ERB-2	755-8596
Dick Wallace	HQ	SL-4	755-3770
B. Rubin	HQ	RES-4	755-3227
P. R. Kurzhals	HQ	RE-4	755-3275
R. R. Nash	HQ	RXB-4	755-3256
J. J. Gangler	HQ	RWM-3	755-2395
C. H. Robins, Jr.	HQ	RS-7	755-8504
Wayne Hudson	HQ	RP-6	755-3279
William Gevarter	HQ	RES-4	755-3227
Art Henderson	HQ	RC-3	755-8501
Joe Slomski	HQ	RC-3	755-8501
Rodney Bradford	HQ	RG-14	755-8557
J. G. Lundholm	HQ	RR-6	755-2488
L. R. Holcomb	HQ	RP-6	755-3278
J. Mullin	HQ	RP-6	755-3279

OAST SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

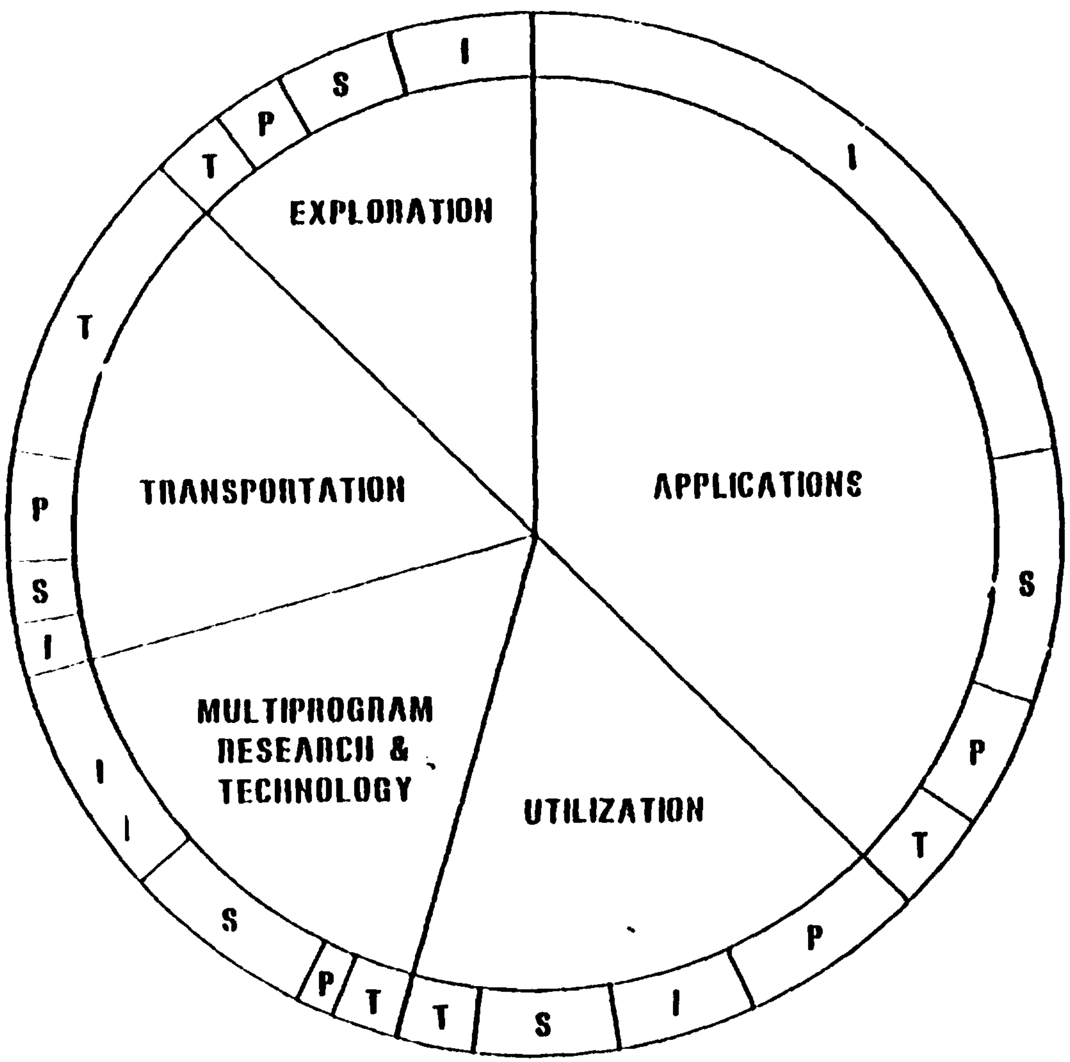
NAME	CENTER	CODE	PHONE NUMBER
Bob Price	HQ	RE	
Del Williams	HQ	RW-3	755-3295
Jim Lazar	HQ	RP-6	755-3280
Jim Downey	MSFC	PA-01	FTS (202) 872-1647
L. S. Yarbrough	MSFC	ER-01	FTS 872-4023
Gene Austin	MSFC		
Georg von Tiesenhausen	MSFC		
L. J. Early	WFC	OD	824-3411
David Aviv	Aerospace		213/648-5925
P. L. Rose	M&S Computing		205/772-3411
Thomas M. Zakrzewski	General Research		703/893-5900
Fred Kabat	General Research		703/893-5900
Dave Riffelmacher	General Research		703/893-5900
Dave Osias	General Research		703/893-5900
Ray Chase	General Research		703/893-5900

SECTION 2

OVERVIEW OF SPACE STUDIES PROGRAM

FY 79 STUDY ISSUES

- DISTRIBUTION OF STUDY FUNDS BY THEME, BY DISCIPLINE
- DISTRIBUTION OF STUDY FUNDS BETWEEN NEAR TERM (READINESS) AND FAR TERM (ENABLEMENT)
- STUDIES RELATING TO NEW STARTS AND AUGMENTATIONS VS. R&T "STUDIES"
- STUDY METHODOLOGY - TREND TOWARDS MAJOR THEME/MULTI-CENTER/MULTI-YEAR (E.G., SSTO, GLOBAL SERVICES)
- JOINT FUNDING OF STUDIES
- 5-YEAR PLANNING INSIGHTS
    - AGENCY
    - OAST
- STUDY PROGRAM PURPOSE - A RESTATEMENT
- OAST DISCIPLINES/INTEREST SPAN



APPLICATIONS

- Advanced Global Services Concepts
- Advanced Penetrator Concepts
- Seasat B Readiness
- Public Services Platform Readiness
- Pollution Monitoring Mission Readiness
- Post Landsat Concepts

UTILIZATION

- Nonterrestrial Materials Utilization
- Space Utilization Grants

MULTIPROGRAM R&T

- Advanced Automation Needs
- Pointing and Control Systems
- Software Forecasting

TRANSPORTATION

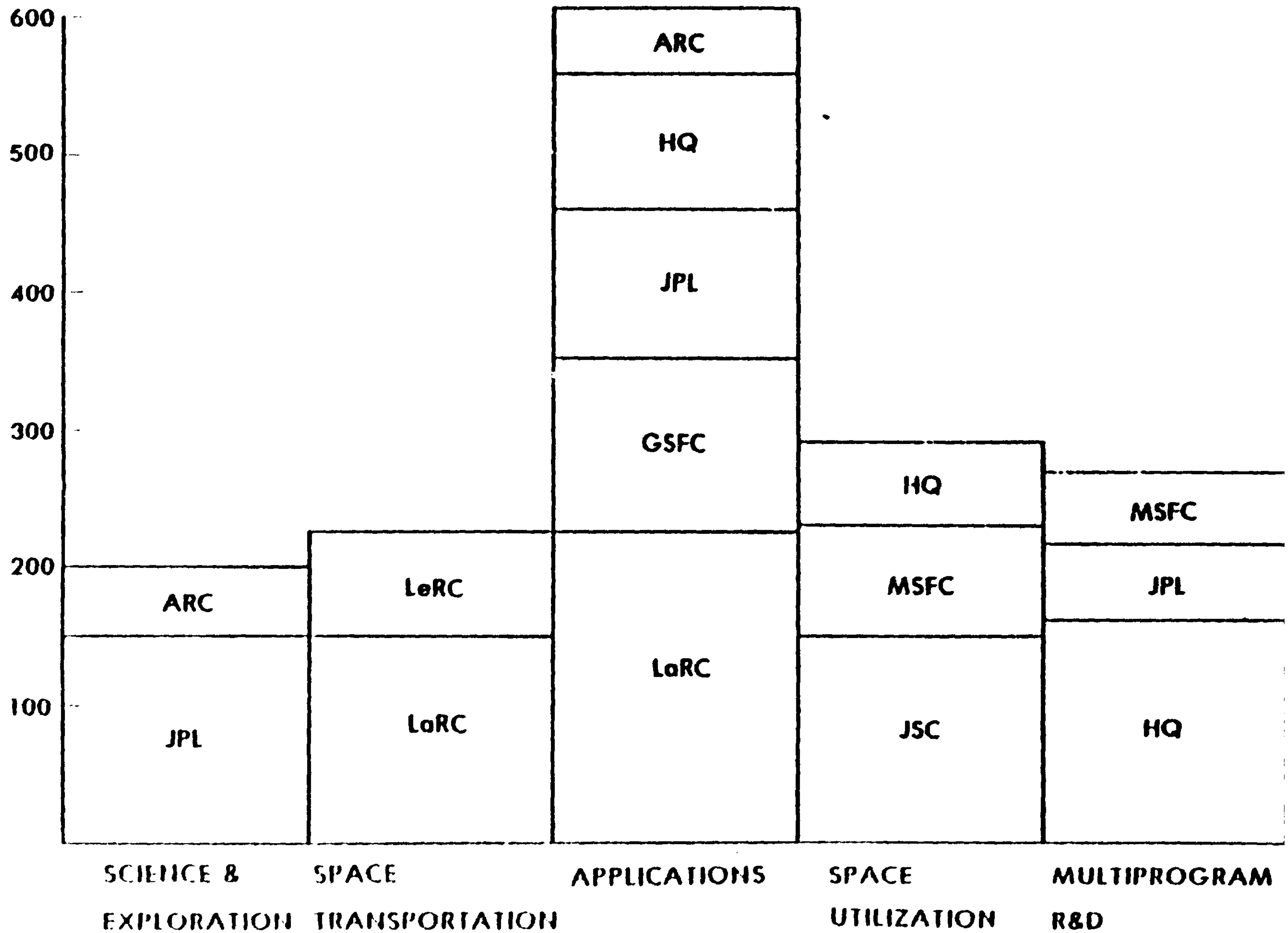
- Integrated Space Transportation Systems
- Low Thrust Propulsion

EXPLORATION

- Advanced Planetary Mission Concepts
- Advanced Space Astrophysics Concepts
- VOIR Readiness
- Mars Sample Return Readiness

Figure 1 — Space Systems Studies Program

OAST SPACE SYSTEM STUDIES - FY78 NET R&D FUNDING



MAJOR THEME/MULTI-CENTER/MULTI-YEAR STUDIES

EXISTING

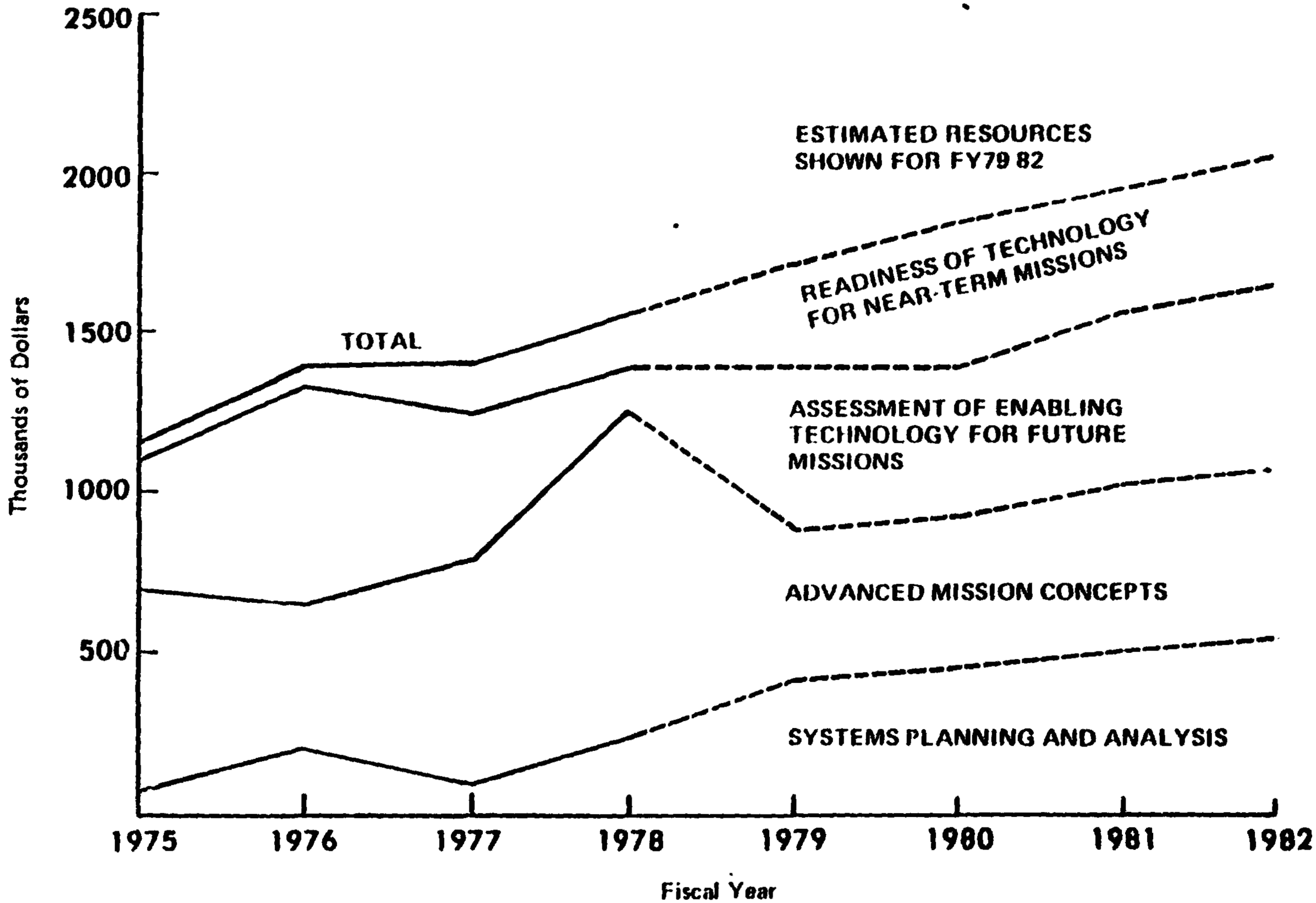
- GLOBAL SERVICES CONCEPTS
  - LaRC - LEAD
  - JPL
  - GSFC
  - AEROSPACE
- INTEGRATED TRANSPORTATION TECHNOLOGY
  - LaRC - LEAD
  - LeRC
- NONTERRESTRIAL MATERIALS UTILIZATION
  - ARC
  - MSFC
  - JSC

POSSIBILITIES

- PLANETARY EXPLORATION - INTENSIVE PHASE
  - JPL
  - ARC
  - JSC
- INTEGRATED ASTROPHYSICS PLATFORM
  - ARC
  - GSFC
  - MSFC
  - JPL

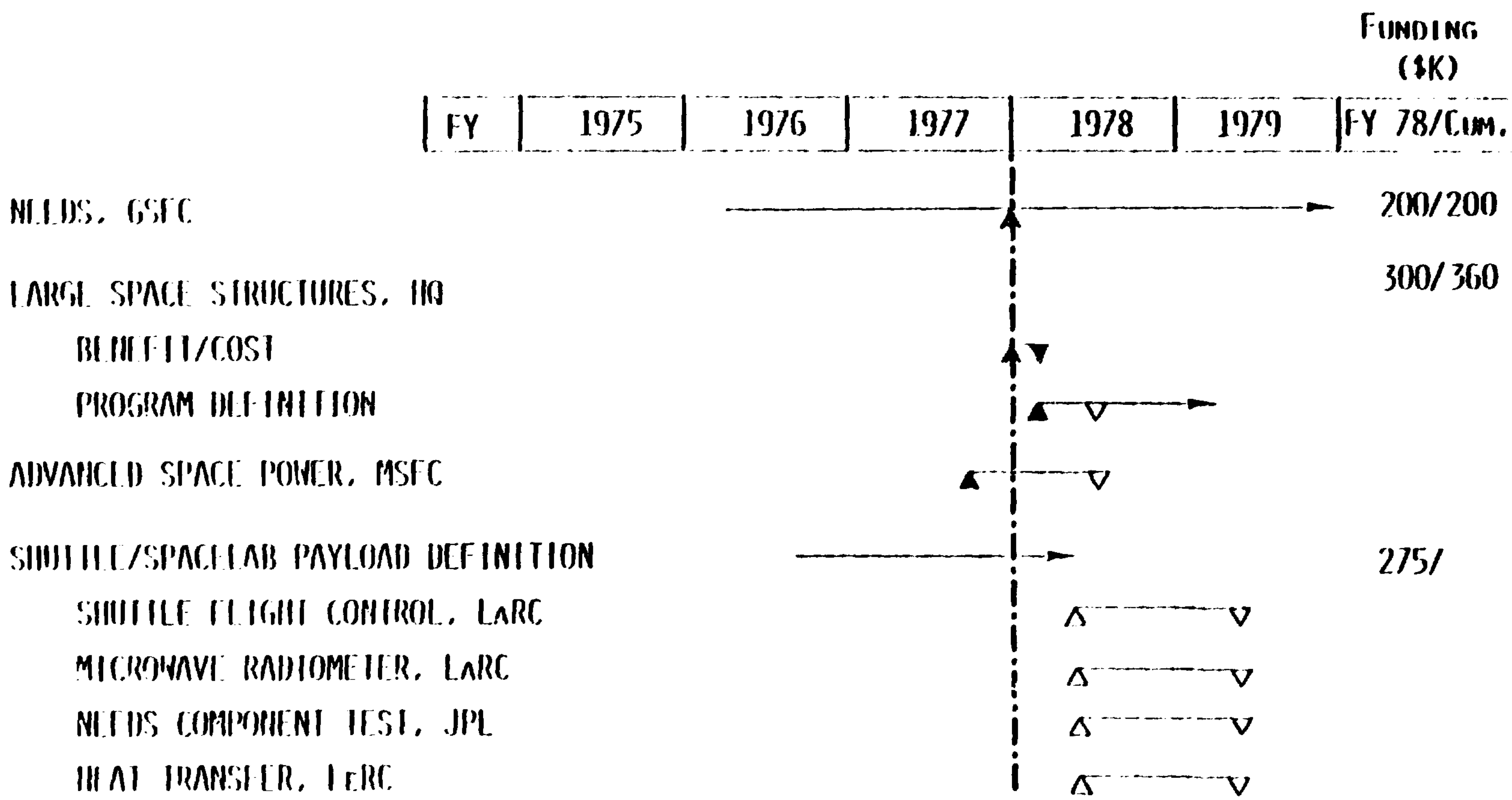
FY75-82 RESOURCES FOR OAST SPACE SYSTEM STUDIES

NET R&D FUNDS



NEW INITIATIVES/AUGMENTATIONS - PROGRAM DEVELOPMENT

CONDUCT STUDIES TO DEVELOP TECHNICAL PLANS, SCHEDULES, & COSTS FOR TECHNOLOGY INITIATIVES & AUGMENTATIONS.



FY 78 OAST TECHNOLOGY INITIATIVES AND AUGMENTATIONS

	Information Systems		Spacecraft Systems					Transportation Systems			Power Systems	
	(79)* NEEDS	(80) ESS	(81) LSST	(81) Nonlinear Large Deflection	(81) Automated Operations	(83) Nonterrestrial Resources	(83) Long-Life Composites	(80) Reusable Propulsion	(83) CASTS	(83) Low-Thrust Propulsion	(80) MOPP	(83) High-Performance Power
1. Science & Exploration	X	X	X		X		X					X
2. Applications	X	X	X		X						X	
3. Space Utilization			X	X	X	X		X			X	X
4. Space Transportation								X	X	X		
5. Multiprogram R&D	X	X	X	X	X			X		X	X	
6. Discipline	X	X	X								X	X

*Estimated Start Date

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OVERVIEW OF OAST SPACE STUDIES PROGRAM S. Sadin (HQ)

DISCUSSION: Should joint funding with other program offices and disciplines be sought to increase scope of studues program?

SECTION 3

SESSION 'U'

REVIEW OF SPACE UTILIZATION STUDY PROGRAM

LUNAR RESOURCE UTILIZATION FOR SPACE CONSTRUCTION STUDY

OAST SPACE SYSTEMS STUDIES

REVIEW MEETING

HEADQUARTERS

JANUARY 11-12, 1978

LUNAR RESOURCES FOR SPACE CONSTRUCTION STUDY	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	10/14/77

OBJECTIVES:

- o ESTABLISH METHODOLOGY AND CRITERIA FOR COMPARING THE USE OF LUNAR VS. EARTH MATERIALS FOR SPACE CONSTRUCTION
- o DEVELOP AND DEFINE CONCEPTS FOR UTILIZING LUNAR RESOURCES
- o ESTABLISH THE PROGRAM REQUIREMENTS NECESSARY FOR LUNAR RESOURCE UTILIZATION TO BE COST EFFECTIVE
- o PREPARE RECOMMENDATIONS AND PLANS FOR FURTHER WORK REQUIRED TO ALLOW A CHOICE TO BE MADE BETWEEN ALTERNATIVE SYSTEMS

LUNAR RESOURCES FOR SPACE CONSTRUCTION	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	10/14/77

TASK OUTLINE:

- DEVELOP COMPARSION METHODOLOGY AND CRITERIA
- DEVELOP MATERIALS REQUIREMENTS RANGE AND SCENARIOS
- DEVELOP AND DEFINE LUNAR UTILIZATION SYSTEMS CONCEPTS
  - SPACE MANUFACTURING SITES
  - LUNAR SURFACE MANUFACTURING SITES
- DETERMINE PROGRAM REQUIREMENTS NECESSARY FOR COST EFFECTIVE LUNAR RESOURCE UTILIZATION
- PERFORM SENSITIVITY AND UNCERTAINTY ANALYSIS
- DOCUMENT RECOMMENDATIONS AND PLANS FOR FURTHER WORK REQUIRED

unar Resources For SPS Construction Study

FUNCTION - LOCATION

	Earth	LEO	GEO	L-5	Lunar Orbit	Lunar Surface
Mining	X	—	—	—	—	
Beneficiation	X	—	—		—	
Smelting	X	—	—		—	
Refining	X	—	—		—	
Forming	X	—	—		—	
Processing	X	—	—		—	
Component MFg.	X	—			—	
Initial Assembly	—	X				—
Final Assembly	—		X			—

BASELINE EARTH BASED

FUNCTION - LOCATION

	Earth	LEO	GEO	L-5	Lunar Orbit	Lunar Surface
Mining		—	—	—	—	X
Beneficiation		—	—		—	X
Smelting		—	—		—	X
Refining		—	—		—	X
Forming		—	—		—	X
Processing		—	—		—	X
Component Mfg.		—			—	X
Initial Assembly	—				X	—
Final Assembly	—		X			—

POSSIBLE LUNAR SURFACE CONCEPT

Lunar Resources For SPS Construction Study

FUNCTION - LOCATION

	Earth	LEO	GEO	L-5	Lunar Orbit	Lunar Surface
Mining		—	—	—	—	X
Beneficiation		—	—	X	—	
Smelting		—	—	X	—	
Refining		—	—	X	—	
Forming		—	—	X	—	
Processing		—	—	X	—	
Component Mfg.		—		X	—	
Initial Assembly	—			X		—
Final Assembly	—		X			—

POSSIBLE L-5 CONCEPT

LUNAR RESOURCES FOR SPACE CONSTRUCTION STUDY	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	10/14/77

KEY TECHNICAL AREAS

	SOURCE
MASS DRIVER - LINEAR MOTOR	LITERATURE
ROTARY PELLET LAUNCHER	LITERATURE
MASS CATCHER - HEPPENHEIMER CONCEPT	LITERATURE
LIGHT GAS GUN	LITERATURE & JSC
CALCIUM/OXYGEN ROCKET	JSC CONCEPT
LUNAR BASE, MINING FACILITY (AND MANUFACTURING FACILITY)	JSC (MSFC)
SPACE BASE AND MANUFACTURING FACILITY	MSFC
LUNAR MATERIAL PROCESSING	JSC & INDUSTRY

STUDY TEAM MEMBERS

MR. EARLE CRUM	STUDY MANAGEMENT
MR. GEORG VON TIESENHAUSEN	STUDY MANAGEMENT
DR. RICHARD WILLIAMS	STUDY MANAGEMENT
DR. DAVID McKAY	LUNAR SOIL PROPERTIES
DR. ROBERT RIED	STRUCTURES
MR. GLENN ECORD	CHEMICAL PROCESSES
MR. JERRY PORADEK	SYSTEMS EVALUATION
MR. MAX KRCHNAK	PROGRAM PLANNING
MR. CLARKE COVINGTON	SPS DEFINITION
MS. DEBBIE WEBB	COST ESTIMATION
MR. PHILLIP WILLIAMS	FLIGHT OPERATIONS
CONTRACTOR STUDY MANAGERS	STUDY MANAGEMENT

LUNAR RESOURCES UTILIZATION STUDIES	FUTURE PROGRAMS OFFICE	
	E M CRUM	1/12/78

SCHEDULE OF KEY EVENTS

8/26/77	HQ RTOP APPROVAL RECEIVED AT CENTER
9/20-21/77	LUNAR RESOURCES UTILIZATION STUDIES MEETING HELD AT CENTER (JSC, HQ, AND MSFC)
10/3/77	NASA COUNCIL PRESENTATION BY STAN SADIN
10/14/77	DRAFT SOW AND PR SUBMITTAL
11/11/77	RFP ISSUED
12/23/77	PROPOSALS RECEIVED (SECURE STORAGE UNTIL 1/3/78)
3/1/78	CONTRACT AWARD
3/1/79	CONTRACT COMPLETE

Lyndon B. Johnson Space Center

PREPARED BY R. J. WILLIAMS

EXTRATERRESTRIAL MATERIALS - MINING AND PROCESSING	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	1/12/78

ISSUES

- IN WHAT WAYS CAN LUNAR MATERIALS BE PROCESSED INTO INDUSTRIALLY SIGNIFICANT FEEDSTOCKS BY IN-SPACE FACILITIES?
- WHAT ARE THE MAJOR TECHNICAL PROBLEMS OF SCALE AND IMPLEMENTATION FOR THE IDENTIFIED PROCESSES?

GOALS

- DOCUMENT PROCESSING SCHEMES AND THE RATIONALES FOR THEIR SELECTION
- DEFINE SCALE OF PROCESS ELEMENTS, REAL TECHNICAL PROBLEMS, AND RELEVANT EXPERIMENTS
- EVALUATE THE RATIONALE FOR SELECTION OF THE MAJOR PRODUCTS

EXTRATERRESTRIAL MATERIALS - MINING AND PROCESSING	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	1/12/78

STATUS

- USRA/LSI CONTRACT
- 790-40-42
- FY 78: 85K, 2.0 MY
- 6/1/77 - 9/30/78

RESULTS

- PARTICIPATED IN AMES SUMMER STUDY AND LA JOLLA WORKSHOP (PLANETARY RESOURCE EXPLORATION)
- CHLOROCARBONATION PROCESS DEFINED IN DETAIL
  - SCALES FOR REACTANT RECYCLING AND HEAT REJECTION ARE VERY LARGE
  - FURTHER QUANTIFICATION REQUIRES EXPERIMENTS ON REACTION KINETICS
  - REPORT DUE 2/78
- CONSULTING EFFORTS ON SCALE OF LUNAR MINING AND ON ELECTROSTATIC AND MAGNETIC BENEFICIATION TECHNIQUES INITIATED (1/78).
- INVESTIGATIONS OF OTHER REFINING TECHNIQUES BEGUN
- SPECIAL SESSION PLANNED AT LUNAR SCIENCE CONFERENCE (3/17/78)

OXYGEN EXTRACTION RESEARCH	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	1/12/78

ISSUE

- SOME CERAMICS ARE ELECTROLYTES FOR OXYGEN AT ELEVATED TEMPERATURES--UNDER WHAT CONDITIONS CAN THESE BE USED TO EXTRACT OXYGEN FROM REFINING GASES OR SILICATES AND OXIDES BY ELECTROLYSIS.

GOALS

- THERMOCHEMICAL MODELS
- LABORATORY TEST SYSTEMS
- EVALUATION OF ADVANCED MATERIALS AND SYSTEMS

Lyndon B. Johnson Space Center

PREPARED BY R. J. WILLIAMS

OXYGEN EXTRACTION RESEARCH	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	1/12/78

STATUS

- IN-HOUSE/JSC
- 506-16-27
- FY78: 55K, 1.0 MY (SC), 0.4 MY (CC)
- BEGAN: 12/1/77

RESULTS

- MODEL FOR THE EVOLUTION OF C-O GASES IN EQUILIBRIUM WITH GRAPHITE AS A FUNCTION OF TEMPERATURE AND PRESSURE DEVELOPED
- TEST SYSTEM DESIGNS CONCEPTUALIZED

ISSUES

- o WHAT LUNAR RESOURCES ARE THERE?
- o WHAT ARE THE PHYSICAL AND CHEMICAL PROPERTIES OF THESE RESOURCES?

GOALS

- o EVALUATION OF RESOURCE MODELS
- o ENGINEERING HANDBOOK

LUNAR MATERIALS HANDBOOK	FUTURE PROGRAMS OFFICE	
	E. M. CRUM	1/12/78

STATUS

- IN-HOUSE/JSC
- 790-40-17
- FY78: 10K, 0.3 MY (SC), 0.1 MY (CC)
- 12/1/77 - 2/28/78

RESULTS

- REALISTIC RESOURCES
  - ANORTHITE
  - MARE SOILS
  - ILMENITE
- HANDBOOK: DRAFT

ORGANIZATION:	MARSHALL SPACE FLIGHT CENTER	NAME: DATE:

OAST SPACE SYSTEMS STUDY REVIEW

JANUARY 11, 1978

EXTRATERRESTRIAL PROCESSING AND MANUFACTURING

OF

LARGE SPACE SYSTEMS

INTRODUCTION

- PAST AND PRESENT STUDIES IDENTIFIED POTENTIAL FUTURE LARGE SPACE SYSTEMS LIKE:

  LARGE FUTURE COMMUNICATION SYSTEMS, HABITATS, MANUFACTURING FACILITIES, SATELLITE POWER SYSTEMS, AND PROPELLANT FACILITIES.

- A NUMBER OF NASA SPONSORED SUMMER STUDIES INDICATED POTENTIAL ECONOMIC AND ENVIRONMENTAL ADVANTAGES FOR EXTRATERRESTRIAL MATERIAL UTILIZATION.

- NASA NEEDS TO INVESTIGATE THESE FINDINGS FURTHER FOR INFORMED FUTURE PROGRAM OPTION PLANNING.

- THE STUDY DESCRIBED HEREAFTER CONCENTRATES ON ONE KEY ELEMENT WITHIN A COMPLEX OVERALL SCENARIO.

ORGANIZATION	MARSHALL SPACE FLIGHT CENTER	NAME
PROGRAM DEVELOPMENT	EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS	PS01/VON TIESENHAUSEN DATE: JANUARY 1978

INTRODUCTION (CONCLUDED)

THE FOLLOWING OVERALL PROGRAM IMPLEMENTATION MODEL IS THE FRAMEWORK FOR THE STUDY PERFORMANCE. THE MODEL POINTS OUT THE SEGMENT OF THE MODEL COVERED BY THIS STUDY AND RELATES IT TO OTHER EFFORTS.

EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS - STUDY MODEL

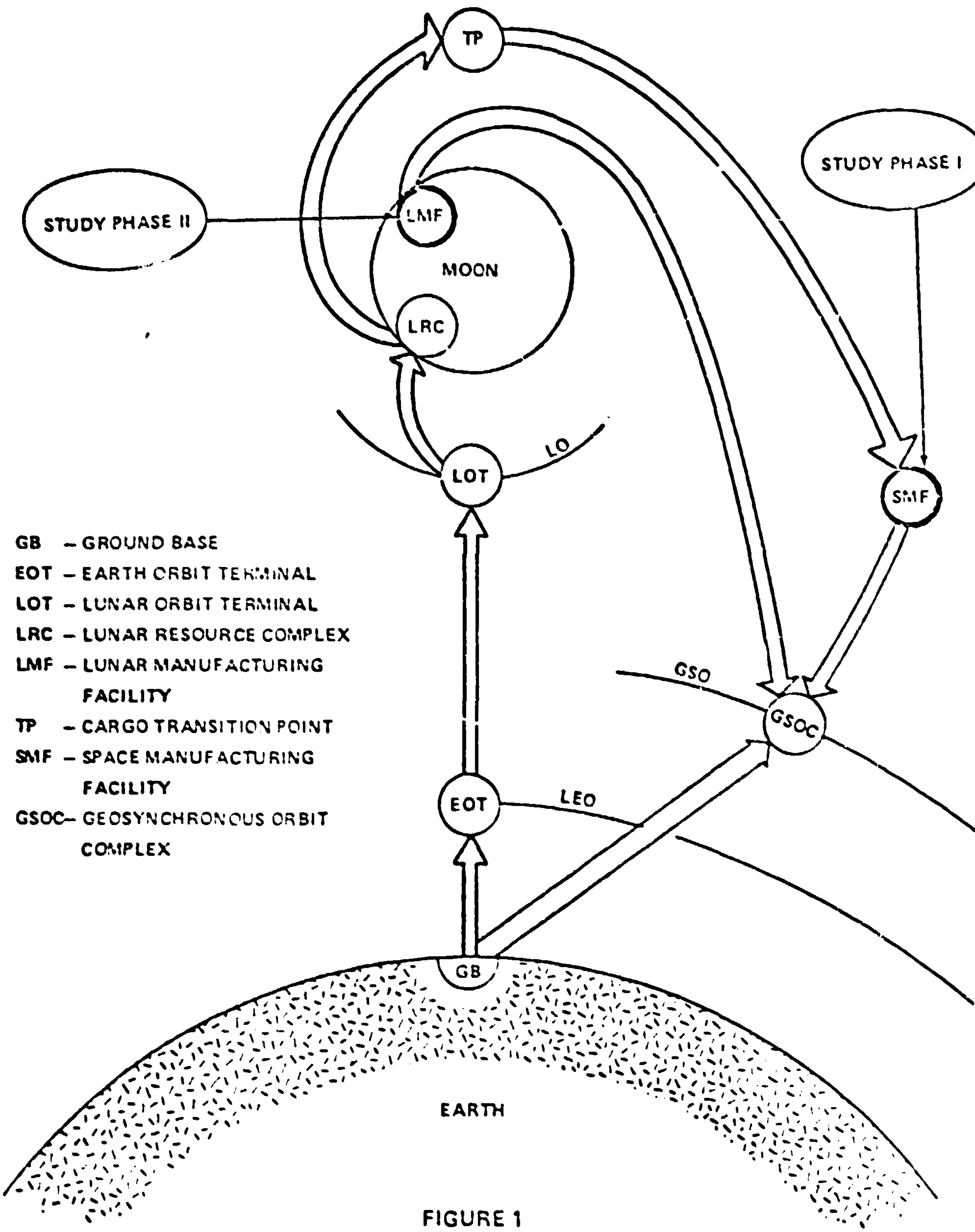

FIGURE 1

ORGANIZATION:	MARSHALL SPACE FLIGHT CENTER	NAME:
PROGRAM DEVELOPMENT	EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS	PS01/VON TIESENHAUSEN DATE: JANUARY 1978

STUDY OBJECTIVE

- o DEFINITION AND EVALUATION OF A SPACE MANUFACTURING FACILITY (SMF) AND A LUNAR MANUFACTURING FACILITY (LMF) FOR LARGE SPACE SYSTEMS.
- o COMPARATIVE ASSESSMENT BETWEEN SMF AND LMF.

ASSUMPTIONS, GUIDELINES AND CONSTRAINTS

- o A BIBLIOGRAPHY IS PROVIDED AS A STUDY BASIS.
- O LUNAR MATERIALS TO BE COVERED ARE:

  - SILICON
  - SILICA
  - ALUMINUM
  - IRON
  - SLAG
  - CALCIUM
  - MAGNESIUM
  - TITANIUM
  - OXYGEN

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ASSUMPTIONS, GUIDELINES AND CONSTRAINTS (CONCLUDED)

	LOW OPTION	MEDIUM OPTION	HIGH OPTION
o ASSUMED ANNUAL PRODUCTION RATES (KG)	10^5	10^7	5×10^8
o ASSUMED TOTAL PRODUCTION (KG)	10^7	3×10^8	1.5×10^{10}

- PRODUCTS SHALL INCLUDE:
  - SILICON PHOTOVOLTAIC SOLAR ENERGY CONVERTERS
  - GLASS FIBER COMPOSITE STRUCTURES
  - ALUMINUM STRUCTURES
  - POWER DISTRIBUTION SYSTEMS
  - RF GENERATORS
  - ANTENNAE
  - RADIATION SHIELDING
  - SPS PROGRAM (HIGH OPTION ONLY)
- FULLY AUTOMATED OPERATIONS.
- 20-30 YEAR OPERATIONAL LIFETIME.

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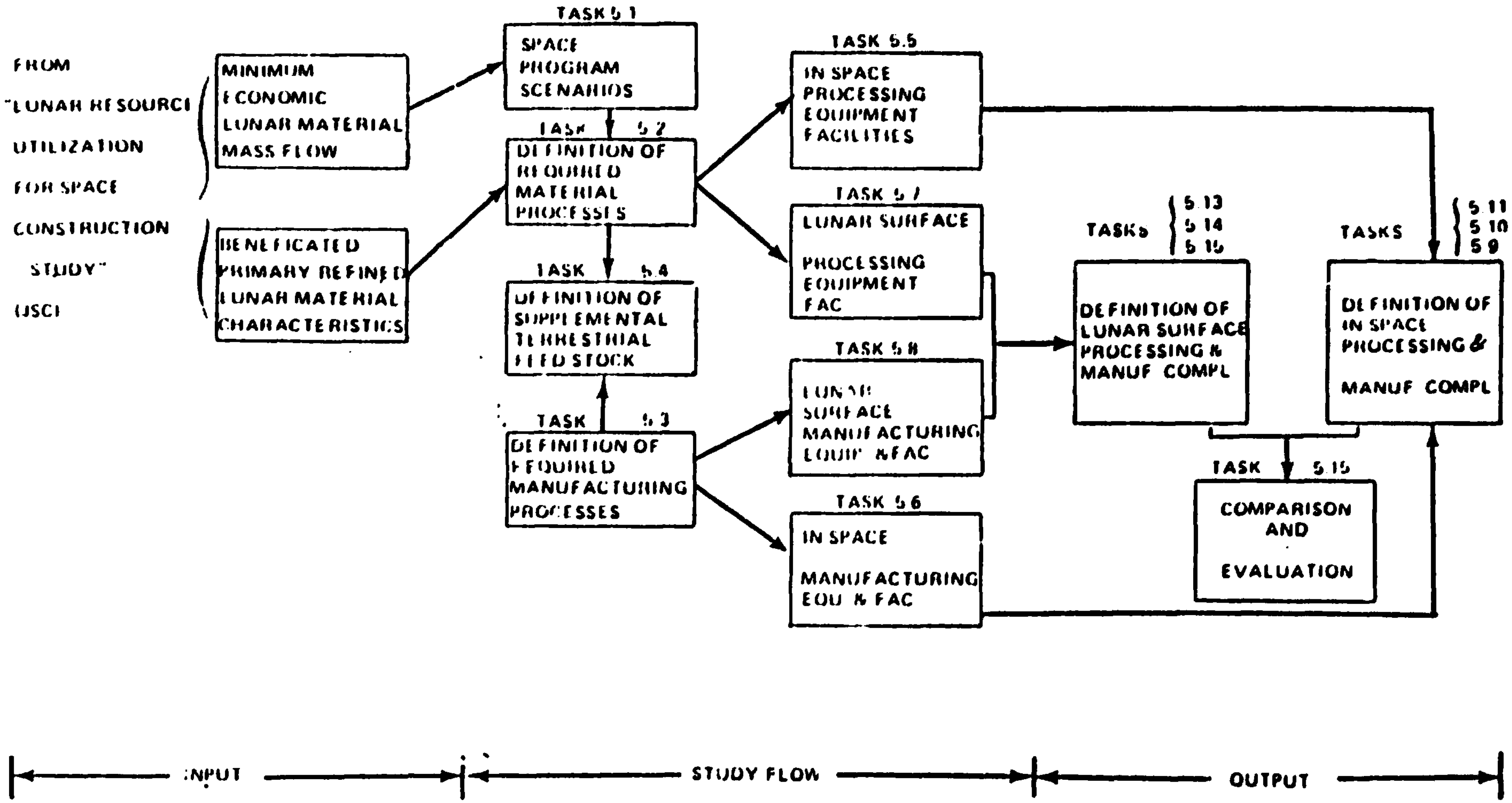
FIGURE 2 STUDY LOGIC FLOW FOR EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS



SPACE MANUFACTURING FACILITY (SMF)

REQUIRED ACTIVITIES

- o PERSONNEL AND CARGO RECEPTION FROM EOT AND L2
- o PERSONNEL HABITATION
- o CONTROL AND MANAGEMENT OF OPERATIONS AND LOCAL TRAFFIC
- o CONTROL OF LAUNCH OPERATIONS TO GSOC AND EOT
- o PERSONNEL AND CARGO LOCAL TRANSPORT
- o CARGO STORAGE
- o CHEMICAL MATERIALS PROCESSING
- o METALLURGICAL MANUFACTURING
- o PHOTOVOLTAIC BLANKET MANUFACTURING
- o COMPONENT MANUFACTURING
- o PRODUCTION CONTROL
- o ASSEMBLY AND TEST

ORGANIZATION: PROGRAM DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS	NAME: PS01/VON TIESENHAUSEN DATE: JANUARY 1978

PROGRAM SUBELEMENTS

- o LOCAL TRANSPORTATION
- o LEO-SMF TRANSPORTATION (P&C)
- o TP -SMF TRANSPORTATION (P&C)
- o SMF CARGO RECEIVING STATION
- o SMF STAGING AND CARGO BASE
- o SMF HABITAT BASE
- o SMF OPERATIONAL CONTROL STATION
- o SMF CHEMICAL PROCESSING FACILITY
- o SMF METALLURGICAL MANUFACTURING FACILITY

PROGRAM SUBELEMENTS (CONCLUDED)

- SMF SILICON PHOTOVOLTAIC MANUFACTURING FACILITY
- SMF COMPONENT MANUFACTURING FACILITY
- SMF PRODUCTION CONTROL STATION
- SMF ASSEMBLY COMPLEX
- SMF TEST STATION
- SMF EQUIPMENT AND OPERATIONS
- SMF LOCAL TRANSPORTATION
- POWER SYSTEMS

ORGANIZATION: PROGRAM DEVELOPMENT	MARSHALL SPACE FLIGHT CENTER EXTRATERRESTRIAL PROCESSING AND MANUFACTURING OF LARGE SPACE SYSTEMS	NAME: PS01/VON TIESENHAUSEN DATE: JANUARY 1978

STUDY SCHEDULE FOR PHASE I

SIX MONTHS PLUS ONE MONTH FOR DOCUMENTATION

STUDY FUNDING FOR PHASE I

$80K

BIBLIOGRAPHY
APPENDIX B

1. Space Settlements. A Design Study NASA SP-413, 1975, Publishing Date 1977.

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3. Space Manufacturing from Non-Terrestrial Materials. NASA-Ames OAST Study, 1976.

4. Space Manufacturing Facilities. Space Colonies, Proceedings of the Princeton/AIAA/NASA Conference, 1975.

5. In-Space Production of Large Space Systems from Extra-terrestrial Materials - A Program Implementation Model. Georg F. von Tiesenhausen, Program Development, George C. Marshall Space Flight Center, NASA-TM78143 October 1977.

6. Lunar Resources and their Utilization, W. C. Phinney, NASA Johnson Space Center; D. Criswell, Lunar Science Institute; E. Drexler, MIT; J. Garmirian, Hope College. Third Princeton/AIAA Conference on Space Manufacturing Facilities, May 1977. Report No. 77-537.

7. A Factory Concept for Processing and Manufacturing with Lunar Materials, G. W. Driggers, SAI, Huntsville, AL. Third Princeton/AIAA Conference on Space Manufacturing Facilities, May 1977. Report No. 77-538.

8. Systems Analysis of A Potential Space Manufacturing Facility G. W. Driggers, SAI, Huntsville, AL. Third Princeton/AIAA Conference on Space Manufacturing Facilities, May 1977. Report No. 77-554.

9. Demandite, Lunar Materials and Space Industrialization. D. R. Criswell, The Lunar Science Institute. 3303NASA Road One, Houston, TX 77058.

10. Engineering A Space Manufacturing Center, Dr. Gerard O'Neill. Astronautics and Aeronautics, October 1976.

SESSION 'U' - SPACE UTILIZATION

Space Utilization Studies (S. Sadin, HQ)

In the absence of an ARC representative to present the status of this study, S. Sadin made some brief remarks. Results of the workshops held the last three summers were summarized, and the point was made that they had provided valuable input to the JSC and MSFC studies.

DISCUSSION: Comments were made concerning possible "pollution" from a mass driver for OTV propulsion, and the general utility of such a device was questioned. The future direction of this study effort was discussed.

Lunar Resources Utilization Studies (E. Crum, JSC)

DISCUSSION: Studies should consider lunar propulsion trade-offs and alternatives to the mass driver for a lunar launch vehicle.

Extraterrestrial Processing and Manufacturing of Large Space Systems (G. von Tiesenhausen, MSFC)

DISCUSSION: Question raised about asteroid usage in addition to processing lunar materials, and possible OSS interest in such efforts.

Discussion of FY 79 Plans in Space Utilization

Continuation of present efforts. Mr. von Tiesenhausen wanted to expand efforts to design end-to-end system and examine interfaces and how this affected technology. Stan Sadin did not feel that such a far-term project should be pushed to that point at such an early date.

In FY 79, the MSFC study will examine the lunar-based processing and manufacturing option.

SECTION 4

SESSION 'T'

REVIEW OF SPACE TRANSPORTATION STUDY PROGRAM

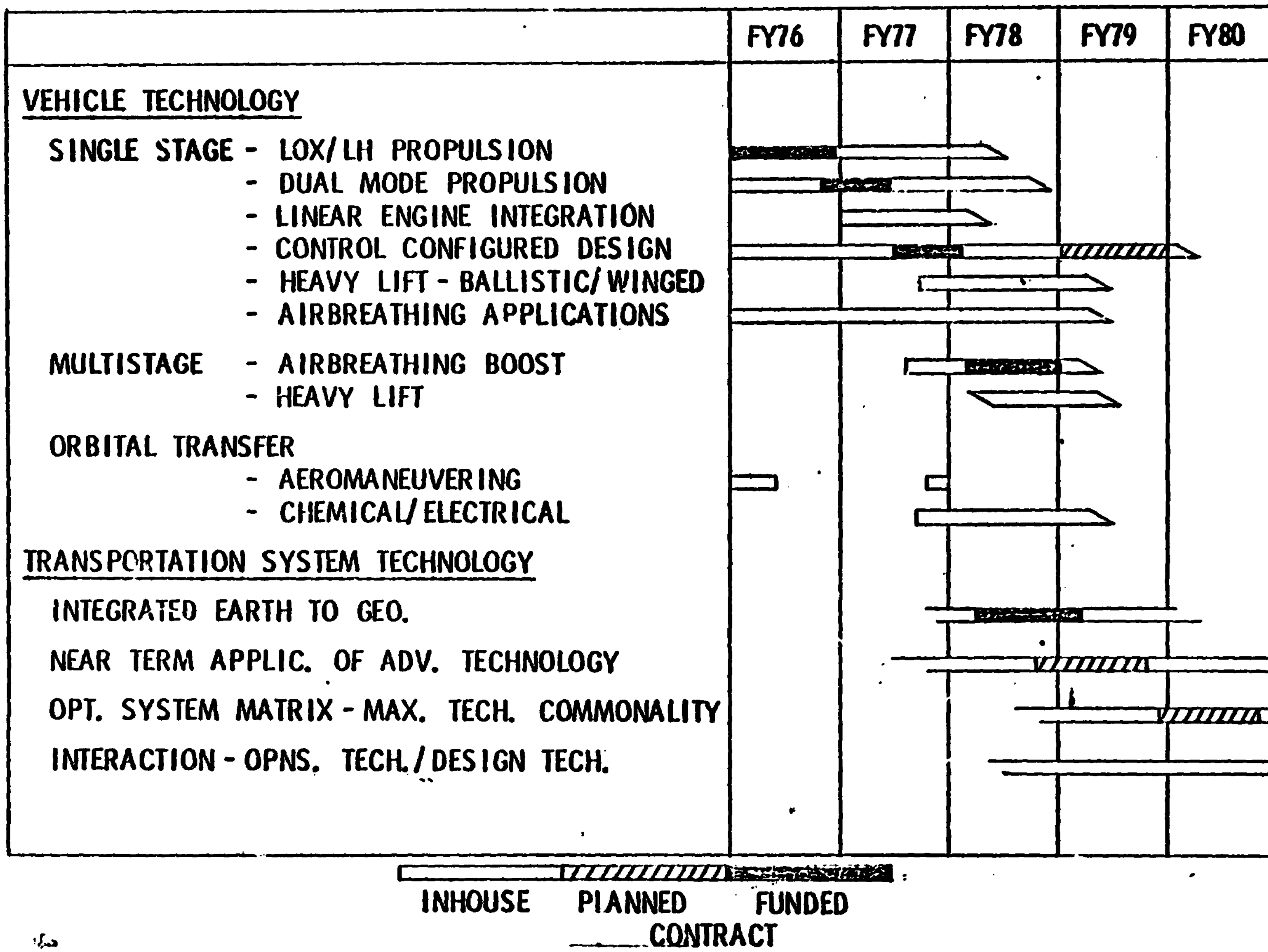
ADVANCED SPACE TRANSPORTATION TECHNOLOGY STUDIES

OAST SPACE SYSTEMS STUDIES REVIEW MEETING

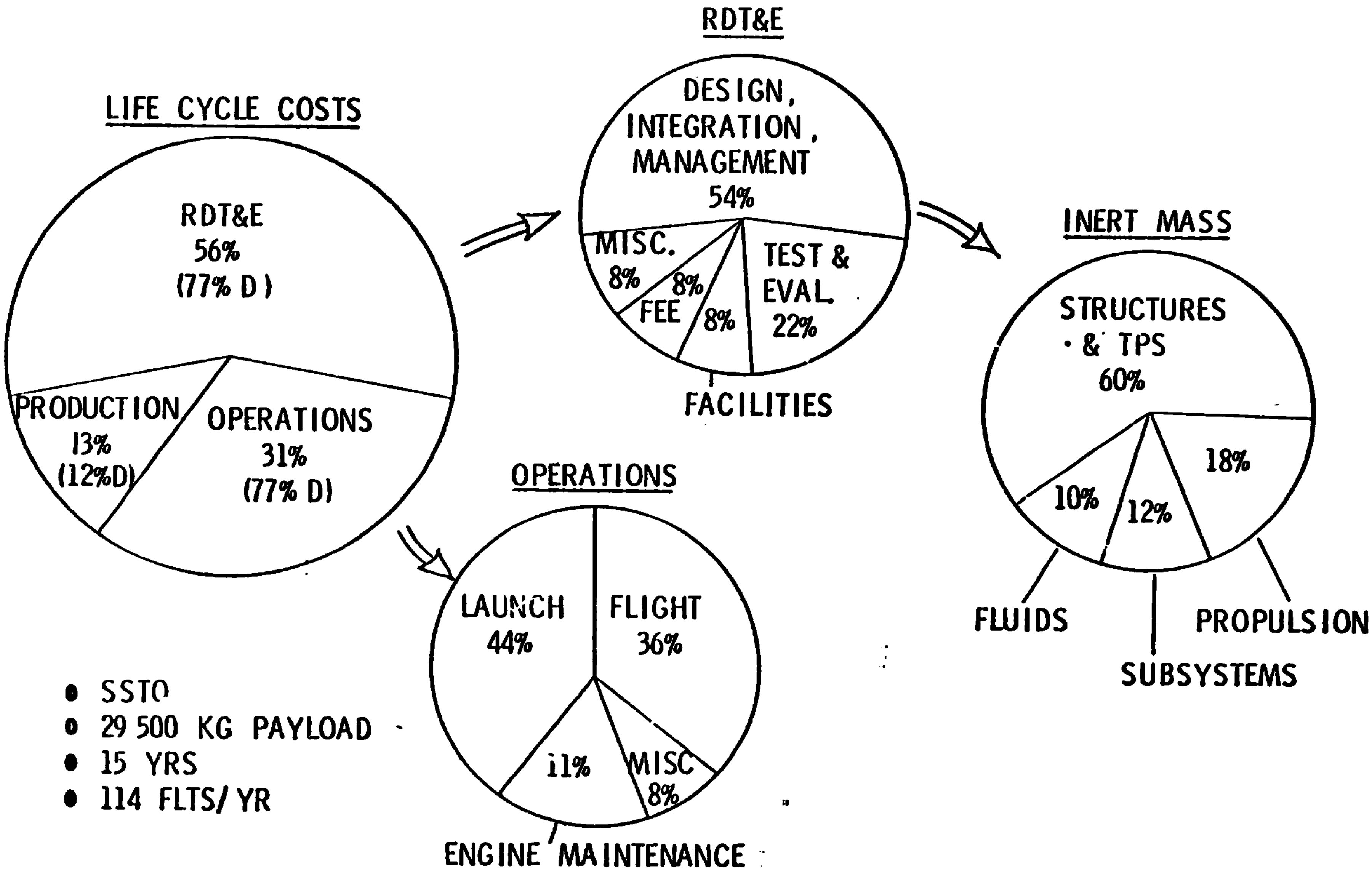
JANUARY 11-12, 1978

B. Z. Henry
LaRC - SSD

ADVANCED SPACE TRANSPORTATION TECHNOLOGY STUDIES

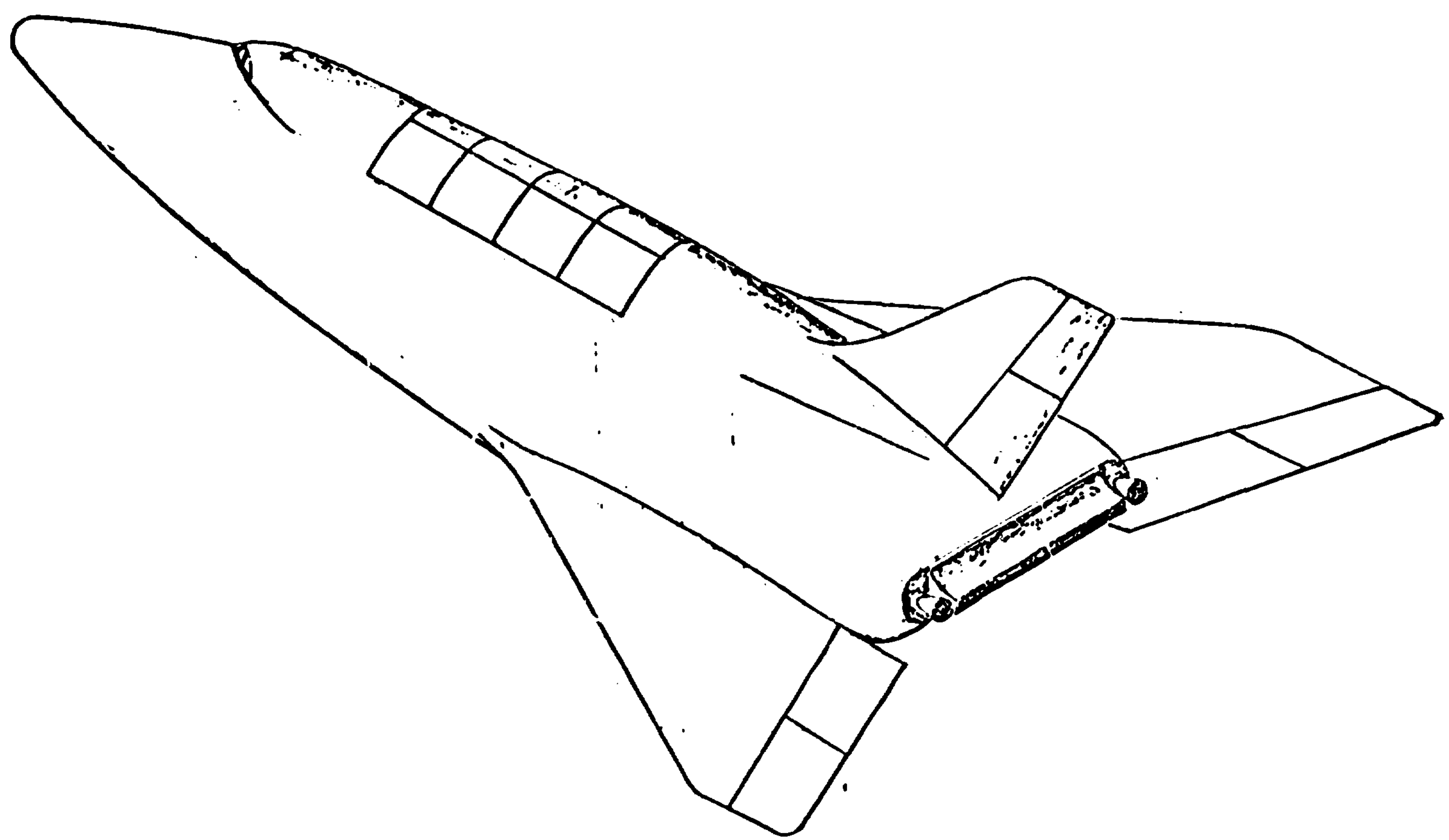


TARGET AREAS FOR TECHNOLOGY ADVANCES



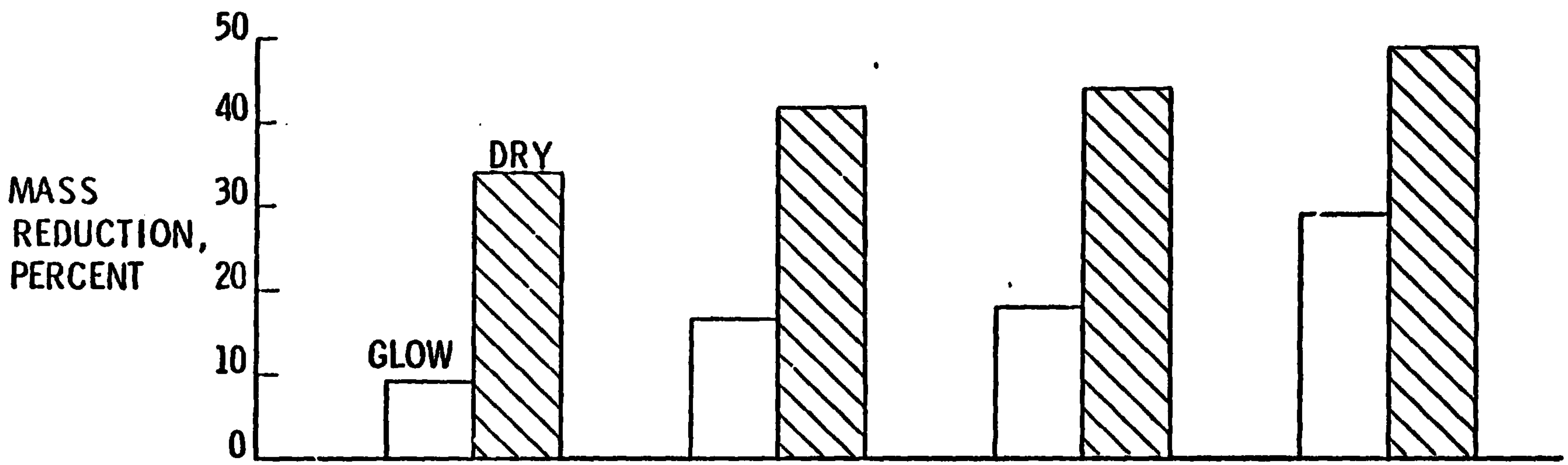
- SSTO
- 29 500 KG PAYLOAD
- 15 YRS
- 114 FLTS/YR

SINGLE-STAGE-TO-ORBIT VEHICLE
INTEGRATED LINEAR ENGINE



DUAL MODE PROPULSION SYSTEM COMPARISONS

REFERENCE VEHICLE: VTOHL LOX/ LH_2 SSTO
GLOW = 1 952 000 KG
DRY MASS = 206 000



CASE	LINEAR	SERIES	PARALLEL	DUAL EXPANDER
MODE	INTEGRAL PARALLEL	INTEGRAL SERIES + SEPARATE	SEPARATE PARALLEL	INTEGRAL PARALLEL
CYCLE RP/ LH	GG/ SC	SC/ SC	GG/ SC	GG/ SC

STUDY: APPLICABILITY OF THE CONTROL CONFIGURED DESIGN APPROACH TO ADVANCED EARTH ORBITAL TRANSPORTATION SYSTEMS

OBJECTIVE: STUDY APPLICABILITY AND PERFORMANCE GAINS OF CONTROL CONFIGURED DESIGN CONCEPTS AS APPLIED TO A SINGLE-STAGE-TO-ORBIT VEHICLE

TASKS:

I - APPLICABILITY OF CCV TO SSTO TECHNOLOGY STUDY (LITERATURE SURVEY)

II - STUDY RANGE OF STATIC STABILITY AND CONTROL POWER OVER ENTRY MISSION PROFILE (6D MOTION STUDIES)

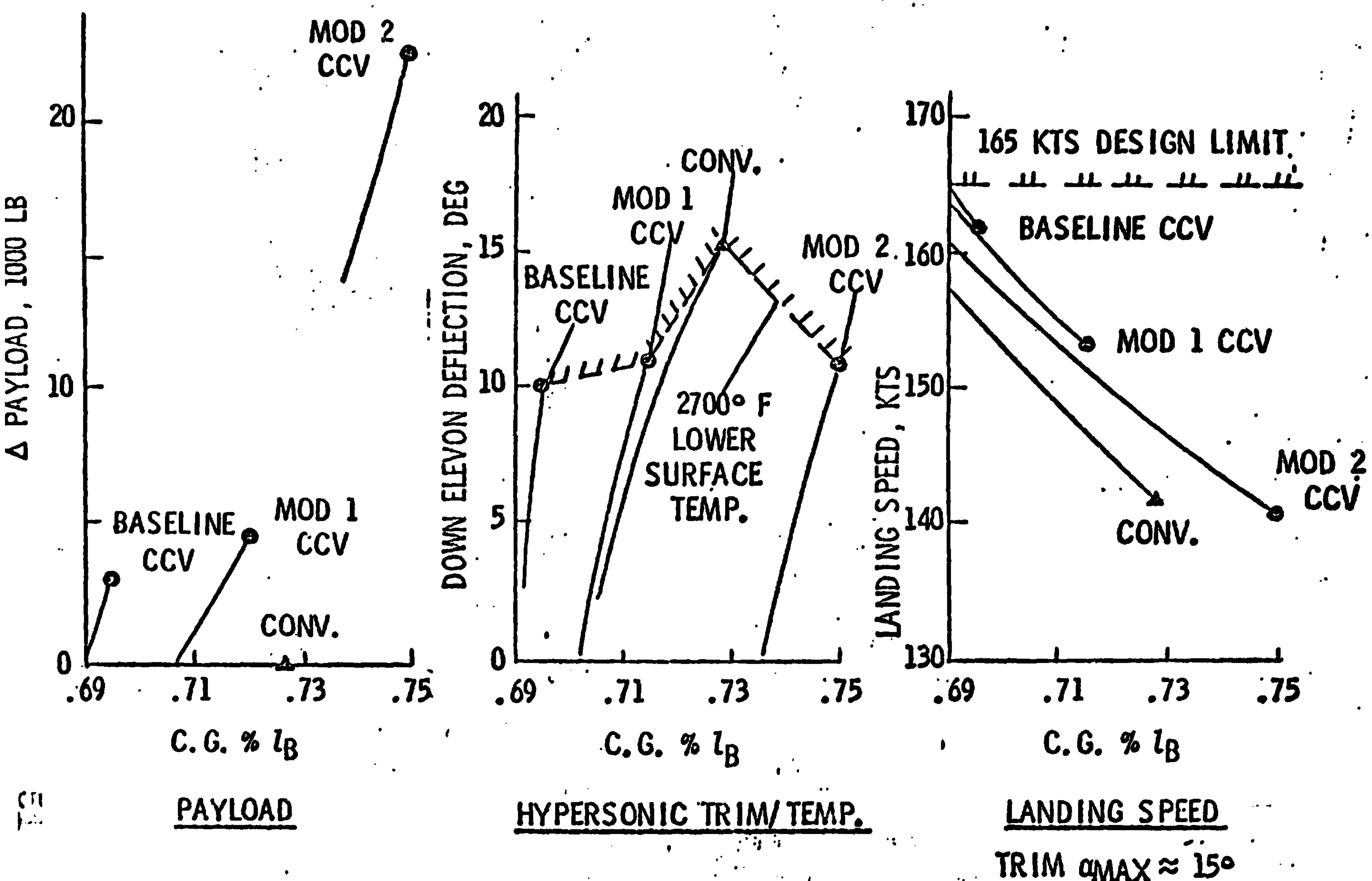
III - ESTABLISH LEVELS OF REQUIRED DAMPING AND RIGID MODE AUGMENTED FREQUENCY AND DETERMINE IF CURRENT HANDLING QUALITY CRITERIA ARE APPLICABLE TO CCV (6D MOTION STUDIES)

IV - IDENTIFY TECHNOLOGY ADVANCES MOST PROMISING TO CCV DESIGN

CONTRACT: NAS1-14833, $75K, 12 MONTHS (SUPPORTED BY CODE RA)
FINAL ORAL PRESENTATION NOVEMBER 30, 1977, COMPLETION MARCH 1, 1978

CCV STUDY PERFORMANCE SUMMARY

GLOW = 1.47×10^6 KG



STUDY RESULTS

- o UNSTABLE SSTO DESIGNS CAN BE CONTROLLED WITH STATE-OF-THE-ART TECHNIQUES FOR NEGATIVE STATIC MARGINS UP TO 0.14 $\bar{c}$.
- o THE MAIN DESIGN CONSIDERATIONS FOR THE CCV DESIGN ARE:

    1. AFT C.G.
    2. HYPERSONIC TRIM
    3. CONTROL SURFACE FLOW SEPARATION AND HEATING CONSTRAINTS

- o THE CRITICAL TASK OF CCV DESIGN IS OPTIMIZATION OF THE WING-BODY CONFIGURATION FOR HYPERSONIC TRIM.
- o OPTIMIZED CCV DESIGN CAN BE CONTROLLABLE AND OFFERS SUBSTANTIAL PAYLOAD GAINS OVER STABLE VEHICLE DESIGNS.

WINGED VS. BALLISTIC HEAVY-LIFT VEHICLE
TECHNOLOGY QUESTIONS

WINGED - FLIGHT WITH FAR AFT C.G.

- PAYLOAD SHROUD MECHANICS

BALLISTIC - BASE HEAT SHIELD DESIGN
  ASCENT - PLUME HEATING
  ENTRY - MULTIPLE PENETRATIONS

- BASE VOLUME UTILIZATION

- EFFICIENT, LOAD CARRYING TANKAGE

COMMONALITY - SHUTTLE, WINGED HLLV INVOLVE MANY COMMON TECHNOLOGIES

- BALLISTIC INTRODUCES DIFFERENT CONCERNS

STUDY: TURBOJET-BOOSTED TWO-STAGE-TO-ORBIT SPACE TRANSPORTATION SYSTEM DESIGN STUDY

OBJECTIVE - TO IDENTIFY CRITICAL AND UNIQUE PROBLEMS, DEVELOP SOLUTIONS, INCORPORATE INTO CONCEPTUAL DESIGN

TASKS

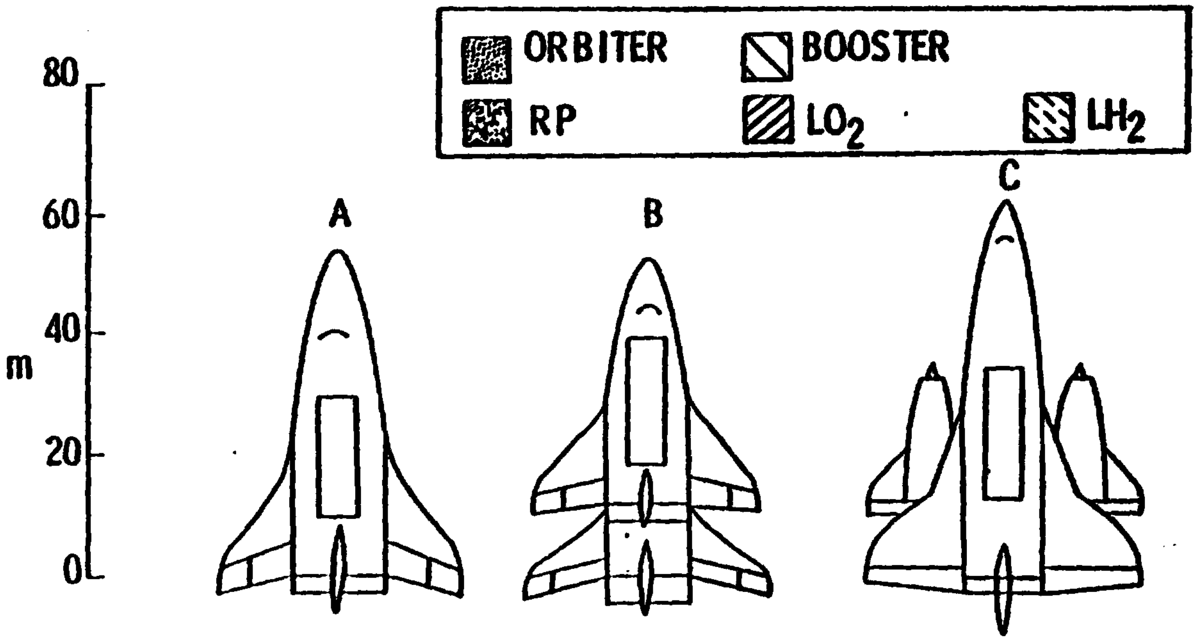
- DISCIPLINARY ANALYSES AND DESIGN TRADES
- CONCEPTUAL DESIGN AND PERFORMANCE ANALYSIS
- PRELIMINARY COST ANALYSIS
- TECHNOLOGY REQUIREMENTS ANALYSIS

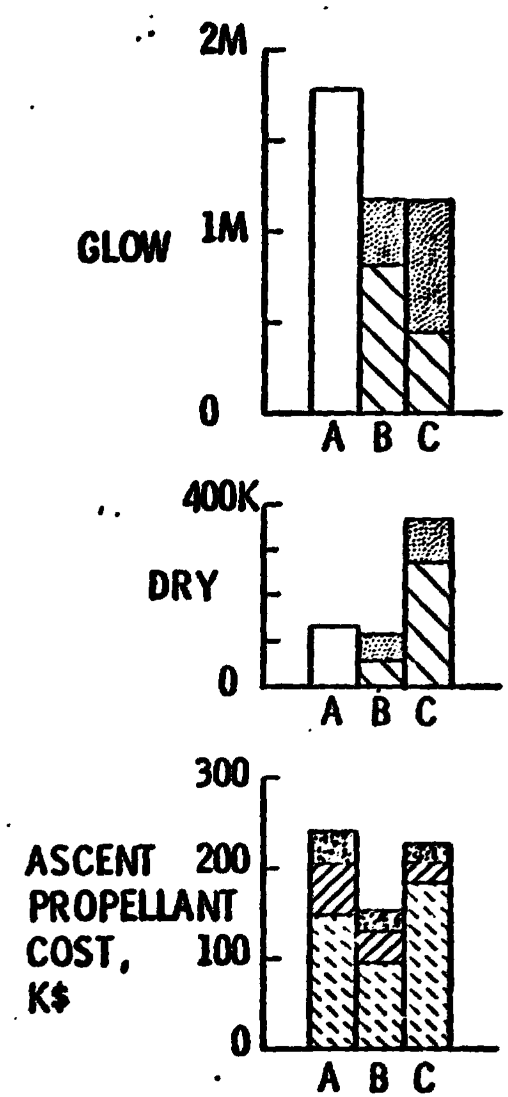
CONTRACT - $107K, 8.5 MO. (SUPPORTED BY CODE RA)

INITIATED DECEMBER 7, 1977 - BOEING

LAUNCH OPTION COMPARISON

PAYLOAD = 29 500 KG



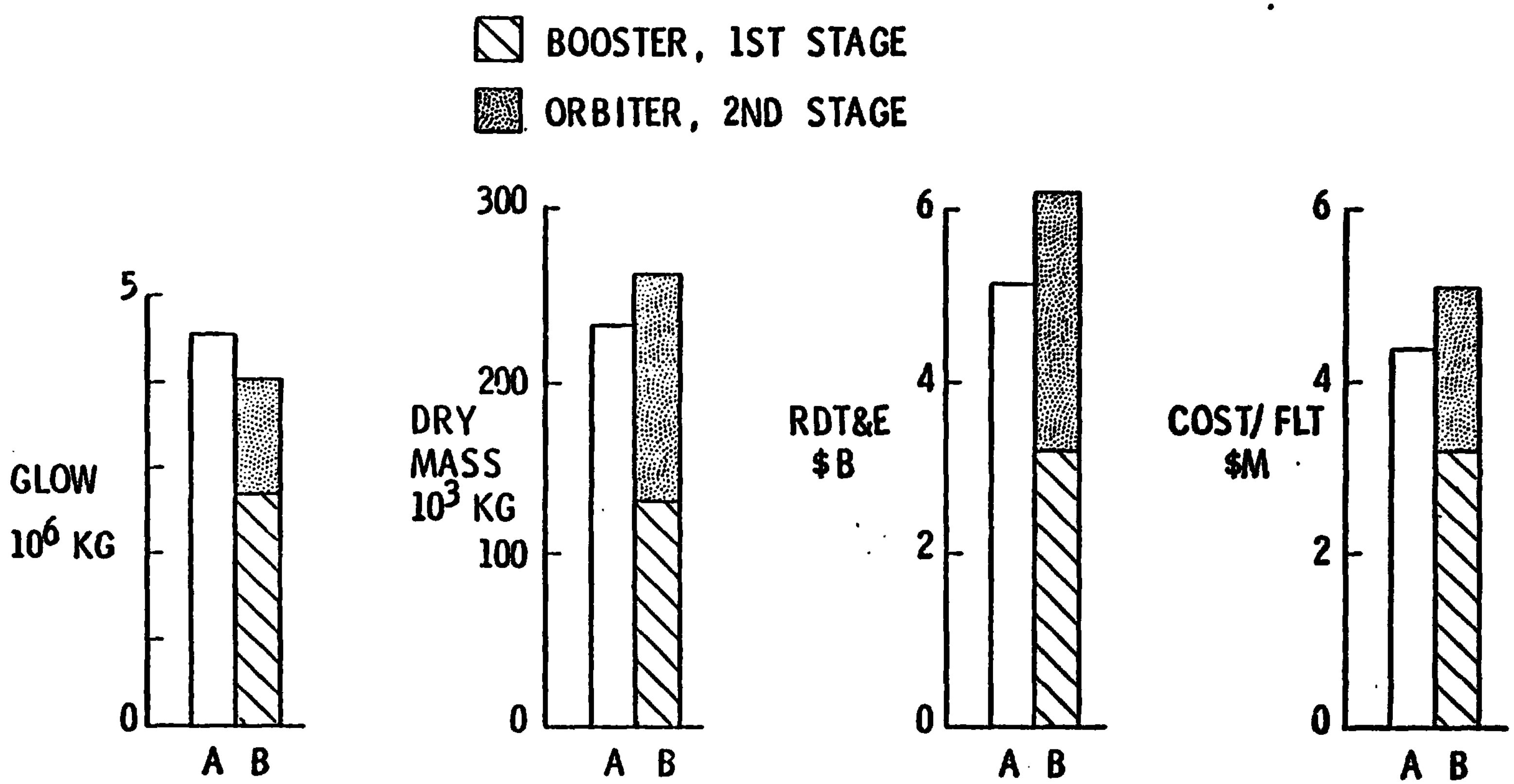


OPERATIONAL MODE	VTOHL SSTO	VTOHL STAGED M = 6	HTOHL STAGED M = 3.5
PROPULSION	SSME GROWTH GAS GEN. RP PARALLEL	SSME GROWTH GAS GEN. RP SERIES	SSME GROWTH ADV. T.J. SERIES
STRUCT. & SUBSYSTEMS	NORMAL GROWTH 1995 IOC	SAME	SAME

55

SINGLE VS. TWO STAGE WINGED HLLV

200 000 KG PAYLOAD, ACCELERATED TECHNOLOGY (1995 IOC)



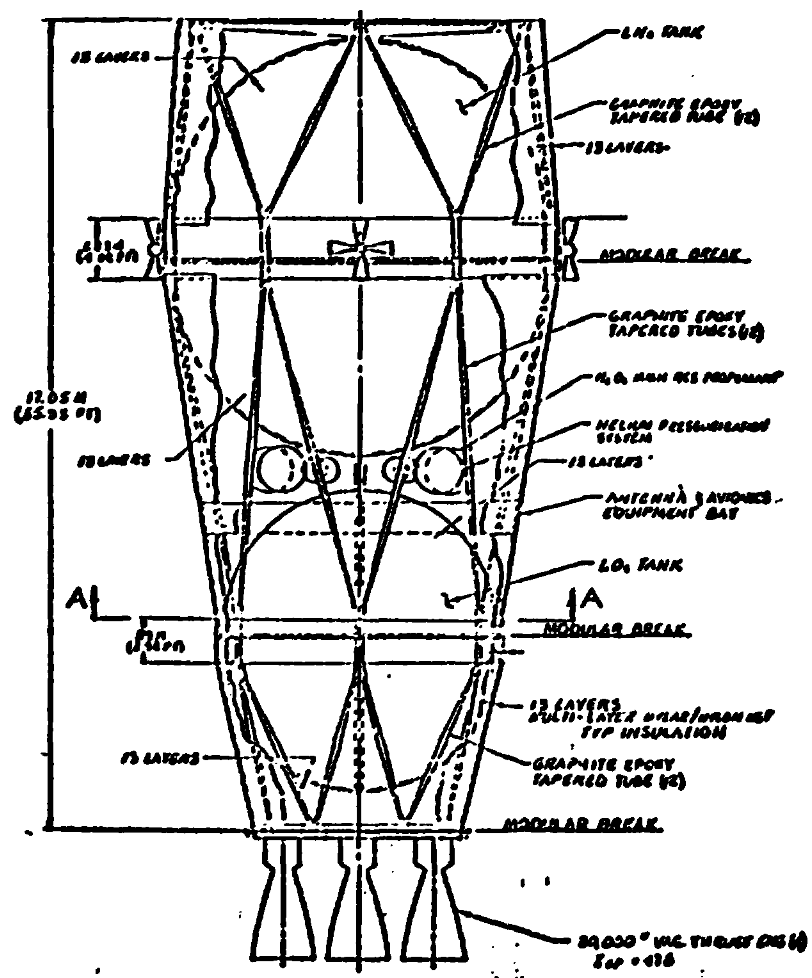
A - SSTO, DUAL EXPANDER

B - TWO STAGE (M = 6), SERIES BURN GAS GENERATOR RP BOOSTER ENGINE

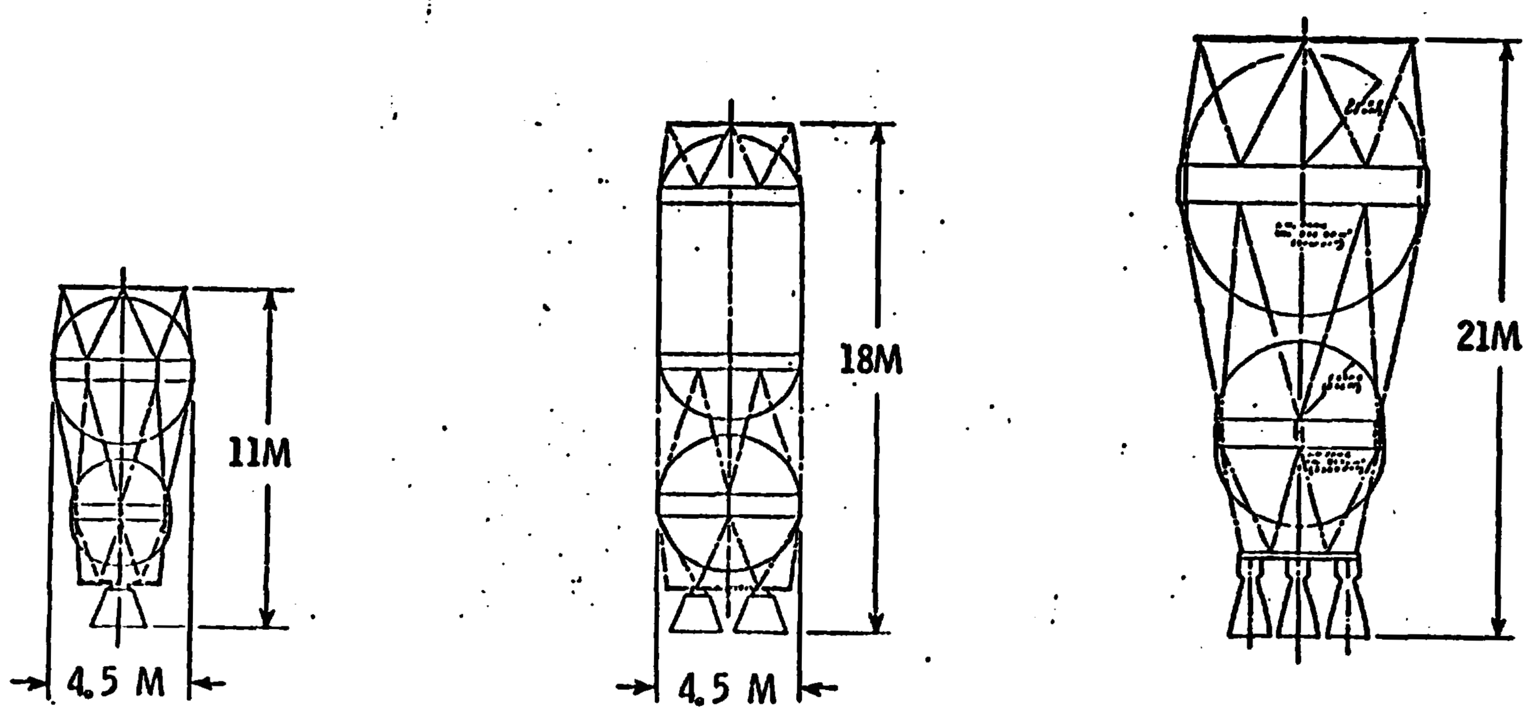
1/9/78
CHE

REPRESENTATIVE OTV STUDY CONCEPT

LOX/ LH, SPACE BASED



OTV STUDY VEHICLES - LOX/LH



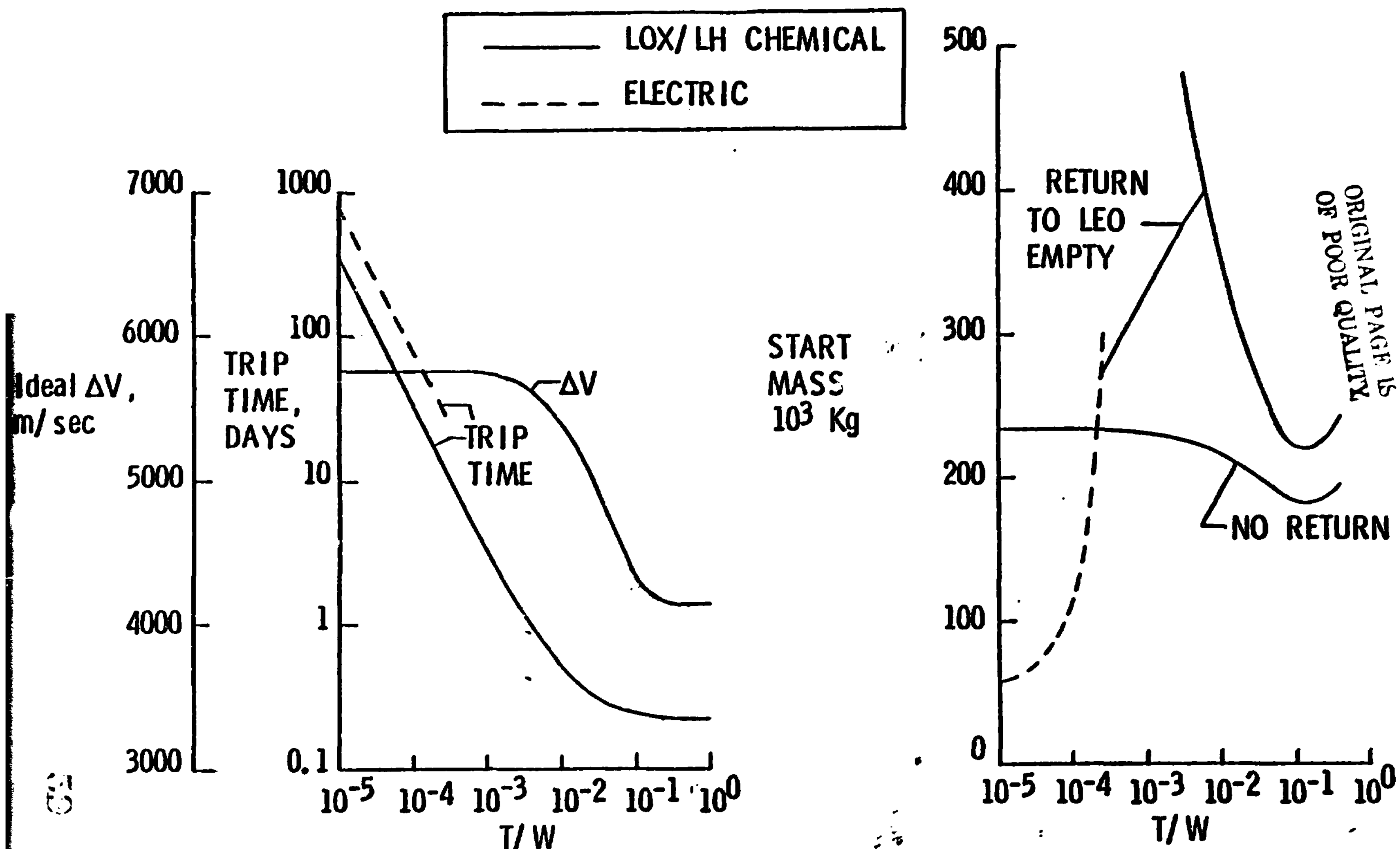
1 ENG	2 ENG	4 ENG
SHUTTLE MASS COMPATIBLE	SHUTTLE VOLUME OMPATIBLE	HLLV COMPATIBLE

OTV SIZING AND PERFORMANCE TRADES

LEO 28.5° INCLINATION

GEO 0°

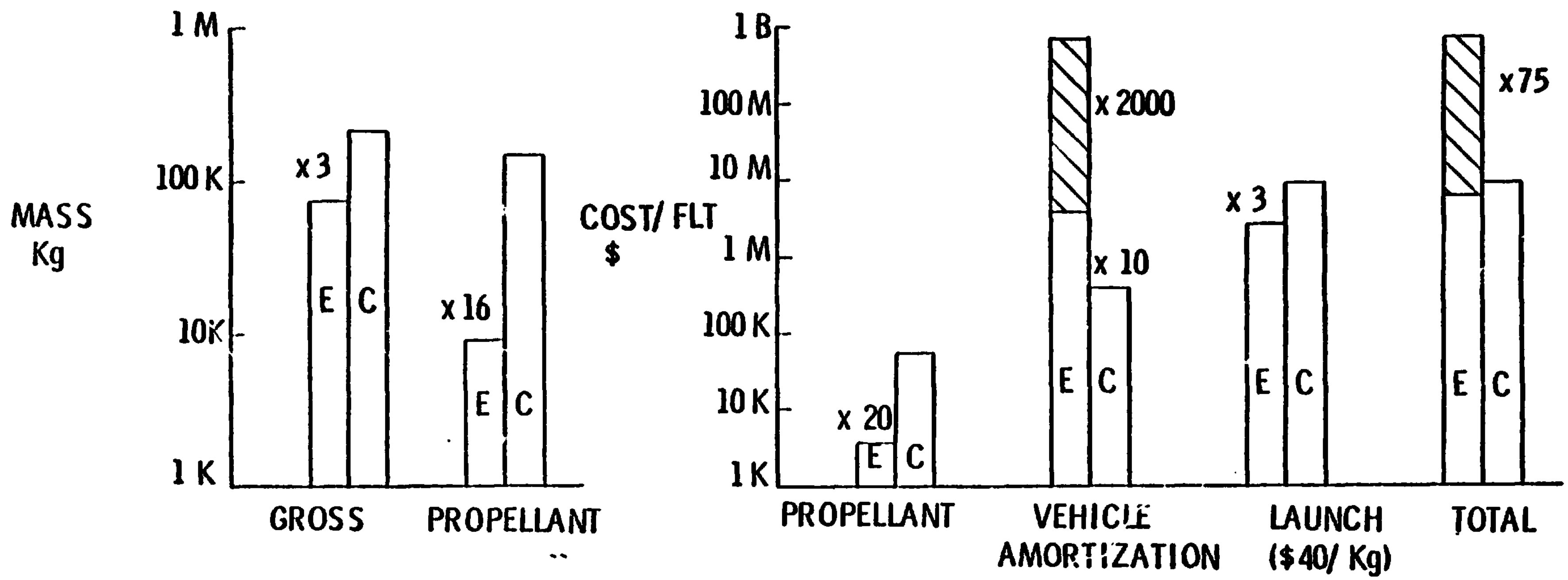
Delivered Payload = 50,000 Kg



ORIGINAL PAGE IS OF POOR QUALITY

COMPARISON OF ELECTRIC AND CHEMICAL CARGO OTV

50,000 Kg GEO DEPLOY



- o VEHICLE COSTS ARE A MAJOR CONCERN FOR ELECTRICAL
- o LOW LAUNCH COSTS COULD FAVOR A CHEMICAL

STUDY: TECHNOLOGY REQUIREMENTS FOR FUTURE EARTH-TO-GEOSYNCHRONOUS ORBIT TRANSPORTATION SYSTEMS

OBJECTIVE - TO ASSESS THE TECHNOLOGY REQUIREMENTS OF A VEHICLE MATRIX REPRESENTATIVE OF AN INTEGRATED EARTH-GEO. TRANSPORTATION SYSTEM

TASKS - EVALUATE THE CAPABILITIES OF EARTH-ORBIT AND ORBIT-ORBIT SYSTEMS AS A FUNCTION OF TIME WITH NORMAL TECHNOLOGY GROWTH.

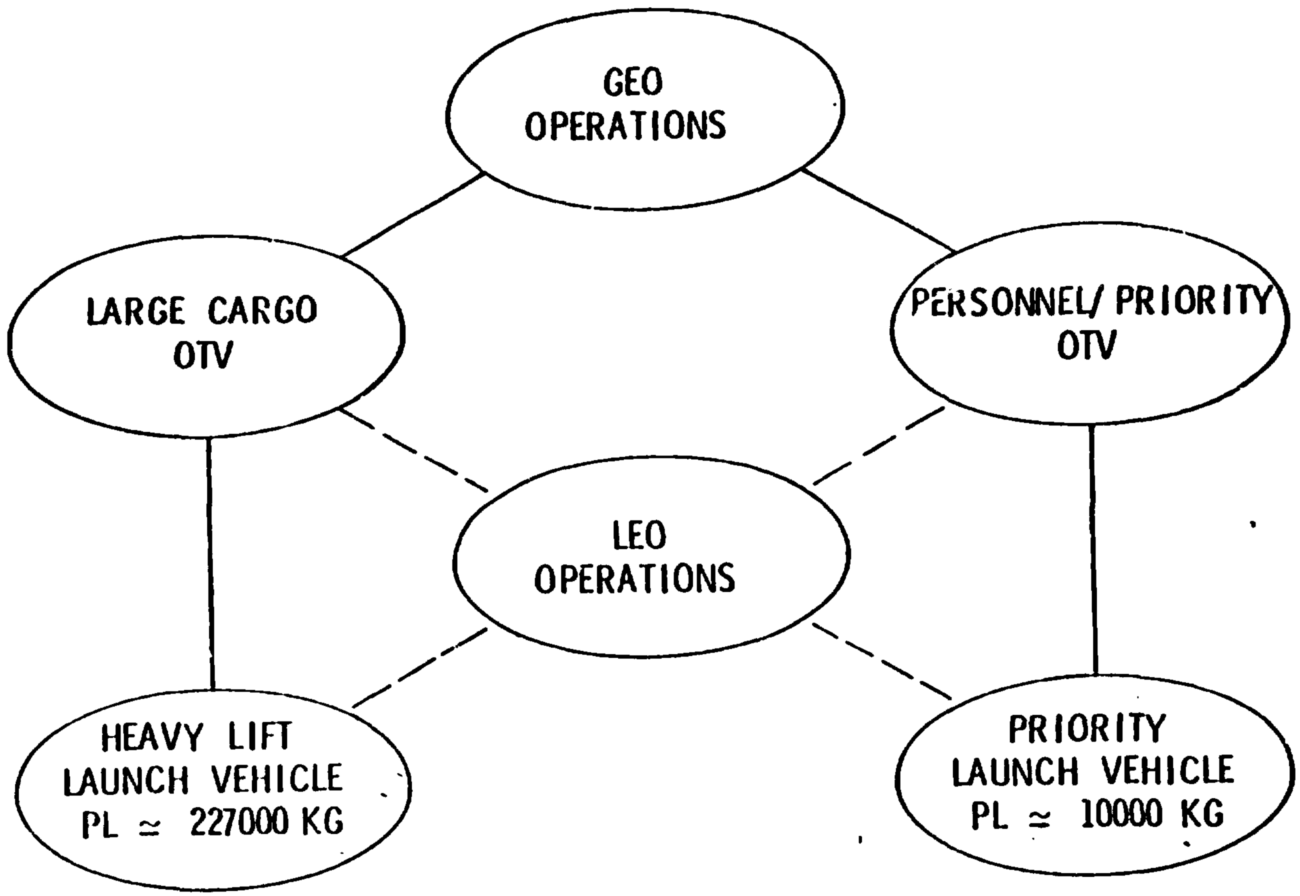
- DETERMINE COSTS AND BENEFITS RESULTING FROM THE ACCELERATION OF TECHNOLOGY GROWTH IN AREAS OFFERING POTENTIAL HIGH YIELD.

- DEFINE PERFORMANCE POTENTIAL OF FUTURE SYSTEMS INCORPORATING ACCELERATED TECHNOLOGY GROWTH LEVELS AS A FUNCTION OF TIME.

CONTRACT - $192K, 12 MONTHS

INITIATED FEBRUARY 1, 1978 - BOEING

INTEGRATED TRANSPORTATION SYSTEM TECHNOLOGY
VEHICLE STUDY MATRIX



PLANS AND DIRECTIONS - TRANSPORTATION TECHNOLOGY

CONTINUATION OF EFFORTS TO QUALITATIVELY EVALUATE TECHNOLOGY REQUIREMENTS AND GROWTH

RESOLUTION OF UNANSWERED QUESTIONS

- HLLV - WINGED OR BALLISTIC
  - SINGLE- OR MULTI-STAGE
- AIRBREATHING PROPULSION APPLICATION

DEFINE NEAR-TERM APPLICATIONS OF ACCELERATED ADVANCED TECHNOLOGY

DEFINE OPTIMAL TRANSPORTATION SYSTEM/TECHNOLOGY DEVELOPMENT PROGRAM

INCREASE EMPHASIS ON DEVELOPMENT OF IDENTIFIED CRITICAL AND/OR HIGH YIELD TECHNOLOGIES

- STRUCTURES AND MATERIALS
- PROPULSION
- AERORTHERMODYNAMIC DATA BASE
- OPERATIONS
- DESIGN INTEGRATION

STUDY: NEAR TERM APPLICATION OF ACCELERATED ADVANCED TECHNOLOGY

OBJECTIVE - TO DEFINE A TECHNOLOGY DEVELOPMENT PROGRAM WHICH BENEFITS NEAR-TERM SYSTEMS AND PROVIDES DEVELOPMENT CONTINUITY TO MEET FAR-TERM SYSTEM REQUIREMENTS.

APPROACH - SENSITIVITY ANALYSES OF NEAR-TERM SYSTEMS TO DEFINE POTENTIAL HIGH YIELD AREAS

- CORRELATION OF IDENTIFIED HIGH-YIELD AREAS FOR FAR-TERM APPLICATIONS WITH NEAR-TERM REQUIREMENTS

- DEFINITION OF MOST EFFECTIVE OVERALL TECHNOLOGY DEVELOPMENT PROGRAM

CONTRACT - $150K, 10 MONTHS

FY78

STUDY: OPTIMAL TRANSPORTATION SYSTEM/TECHNOLOGY DEVELOPMENT PROGRAM

OBJECTIVE - DEFINE FUTURE SYSTEM WHICH MAXIMIZES COMMONALITY AND BENEFITS OF SELECTED ADVANCES IN TECHNOLOGY

APPROACH - ANALYSES OF POTENTIAL APPROACHES TO SUPPORT REQUIREMENTS OF THE VARIOUS ELEMENTS OF THE TOTAL SYSTEM

- IDENTIFICATION OF TECHNOLOGY DRIVERS FOR EACH, CORRELATION WITH IDENTIFIED HIGH YIELD AREAS
- DETERMINATION OF SYSTEM WHICH DERIVES MAXIMUM BENEFIT FROM A COMMON TECHNOLOGY PROGRAM
- DEFINITION OF MOST EFFECTIVE DEVELOPMENT PHASING

CONTRACT - $150K, 12 MONTHS

FY 79

NASA

PROGRAM STATUS PRESENTATION

TO

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

NASA HEADQUARTERS

by

James J. Pelouch, Jr.

Propulsion Systems Section

Space Propulsion and Power Division

LEWIS RESEARCH CENTER

January 11 & 12, 1978

SYSTEMS CONCEPTS BRANCH

PROPULSION SYSTEMS SECTION

WORK OBJECTIVE: DEFINE THE REQUIREMENTS FOR FUTURE SPACE PROPULSION SYSTEMS AND DETERMINE THE APPLICABILITY OF CURRENT AND PLANNED PROPULSION TECHNOLOGY TO THESE REQUIREMENTS. PROMOTE A MUTUAL AWARENESS BETWEEN THE PROPULSION USES AND PROPULSION TECHNOLOGY COMMUNITIES.

CURRENT SCOPE: EARTH ORBIT AND PLANETARY APPLICATIONS

CURRENT STUDY ACTIVITIES:

- PROPULSION SYSTEM PERFORMANCE FORECASTING
  - Advanced Chemical
  - Electrostatic
  - Thermo-electric
  - Induction
- LOW-THRUST CONCEPTS ANALYSES FOR OPERATIONS BETWEEN LEO AND GEO
  - Chemical
  - Electric
- COST, PERFORMANCE AND RELIABILITY STUDIES OF ELECTROSTATIC PROPULSION FOR PLANETARY MISSIONS

DISCIPLINES:
- COST MODELING
- PERFORMANCE ANALYSIS
- PERFORMANCE PREDICTION (CAPABILITIES AND LIMITATIONS)
- MISSION REQUIREMENTS ANALYSIS
- DEVELOPMENT RISK ANALYSIS

AWARENESS: PROPULSION TECHNOLOGY DIRECTIONS ALTERED BY:
- CHANGES IN MISSION MODELS AND PREDICTED TRAFFIC
- EVOLUTIONS IN OTHER SPACE TECHNOLOGY
  - Cost and Weight of Space Power
  - Environmental Effects on Space Power
  - Cost of ETO Transportation
  - Presence of Men in LEO or LEO or both
  - Space System Structural Technology
  - Spacecraft Automation

CURRENT LEVEL-OF-EFFORT:

DIRECT IN-HOUSE	4 M-Y
INDIRECT IN-HOUSE	1 M-Y
R&D	$ 300 K

- ADVANCED CHEMICAL ENGINE STUDY CONTRACTS
- EARTH-ORBITAL APPLICATIONS FOR ELECTRIC PROPULSION
    - CONTRACT OVERVIEW
    - IN-HOUSE COST MODELING
- IN-HOUSE LaRC/LeRC PROGRAM IN LOW-THRUST CHEMICAL PROPULSION
    - PROGRAMMATIC
    - STATUS
    - MISSION REQUIREMENTS
    - PRELIMINARY PROPELLANT PERFORMANCE ESTIMATES
    - COST ANALYSIS

OBJECTIVE: PROVIDE DESIGN AND PARAMETRIC DATA ON ADVANCED ENGINES FOR MIXED-MODE ETO AND OTV VEHICLE STUDIES

IDENTIFY PROPULSION TECHNOLOGY NEEDS

APPROACH: PROPELLANT PERFORMANCE

THRUST CHAMBER COOLING

CYCLE BALANCE

DELIVERED PERFORMANCE, WEIGHT AND ENVELOPE PARAMETRICS

PRELIMINARY DESIGNS (ETO ENGINES)

STATUS: BELL NOZZLE ETO ENGINES

CONTRACT NAS 3-19727

AEROJET - COMPLETE

LINEAR AEROSPIKE ETO ENGINES

CONTRACT NAS3-20114

ROCKETDYNE - COMPLETE

BELL & DUAL-EXPANDER OTV ENGINES
CONTRACT NAS3-21049 (PARALLEL BURN)
AEROJET - END DATE 6/22/78

SERIES BURN STUDY - TBD

STUDY CONTRACT OVERVIEW

OBJECTIVE: IDENTIFY ADVANCES IN ION-BOMBARDMENT ELECTRIC PROPULSION TECHNOLOGY NEEDED TO MEET MISSION REQUIREMENTS OVER NEXT THREE DECADES AND ESTABLISH NATURE OF THESE ADVANCES

FY 78 SCOPE:

- PRIME PROPULSION
- ELECTROSTATIC PROPULSION
- 30-CM EMT BASELINE
- PHOTOVOLTAIC POWER

ISSUES: STUDY SIGNIFICANT COST DRIVERS

- LAUNCH COSTS
- POWER SUPPLY DEGREDATION
- THRUSTER SYSTEM CHARACTERISTICS
- COST AND WEIGHT OF POWER

STATUS: NEGOTIATION COMPLETE - AWARD IMMINENT

COST MODELING

OBJECTIVE: DEVELOP FIRST-ORDER PERSPECTIVES ON ELECTRIC PROPULSION COST DRIVERS

- ORBIT RAISING APPLICATIONS

$$\frac{\text{LEO-GEO COST}}{\text{UNIT OF PAYLOAD MASS}}$$

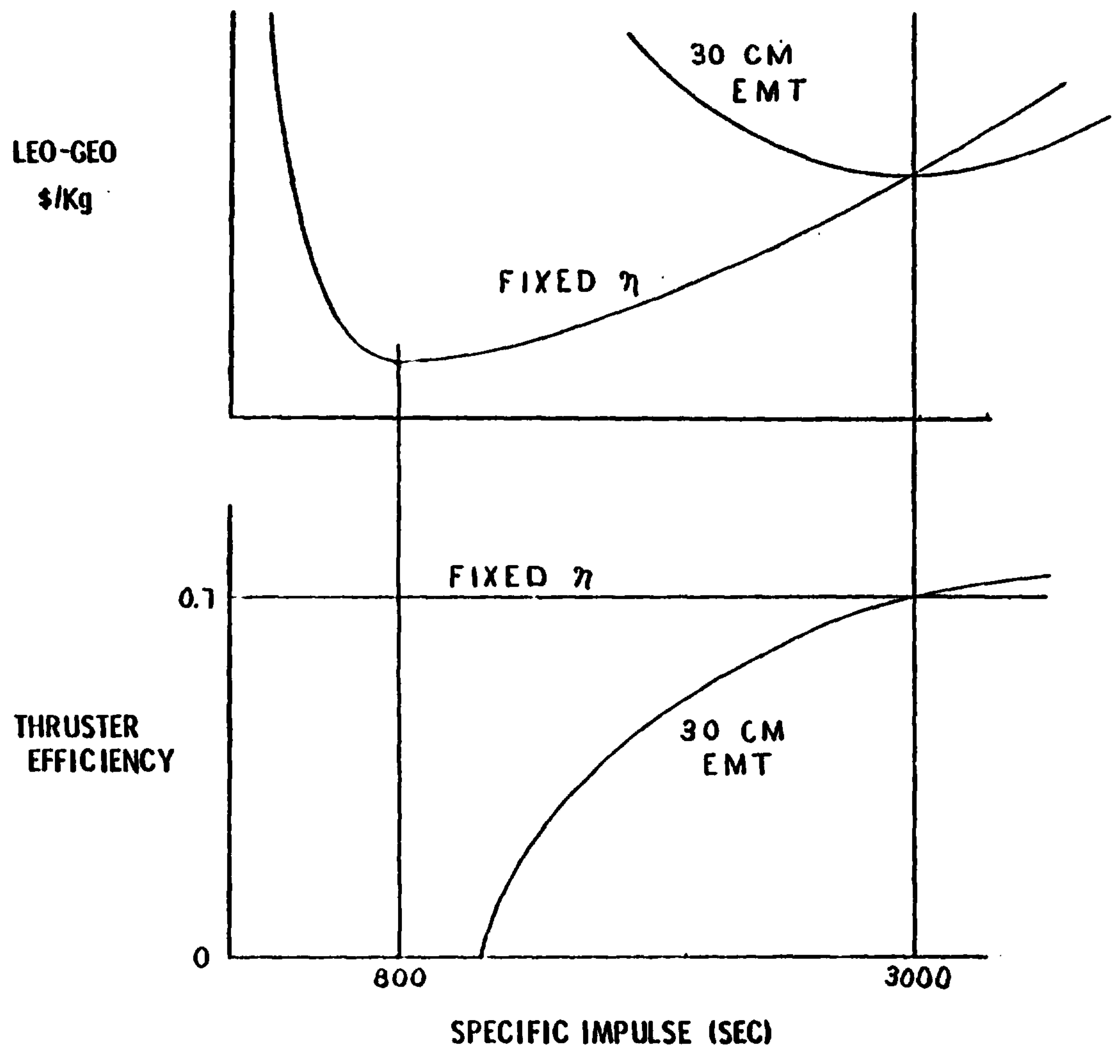
= FUNCTION OF

- $\frac{\text{Cost}}{\text{Power System Power}}$
- $\frac{\text{Power}}{\text{Power System Mass}}$
- $\frac{\text{Thrust}}{\text{Propulsion System Mass}}$
- Thruster Specific Impulse
- Thrust System Efficiency
- ETO Cost
- Leo-Geo Traffic
- OTV Life

MOST OF THESE VARIABLES ARE NOT MUTUALLY INDEPENDENT

- PROBLEM IS VERY COMPLEX

PERFORMANCE OF THRUSTER EFFECTS LEO-GEO COST SIGNIFICANTLY



BUT "OPTIMUM" (I_{sp}) CHARACTERISTIC IS INFLUENCED BY $\frac{\text{Cost}}{\text{Power}}$, $\frac{\text{Power}}{\text{Mass}}$, and $\frac{\text{Thrust}}{\text{Mass}}$

ELECTRIC PROPULSION S.O.A. PRESENTATION AND CONTRACTOR WORK PLAN PRESENTATION

OBJECTIVE: DESCRIBE ELECTROSTATIC PROPULSION STATE-OF-THE-ART TO THE STUDY CONTRACTOR AND DISCUSS ITEMS OF MUTUAL INTEREST IN ELECTRIC PROPULSION TECHNOLOGY

- FEB. 2 & 3, 1978, AT LeRC
- OAST AND OSF AND CENTERS WILL BE INVITED TO ATTEND

IN-HOUSE PLANS

- COST MODELLING
- THRUSTER DATA BASE

PROGRAM OUTLINE

OBJECTIVE: INVESTIGATE THE FEASIBILITY OF CHEMICAL PROPULSION FOR LOW-THRUST ORBIT RAISING AND DEFINE THE TECHNOLOGY OPTIONS

ENGINE SYSTEM

- DEFINE PRELIMINARY CONFIGURATIONS
- PRELIMINARY ANALYSES
  - CHAMBER COOLING AND STRESS
  - PUMP, DRIVE, AND CYCLE
  - DELIVERED PERFORMANCE
  - WEIGHT/ENVELOPE

VEHICLE SYSTEM

- DEFINE PRELIMINARY CONFIGURATIONS
- PRELIMINARY ANALYSES
  - STRUCTURAL
  - THERMAL
  - DYNAMIC/STABILITY
  - WEIGHT/ENVELOPE

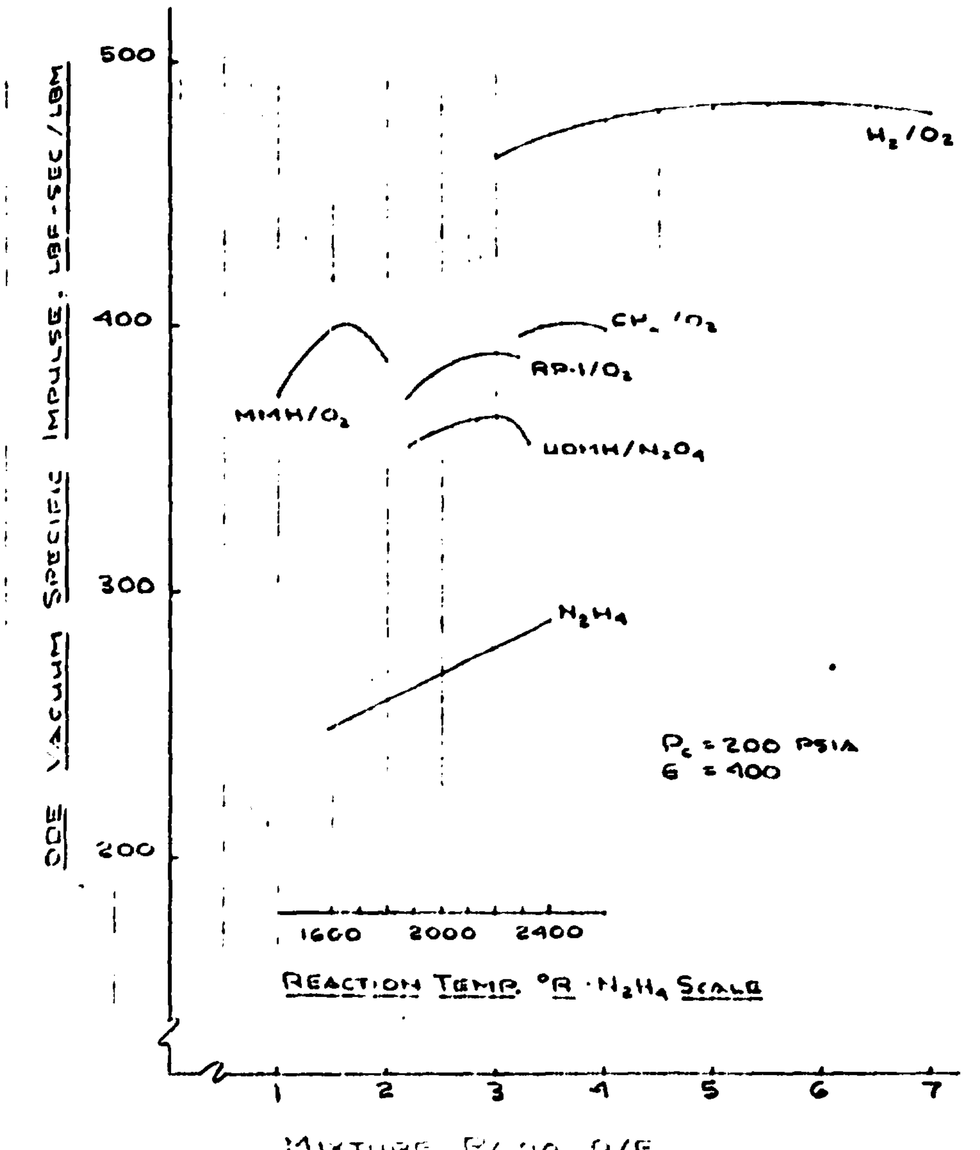
DESIGN OPTIMIZATION

- PERFORMANCE
- SIMPLICITY
- MAX. UTILIZATION OF AVAILABLE TECHNOLOGY
- GROWTH/RECONFIGURING FLEXIBILITY

LeRC STATUS

- SOME INFORMATION OBTAINED ON MISSION REQUIREMENTS
- PRELIMINARY I_{sp} PREDICTION OF VARIOUS PROPELLANT COMBINATIONS COMPLETE
- PRELIMINARY HYDROGEN REGEN. COOLING INFORMATION GENERATED
- COST ANALYSIS IN PROGRESS
- PROPULSION SUBSYSTEM WEIGHT SCALING CALCULATIONS IN PROGRESS
- SEARCHING AND ACCUMULATING INFORMATION ON SHELF HARDWARE

PROPELLANT PERFORMANCE



PRELIMINARY PERFORMANCE

CHAMBER PRESSURE • 200 PSIA

PROPELLANTS	MIXTURE RATIO	AREA RATIO	ESTIMATED DELIVERED PERFORMANCE LBF-SEC/LBM	BULK DENSITY LBM/FT³	ESTIMATED IMPULSE EFFICIENCY %
H_2/O_2	5.75	400	460	22.0	95
MMH/O_2	1.65	400	377	63.7	94
CH_4/O_2	3.65	400	377	52.1	94
RP-1/O_2	3.0	400	367	64.4	94
UDMH/N_2O_4	3.0	400	337	74.0	92
N_2H_4 (MONO)	REACTION TEMP 2260°R	400	254	62.6	90

C3

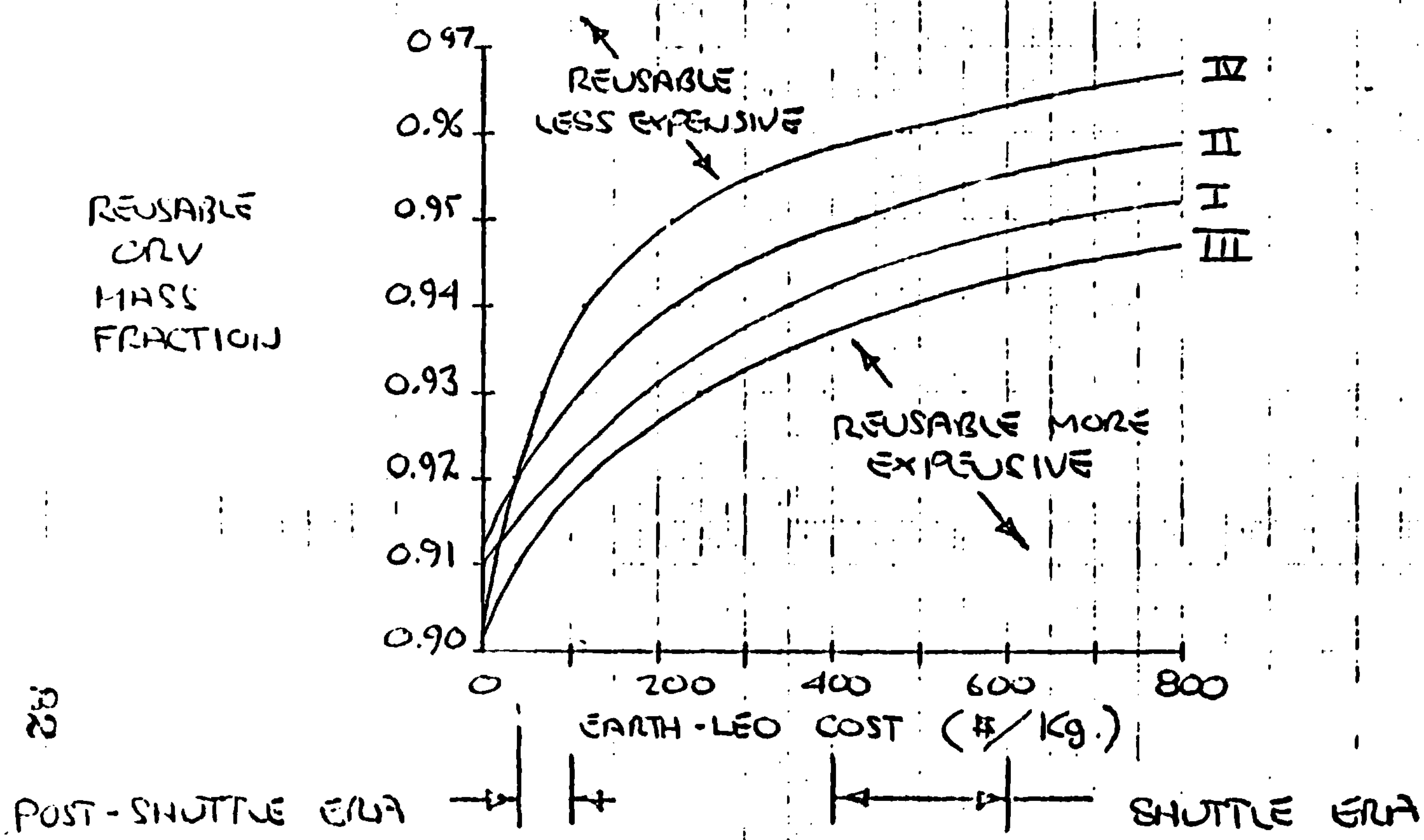
COST ANALYSIS -

- EXPENDABLE VEHICLES - (SHUTTLE ETO)
  - I_{sp} WILL MOST LIKELY HAVE TO EXCEED 350 SEC.
  - NO PRELIMINARY ADVANTAGE FOR H-O OR FOR HIGHER DENSITY PROPELLANTS IN THE 350-400 SEC I_{sp} RANGE (HIGHER MASS FRACTION TENDS TO OFFSET LOWER I_{sp})
  - H-O CAPABLE OF 460 SEC. I_{sp} @ 100 LB. THRUST, 200 PSI Pc

- REUSABLE VAHICLES - (H-O, SINGLE-STAGE, 460 SEC. I_{sp})
  - MASS FRACTION WILL HAVE TO EXCEED 0.95 TO BE COMPETITIVE WITH EXPENDABLE IF ETO COSTS ARE OF SHUTTLE ORDER
  - FOR ETO COSTS $50/Kg., REUSABLE IS A CLEAR WINNER
  - SIMILAR ARGUMENTS SEEM TO EXIST FOR HIGH THRUST OTV'S
  - ALL COST COMPARISONS ARE HIGHLY SENSITIVE TO MISSION DELTA V ASSUMPTIONS

EXPENDABLE/REUSEABLE COST BREAK-EVEN

MASS FRACT.	I_{sp}	PAYLOAD	CASE	I_{sp}	PAYLOAD	LIFE	TRAFFIC
0.89	460 s	5000 Kg.	I	460 s	5000	6 MISSIONS	3 MISSIONS/YEAR
0.89	460	5000	II	460	5000	6	12
0.89	460	5000	III	460	5000	48	12
0.92	470	40000	IV	470	40000	48	12



NOTE: ALL R&D COSTS EXCLUDED

SESSION 'T' - SPACE TRANSPORTATION

Advanced Space Transportation Technology Studies (B. Henry, LaRC)

DISCUSSION: Stan Sadin mentioned that this study was a model of the multi-Center, multi-year theme studies with a fine working relationship existing between the LaRC and LeRC groups, and also with JSC and MSFC personnel, even though these Centers receive no RX funds. The heavy in-house effort in support of this study was also praised.

Space Transportation Studies (J. Pelouch, Jr., LeRC)

DISCUSSION: More discussion of mass driver concepts. Mr. Pelouch stated that he needed to become more familiar with HQ space power for propulsion activities.

Discussion of FY 79 Plans in Space Transportation

Continuation of present efforts. The LaRC study will prepare a technology development program. LeRC is interested in non-transportation propulsion requirements.

The proper place for mass driver propulsion studies in the program was discussed; should it be added to the LaRC system studies or to the JSC utilization effort? This question will be discussed at the future meeting at LaRC.

SECTION 5

SESSION 'M'

REVIEW OF MULTIPROGRAM TECHNOLOGY STUDY PROGRAMS

PRESENTATION TO OAST-CODE RX

STUDY, ANALYSIS AND PLANNING OFFICE

ADVANCED AUTOMATION NEEDS ANALYSIS

PROGRESS REPORT

RTOP NO. 790-40-13

FUNDING: $75K in FY '77
$30K in FY '78

EWALD HEER

JANUARY 11, 1978

ADVANCED AUTOMATION NEEDS ANALYSIS
OBJECTIVES

- IDENTIFY OPPORTUNITIES FOR THE APPLICATION OF MACHINE INTELLIGENCE AND ROBOTICS IN NASA MISSIONS AND SYSTEMS.

- ESTIMATE THE BENEFITS OF SUCCESSFUL ADOPTION OF MACHINE INTELLIGENCE AND ROBOT TECHNIQUES AND PREPARE FORECASTS OF THEIR GROWTH CAPABILITY.

- RECOMMEND PROGRAM OPTIONS FOR RESEARCH, ADVANCED DEVELOPMENT AND IMPLEMENTATION OF MACHINE INTELLIGENCE AND ROBOT TECHNOLOGY FOR USE IN OAST PROGRAM PLANNING.

- BROADEN COMMUNICATION AMONG NASA CENTERS AND UNIVERSITIES AND OTHER RESEARCH ORGANIZATIONS CURRENTLY ENGAGED IN MACHINE INTELLIGENCE AND ROBOTICS RESEARCH.

ADVANCED AUTOMATION NEEDS ANALYSIS
APPROACH

- ESTABLISH A "STUDY GROUP ON MACHINE INTELLIGENCE AND ROBOTICS" CONSISTING OF REPRESENTATIVES FROM UNIVERSITIES AND OTHER INSTITUTIONS WORKING IN THESE AREAS

- PLAN AND HOLD FIVE WORKSHOPS WITH SPEAKERS INVITED FROM NASA, UNIVERSITIES AND INDUSTRY

- IDENTIFY AND DESCRIBE POTENTIAL AREAS OF APPLICATION FOR ADVANCED AUTONOMOUS SYSTEM TECHNOLOGY FOR NASA R&D PROGRAM PLANNING

- PREPARE FINAL REPORT, INCLUDING RECOMMENDATIONS FOR CRITICAL AREAS OF TECHNOLOGY DEVELOPMENT

ADVANCED AUTOMATION NEEDS ANALYSIS

RATIONALE

- NASA OAST HAS SET AMBITIOUS GOALS FOR FLIGHT AND GROUND BASED SYSTEMS TO INCREASE THEIR PERFORMANCE A THOUSANDFOLD BY 1985

- RECENT DEVELOPMENTS IN LARGE-SCALE INTEGRATED ELECTRONICS ENABLE ADVANCED COMPUTING AND INFORMATION SYSTEMS NOT YET CONSIDERED IN NASA PLANNING

- IT IS THEREFORE TIME TO CONSIDER NEW APPROACHES IN ADVANCED AUTOMATION FOR FUTURE NASA PROGRAMS

ADVANCED AUTOMATION NEEDS ANALYSIS

NASA STUDY GROUP ON MACHINE INTELLIGENCE AND ROBOTICS

CHAIRMAN: DR. CARL SAGAN, CORNELL UNIVERSITY

EXECUTIVE SECRETARY: DR. EWALD HEER, JET PROPULSION LABORATORY

DR. JAMES S. ALBUS
NATIONAL BUREAU OF STANDARDS

DR. ROBERT M. BALZER
INFORMATION SCIENCE INSTITUTE

DR. THOMAS O. BINFORD
STANFORD UNIVERSITY

DR. WILLIAM B. GEVARTER
NASA HEADQUARTERS

DR. R. C. GONZALES
UNIVERSITY OF TENNESSEE

DR. PETER HART
STANFORD RESEARCH INSTITUTE

DR. JOHN W. HILL
STANFORD RESEARCH INSTITUTE

MR. GENTRY B. LEE
JET PROPULSION LABORATORY

DR. ELLIOTT C. LEVINTHAL
STANFORD UNIVERSITY

DR. JACK MINKER
UNIVERSITY OF MARYLAND

DR. MARVIN MINSKY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DR. DONALD A. NORMAN
UNIVERSITY OF CALIFORNIA S.D.

DR. RAJ REDDY
CARNEGIE-MELLON UNIVERSITY

DR. CHARLES J. RIEGER
UNIVERSITY OF MARYLAND

MR. STANLEY R. SADIN
NASA HEADQUARTERS

DR. THOMAS B. SHERIDAN
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DR. PATRICK H. WINSTON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DR. WILLIAM WHITNEY
JET PROPULSION LABORATORY

DR. STEPHEN YERAZUNIS
RENSSELAER POLYTECHNIC INSTITUTE

ADVANCED AUTOMATION NEEDS ANALYSIS

WORKSHOP I - NASA PROGRAM OVERVIEW

UNIVERSITY OF MARYLAND, JUNE 27 TO 29, 1977

ACQUAINT THE STUDY GROUP WITH PLANNED NASA PROGRAMS INCLUDING:

- SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE
- PLANETARY EXPLORATION
- GLOBAL RESOURCES AND EARTH OBSERVATION
- SPACE INDUSTRIALIZATION
- LARGE AREA SPACE STRUCTURES
- REMOTELY OPERATED SYSTEMS
- SPACE TRANSPORTATION SYSTEMS AND GROUND OPERATIONS
- FLIGHT OPERATIONS AND MISSION CONTROL
- END-TO-END DATA MANAGEMENT

ADVANCED AUTOMATION NEEDS ANALYSIS

WORKSHOP II A - PLANETARY SURFACE ROVER TECHNOLOGY

JET PROPULSION LABORATORY, SEPTEMBER 28 AND 29, 1977

- RESULTS OF MARS 1984 STUDY
- MANIPULATION FOR PLANETARY SURFACE ROVERS
- LOCOMOTION FOR PLANETARY SURFACE ROVERS
- OPERATIONS FOR PLANETARY SURFACE ROVERS

ADVANCED AUTOMATION NEEDS ANALYSIS

WORKSHOP IIB - COMPUTER ARCHITECTURE FOR FUTURE SPACE MISSIONS

JET PROPULSION LABORATORY, SEPTEMBER 30, 1977

- ARCHITECTURES FOR SPACECRAFT COMPUTERS
- TRENDS IN COMPUTER ARCHITECTURES
- TRENDS IN LSI TECHNOLOGY
- WHAT SHOULD NASA DO IN COMPUTER ARCHITECTURE RESEARCH TO BE TWO ORDERS OF MAGNITUDE MORE COST EFFECTIVE IN 1990?

ADVANCED AUTOMATION NEEDS ANALYSIS

WORKSHOP III - MISSION OPERATIONS AND DATA MANAGEMENT

GODDARD SPACE FLIGHT CENTER, NOVEMBER 15 TO 18, 1977

- NASA DATA MANAGEMENT SYSTEMS
- SYSTEMS DEVELOPMENT METHODOLOGY IN MISSION OPERATIONS
- ADVANCED SOFTWARE TOOLS FOR MISSION OPERATIONS AND HIGH-LEVEL LANGUAGES
- TOPICS IN MAN-MACHINE SYSTEMS

EH; 1-11-78
SECT. 930; p.9

ADVANCED AUTOMATION NEEDS ANALYSIS

WORKSHOP IV - ROBOTS AND MAN-MACHINE SYSTEMS OPERATION

JOHNSON SPACE CENTER, FEBRUARY 1 AND 2, 1978

- SPACE RESOURCES AND COLONIES
- LARGE SPACE SYSTEMS TECHNOLOGY
- MANNED AND AUTOMATED OPERATIONS IN SPACE

WORKSHOP V - IMAGE DATA PROCESSING

NASA HEADQUARTERS, MARCH 8 AND 9, 1978

- PROGRAMS AND APPLICATIONS
- APPLICATIONS AND TECHNOLOGY
- IMAGE SCIENCE

EH; 1-11-78
SECT 930; p 10

ADVANCED AUTOMATION NEEDS ANALYSIS

SCHEDULE AND STATUS

TIME / ACTIVITIES	CY 1977				CY 1978			
	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
SELECT STUDY GROUP	▼							
WORKSHOP I		▼						
WORKSHOP II			▼					
WORKSHOP III				▼				
WORKSHOP IV					▽			
WORKSHOP V					▽			
FINAL REPORT					═════	══▽		
PRESENTATION TO NASA HQ						▽		

ADVANCED AUTOMATION NEEDS ANALYSIS

TENTATIVE CONCLUSIONS AND RECOMMENDATIONS

- OUTPUT OF THIS STUDY WILL SERVE AS BASIS FOR ADVANCED AUTOMATION PROGRAM PLANNING
- A NEW "AUTONOMOUS OPERATIONS" TECHNOLOGY INITIATIVE FOR FY 1980 IS PLANNED
- OAST SPACE SYSTEMS STUDIES FUNDING FOR FY 1979 IS RECOMMENDED; CONDUCTING PLANNING STUDIES TO DEFINE AUTONOMOUS OPERATIONS TECHNOLOGY INITIATIVE

PRESENTATION TO OAST - CODE RX

STUDY, ANALYSIS AND PLANNING OFFICE

STATUS REPORT

TECHNOLOGY ENABLEMENT - MULTIPLE REQUIREMENTS FOR POINTING AND CONTROL

RTOP NO. 790-40-15

FUNDING $25K RX

$25K RE

STUDY LEADER J. B. DAHLGREN

W. E. BACHMAN

JAN. 11, 1978

45

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL

OBJECTIVES

- IDENTIFY POINTING AND CONTROL TECHNOLOGICAL DEVELOPMENTS WHICH SIGNIFICANTLY ADVANCE FUTURE AUTOMATED MISSIONS
    - NEAR-EARTH, LUNAR, SOLAR AND PLANETARY MISSIONS
    - 1985 - 2000 TIME PERIOD
- TO CONTRIBUTE TO THE ADVANCED PLANNING OF A MEANINGFUL AND FOCUSED TECHNOLOGY PROGRAM IN POINTING AND CONTROL FOR AUTOMATED SPACECRAFT

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL

RATIONALE

- PLANNING OF AN EFFECTIVE TECHNOLOGY READINESS PROGRAM DEPENDS ON A SOLID UNDERSTANDING OF THE DRIVER MISSION/TECHNOLOGY REQUIREMENT RELATIONSHIPS

- POINTING AND CONTROL TECHNOLOGY WILL PLAY A KEY ROLE IN FUTURE AUTOMATED SPACECRAFT

    - INCREASED DATA
    - IMPROVED SCIENCE
    - LOWER COSTS
    - MISSION ENABLING

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL

APPROACH

- SELECT A REPRESENTATIVE NASA MISSION SET
- IDENTIFY THE DRIVER MISSION REQUIREMENTS FOR POINTING AND CONTROL TECHNOLOGY
- SYNTHESIZE CANDIDATE SYSTEMS FULFILLING THE DRIVER MISSION REQUIREMENTS
- IDENTIFY THE ENABLING AND SIGNIFICANTLY ENHANCING TECHNOLOGIES REQUIRED OF THE CANDIDATE SYSTEMS
- IDENTIFY REQUIRED TECHNOLOGY READINESS DATES
- ESTABLISH PRIORITIES OF CANDIDATE TECHNOLOGIES BASED ON DRIVER MISSION NET BENEFITS

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL

TECHNOLOGY FIELD

AUTOMATED SYSTEMS

- POINTING AND ARTICULATION CONTROL
- RENDEZVOUS AND DOCKING
- ORBITAL TRANSFER
- STATIONKEEPING
- ATTITUDE STABILIZATION
- FIGURE/SHAPE CONTROL

TECHNOLOGIES

- CONTROL CONCEPTS
- ANALYTICAL TOOLS FOR DYNAMICS INTERACTION
- FAULT TOLERANT TECHNIQUES
- REFERENCE SENSORS
- ELECTRONIC CONTROLLERS
- PLATFORMS
- ACTUATORS

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL

SCHEDULE MILESTONES

MAJOR MILESTONES	MONTH OF COMPLETION
• STUDY STARTED	DEC 1977
• DETAILED STUDY PLAN	JAN 1978
• IDENTIFY DRIVER MISSION REQUIREMENTS	MAR
• HEADQUARTERS REVIEW OF PROGRAM RECOMMENDATIONS AND PRIORITIES	JUNE
• FINAL REPORT	SEPT

TECHNOLOGY ENABLEMENT - POINTING AND CONTROL
STATUS

- DETAIL PROGRAM PLAN HAS BEEN COMPLETED AND REVIEWED AT NASA HEADQUARTERS
- CURRENT EFFORT IS DIRECTED TOWARD IDENTIFYING THE DRIVER MISSIONS
- CENTER CONTACTS BEING ESTABLISHED

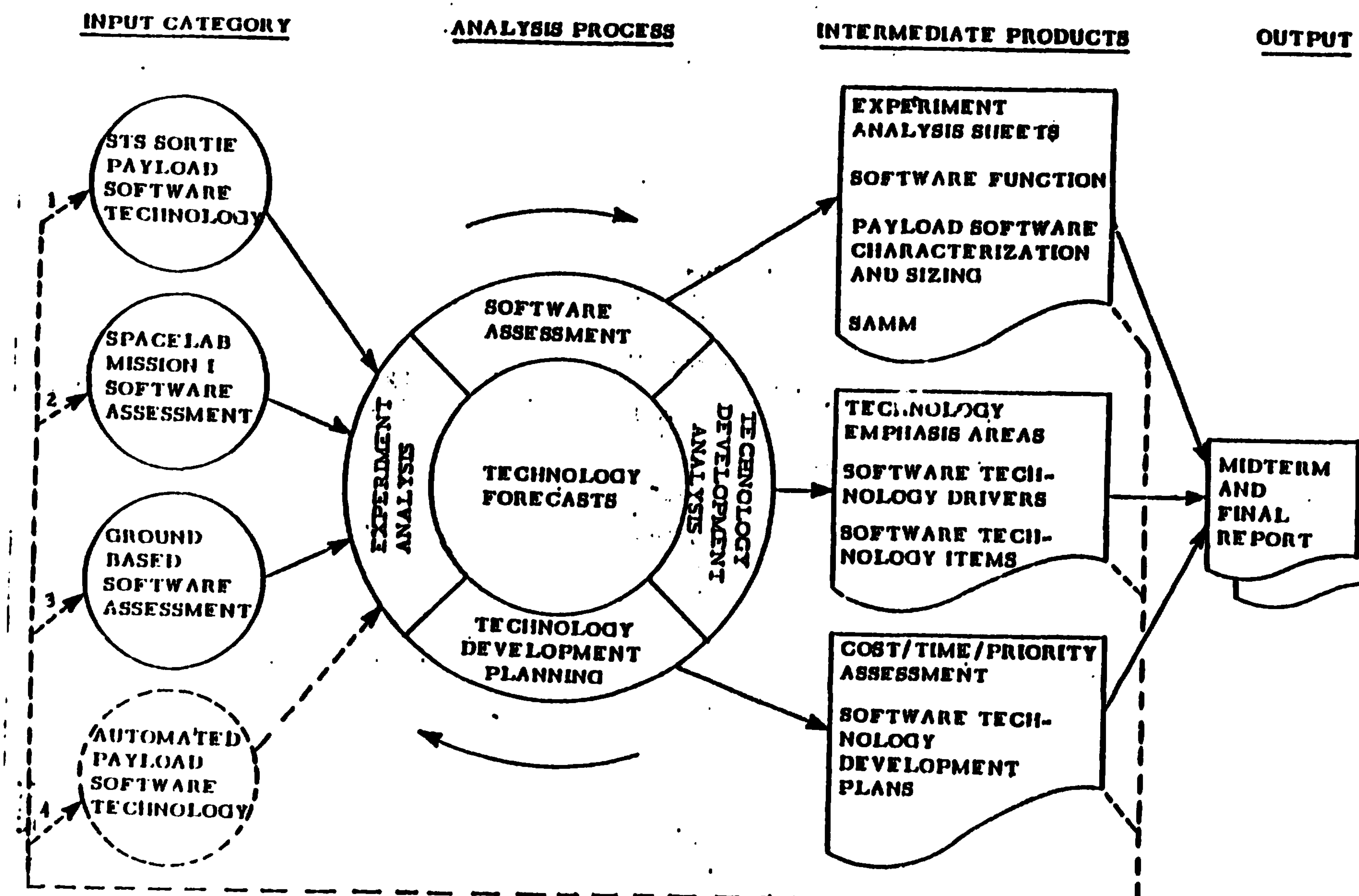
Report No. 78-003
Contract No. NAS8-32047

PAYLOAD SOFTWARE TECHNOLOGY
ANNUAL REVIEW

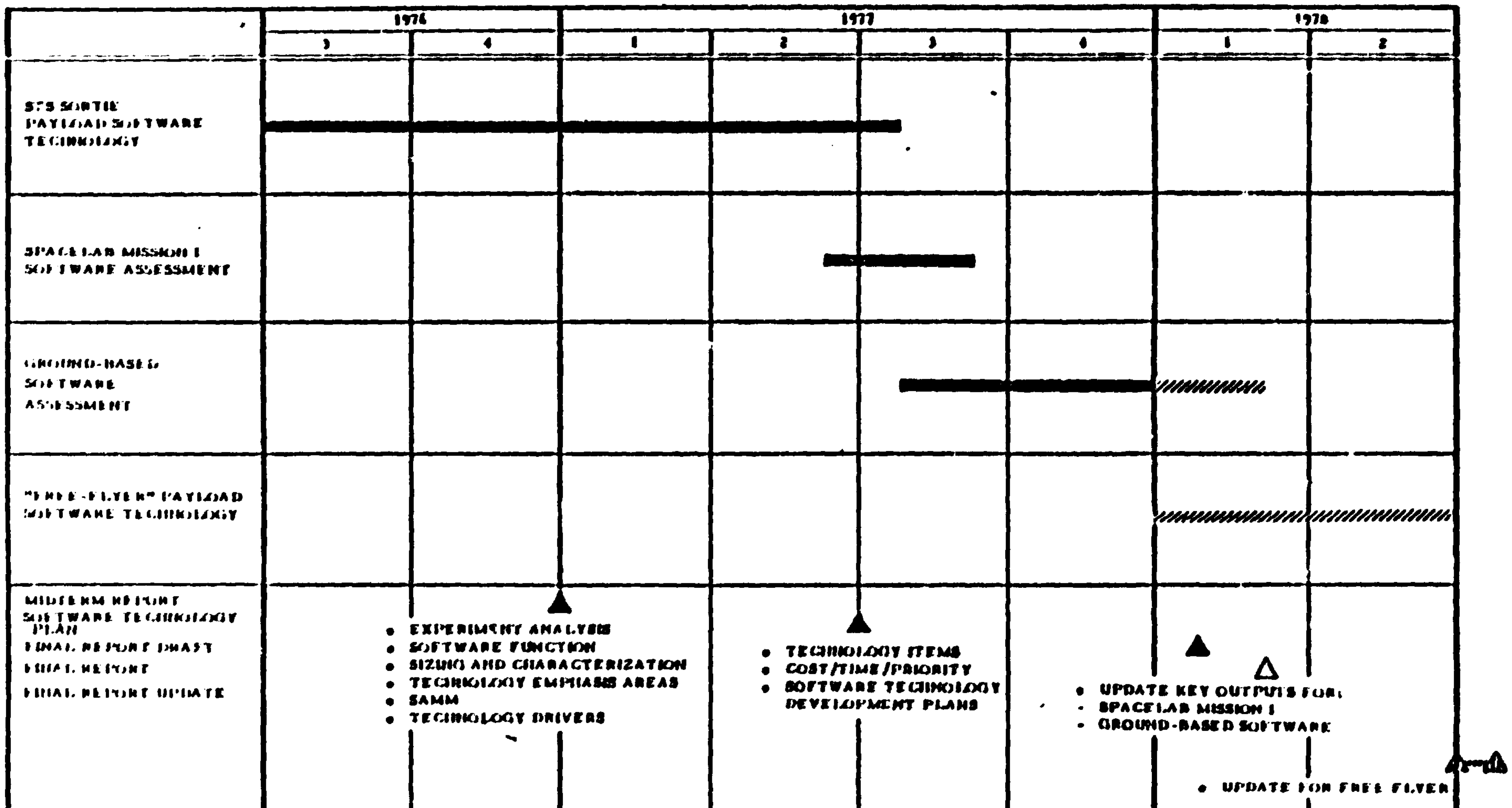
January 10, 1978

M&S COMPUTING, INC.

PAYLOAD SOFTWARE TECHNOLOGY STUDY
FUNCTIONAL FLOW



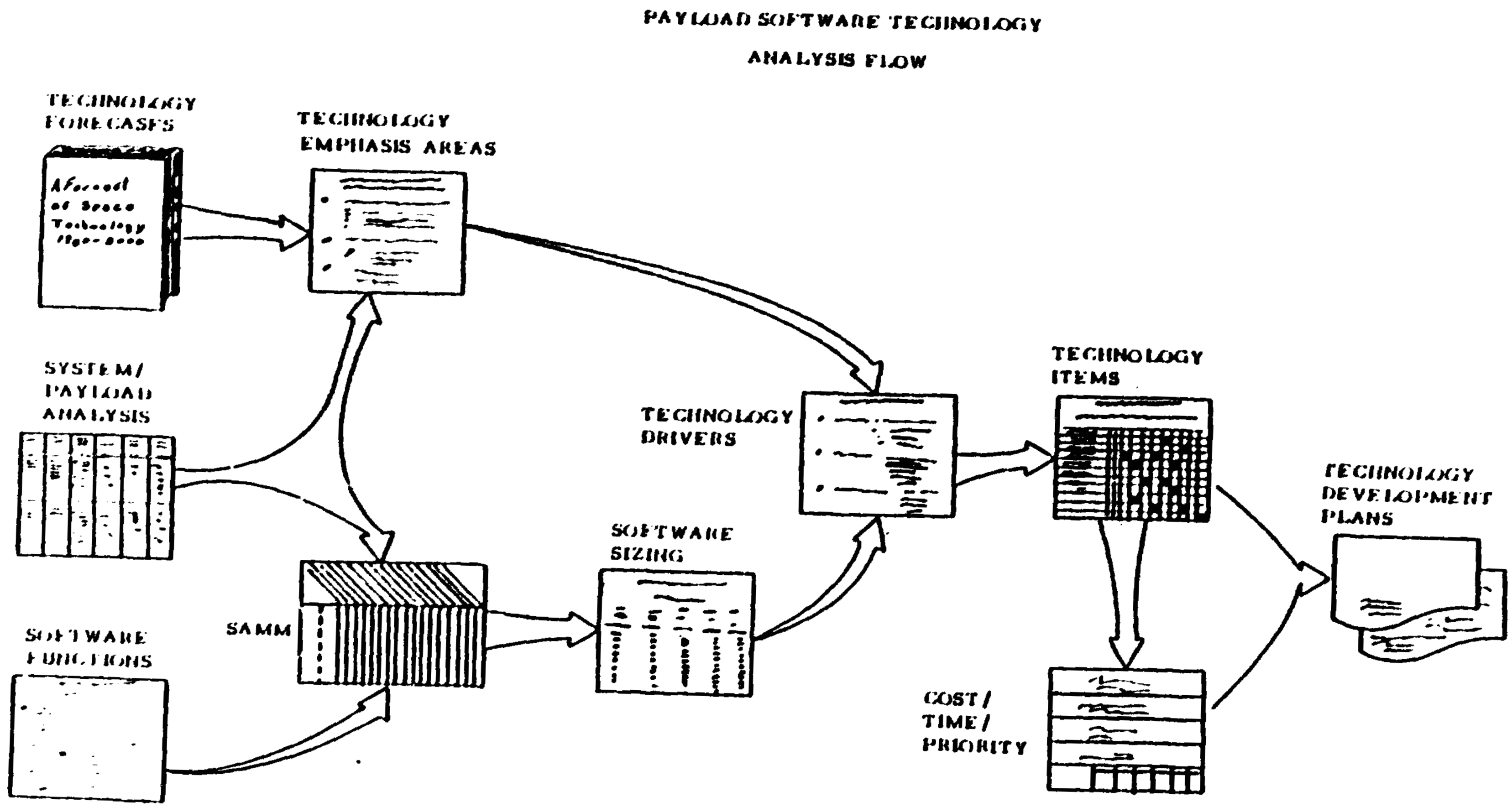
PAYLOAD SOFTWARE TECHNOLOGY
SCHEDULE OVERVIEW



PAYLOAD SOFTWARE TECHNOLOGY

- CURRENT STATUS.
  - MID-TERM REPORT RELEASED (DECEMBER 1976).
  - PAYLOAD SOFTWARE TECHNOLOGY PLAN RELEASED (JUNE 22, 1977).
  - STS SORTIE PAYLOAD SOFTWARE TECHNOLOGY COMPLETED (JULY 1, 1977).
  - SPACELAB MISSION ASSESSMENT COMPLETED (AUGUST 26, 1977).
  - PAYLOAD ELEMENT ANALYSIS SHEETS REVISED AND UPDATED
  - GROUND-BASED SOFTWARE ASSESSMENT IN PROCESS.
  - FINAL REPORT ON SCHEDULE.
- REMAINING ACTIVITY.
  - PUBLICATION OF FINAL REPORT.
  - "FREE-FLYER" ASSESSMENT.

    SUCCESSFUL COMPLETION OF THIS TASK WILL REQUIRE A MINIMUM OF ONE DATA GATHERING TRIP TO GODDARD SPACE FLIGHT CENTER.


PAYLOAD SOFTWARE TECHNOLOGY
ANALYSIS FLOW
TECHNOLOGY FORECASTS
A Forecast of Space Technology
TECHNOLOGY EMPHASIS AREAS
SYSTEM/ PAYLOAD ANALYSIS
SAMM
SOFTWARE FUNCTIONS
SOFTWARE SIZING
TECHNOLOGY DRIVERS
TECHNOLOGY ITEMS
COST / TIME / PRIORITY
TECHNOLOGY DEVELOPMENT PLANS

PAYLOAD SOFTWARE TECHNOLOGY
TECHNOLOGY EMPHASIS AREAS

- o SOFTWARE DEVELOPMENT TECHNOLOGY.
  - COST/TIME REDUCTION METHODS.
  - SOFTWARE RELIABILITY.
  - COST/PERFORMANCE EVALUATION.
  - SOFTWARE/HARDWARE STANDARDIZATION.

- o SOFTWARE SYSTEMS ARCHITECTURE.
  - FUNCTIONAL DISTRIBUTION OF PROCESSING.
  - FAULT TOLERANT SYSTEMS.
  - INTELLIGENT INSTRUMENTS.
  - HUMAN/SYSTEM INTERFACING.
  - *- UTILIZATION OF HIGH-RATE DATA PROCESSORS.
  - *- DATA DISTRIBUTION/SHARING NETWORKS.
  - *- VERY LARGE DATA BASE MANAGEMENT.
  - *- MULTIDIMENSIONAL DATA BASE SYSTEMS.

- o SOFTWARE APPLICATION TECHNOLOGY.
  - IMAGE RECOGNITION PROCESSING.
  - DATA COMPRESSION.
  - AUTOMATED INTELLIGENCE.
  - *- AUTOMATION OF GROUND SUPPORT FUNCTIONS.

*NOT ADDRESSED IN ONBOARD SOFTWARE STUDY

PAYLOAD SOFTWARE TECHNOLOGY

PRIME DRIVING CHARACTERISTICS

Planetary and Deep Space
- Navigation
- Tracking
- Bandwidth/Power
- Long Life

Extra-Terrestrial (SETI)
- Long Life
- Heavy Processing
- Data Volume
- Algorithms

Earth Observations
- Data Rate
- Data Volume
- Stability
- Data Distribution

Solar
- Pointing
- Data Volume

Communication
- Bandwidth
- Power
- Pointing
- Long Life
- Antennas
- Reliability

Navigation
- Tracking
- Stability
- Long Life
- Reliability

Science
- Pointing
- Data Rates
- Stability
- Environment Control

Technology
- Attitude Control
- Stability
- Large Structures
- ECLS

Weather
- Timeline
- Data Distribution

- Bandwidth for data down link is not a problem.
- Data compression/decompression is not a driver.
- Data transfer/distribution is a ground network problem.
- Image processing and classification is receiving ample support and requires no forcing to achieve NASA goals.
- Geometric correction requires no special consideration.

PAYLOAD SOFTWARE TECHNOLOGY
TECHNOLOGY DRIVER SUMMARY

- o SOFTWARE DEVELOPMENT.
  - SOFTWARE DESIGN ENGINEERING.
  - TREND TOWARD S/W DEVELOPMENT BY NON-PROGRAMMERS.
  - FAULT-FREE SOFTWARE.
  - APPLICATION ORIENTED LANGUAGE DESIGN METHODOLOGY.
  - LOW-COST DEVELOPMENT OF AOL COMPILERS.

- o SOFTWARE SYSTEMS ARCHITECTURE.
  - (DISTRIBUTED) SYSTEM PARTITIONING/INTERCONNECTION TECHNIQUES.
  - VERY LARGE STORAGE ACCESS SIMPLIFICATION.
  - SOFTWARE FAULT (OWN OR INDUCED) DETECTION.
  - SOFTWARE RECOVERY (AFTER FAULT DETECTION).
  - HIGH-SPEED BUFFERING TECHNIQUES.
  - DESIGN AND CONTROL OF ADAPTIVE SOFTWARE PROCEDURES.
  - USE OF "NATURAL" COMMUNICATION METHODS.
  - EFFICIENT LARGE ARRAY SEARCH AND SORT PROCEDURES.
  - PARALLEL PROCESSING TECHNIQUES.
  - EFFICIENT LARGE ARRAY MANIPULATION PROCEDURES.

PAYLOAD SOFTWARE TECHNOLOGY

TECHNOLOGY DRIVER-ITEM CORRELATION TABLE

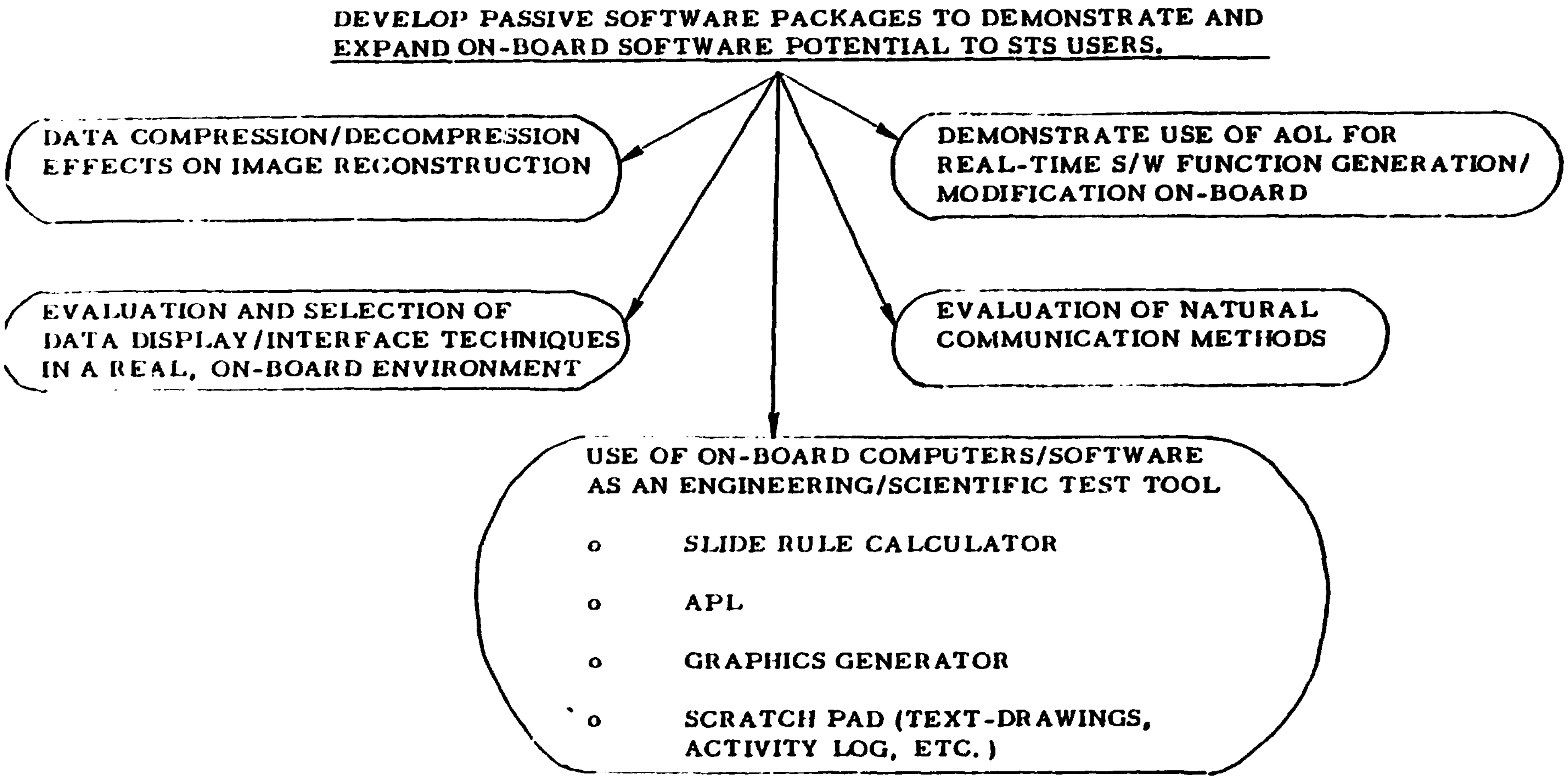
TI NO.	SOFTWARE TECHNOLOGY ITEM	SOFTWARE TECHNOLOGY DRIVER, PS-														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	REQUIREMENTS DECOMPOSITION AND STRUCTURING GUIDELINES	X					X								X*	
2	REQUIREMENTS-TO-CODE TRANSLATION AIDS		X													
3	SIMPLIFIED SOFTWARE DEVELOPMENT SYSTEM DEMONSTRATION MODEL		X													
4	QUERY-GUIDED IMPLEMENTATION METHODS		X													
5	STANDARDIZATION CRITERIA FOR NASA SOFTWARE			X												
6	AOL DESIGN GUIDELINES/STANDARDS				X	X										
7	AOL COMPILER GENERATOR COST FACTORS					X										
8	INTERFACE CRITERIA FOR NASA DISTRIBUTED PROCESSOR APPLICATIONS	X*					X								X	
9	TASK CONTROL STRUCTURES FOR DISTRIBUTED PROCESSOR ENVIRONMENTS						X								X	
10	PROGRAM ORGANIZATION METHODS FOR REAL-TIME FAULT RECOVERY						X*			X					X*	
11	ADAPTIVE HIGH SPEED BUFFERING TECHNIQUES FOR DYNAMIC NETWORKS										X	X*				
12	CONTROL STRUCTURES FOR ADAPTIVE SYSTEMS											X				
13	IMPACTS OF NATURAL COMMUNICATION METHODS ON NASA PAYLOAD SYSTEMS												X			
14	ADAPTIVE SEARCH AND SORT PROCEDURES											X*		X		
15	RESTRUCTURED IMAGE ANALYSIS SOFTWARE FOR PARALLEL PROCESSING														X	
16	OPTIMAL LARGE ARRAY PARTITIONING PROCEDURES															X
17	CLASSIFICATION OF ERROR MECHANISMS		X	X					X	X						
18	GUIDELINES FOR DESIGN DOCUMENTATION CONSISTENCY	X			X											
19	SOFTWARE PROTOTYPING METHODS	X	*	*			*	*	*	*	*	*		*	*	*
20	SOFTWARE TECHNOLOGY MONITORING	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

PAYLOAD SOFTWARE TECHNOLOGY

TOP PRIORITY TECHNOLOGY ITEMS

- TI-01 REQUIREMENTS DECOMPOSITION AND STRUCTURING GUIDELINES.
- TI-08 INTERFACE CRITERIA FOR NASA DISTRIBUTED PROCESSOR ENVIRONMENTS.
- TI-09 TASK CONTROL STRUCTURES FOR DISTRIBUTED PROCESSOR ENVIRONMENTS.
- TI-10 PROGRAM ORGANIZATION METHODS FOR REAL-TIME FAULT RECOVERY.
- TI-15 RESTRUCTURED IMAGE ANALYSIS SOFTWARE FOR PARALLEL PROCESSING.
- TI-17 CLASSIFICATION OF ERROR MECHANISMS.
- TI-20 SOFTWARE TECHNOLOGY MONITORING.

PAYLOAD SOFTWARE TECHNOLOGY
SPACELAB MISSION 1
SOFTWARE TECHNOLOGY POTENTIAL



PAYLOAD SOFTWARE TECHNOLOGY
GROUND SOFTWARE ASSESSMENT

<u>TECHNOLOGY DRIVERS</u>

- DATA DISTRIBUTION THROUGH GROUND NETWORKS.
- IDENTIFICATION, PROCESSING, PROTECTION AND CONTROL OF SENSITIVE, HIGH RESOLUTION DATA.
- STORAGE/RETRIEVAL OF ARCHIVAL DATA.
- PRIORITY, SELECTION, AND SCHEDULING OF TARGETS FOR ULTRA-HIGH RESOLUTION IMAGERS.
- S/W DEVELOPMENT SCHEDULE, COST, AND PERFORMANCE.
- DEVELOPMENT/SUPPORT OF LOW-COST USER TERMINAL NETWORKS AND PROCESSING SYSTEMS.
- INTEGRATION OF REMOTELY SENSED DATA INTO EXISTING LARGE SCALE DATA SYSTEMS.

PAYLOAD SOFTWARE TECHNOLOGY
GROUND-BASED SOFTWARE TECHNOLOGY ITEMS

- PARALLEL PREPROCESSING AND DISTRIBUTION.
  - ONBOARD RADIOMETRIC CORRECTION.
  - ONBOARD QUALITY ASSESSMENT.
  - CHANGE DETECTION.
  - LOW-COST GROUND SYSTEM SOFTWARE.
- EARTH MODEL DATA BANK.
  - RESOLUTION LEVELS.
  - SPECTRAL BANDS.
  - TEMPORAL BANDS.
  - SECURITY/CONTROL OF HIGH-RESOLUTION DATA.
  - STORAGE AND RETRIEVAL TECHNIQUES.
- INTEGRATION OF NEW DATA FORMS INTO EXISTING DATA SYSTEMS.
  - WEATHER.
  - CROP FORECASTING.
- SOFTWARE DEVELOPMENT/ENGINEERING.
  - NARRATIVE DESIGN.
  - DESK-TOP DEVELOPMENT SYSTEMS.
  - HIGH-LEVEL PROTOTYPING TECHNIQUES.

PAYLOAD SOFTWARE TECHNOLOGY
SOFTWARE TECHNOLOGY DEVELOPMENT PLAN

SECTION I - INTRODUCTION - This section describes the purpose of this plan, the scope of the plan, and the manner in which the plan is organized.

SECTION II - SUMMARY - This section is an executive summary of the Software Technology Development Plan and its derivation.

SECTION III - DESCRIPTION OF SOFTWARE TECHNOLOGY ITEMS - This section is the description and planned approach to each of the Software Technology Development studies selected.

3.1 Item TI-01

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3.n Item TI-n

APPENDIX A - Technology Driver Derivation.

APPENDIX B - Software Technology Item Derivation Worksheets.

APPENDIX C - Cost/Time/Priority Assessment.

PAYLOAD SOFTWARE TECHNOLOGY
FINAL REPORT OUTLINE

VOLUME I - FINAL REPORT

I. INTRODUCTION.

II. EXECUTIVE SUMMARY.

III. TECHNOLOGY FORECAST REVIEW.

IV. STS SORTIE PAYLOAD SOFTWARE TECHNOLOGY ANALYSIS.

- 4.1 EXPERIMENT ANALYSIS.
- 4.2 TECHNOLOGY DRIVER SELECTION.
- 4.3 TECHNOLOGY DRIVER ANALYSIS.
- 4.4 TECHNOLOGY ITEM SELECTION.
- 4.5 COST/TIME/PRIORITY ASSESSMENT.
- 4.6 TECHNOLOGY DEVELOPMENT ANALYSIS/PLAN.

V. SPACELAB MISSION I SOFTWARE ASSESSMENT.

- 5.1 - 5.6 (SAME AS SECTION IV).

VI. GROUND-BASED SOFTWARE ASSESSMENT.

- 6.1 - 6.6 (SAME AS SECTION IV).

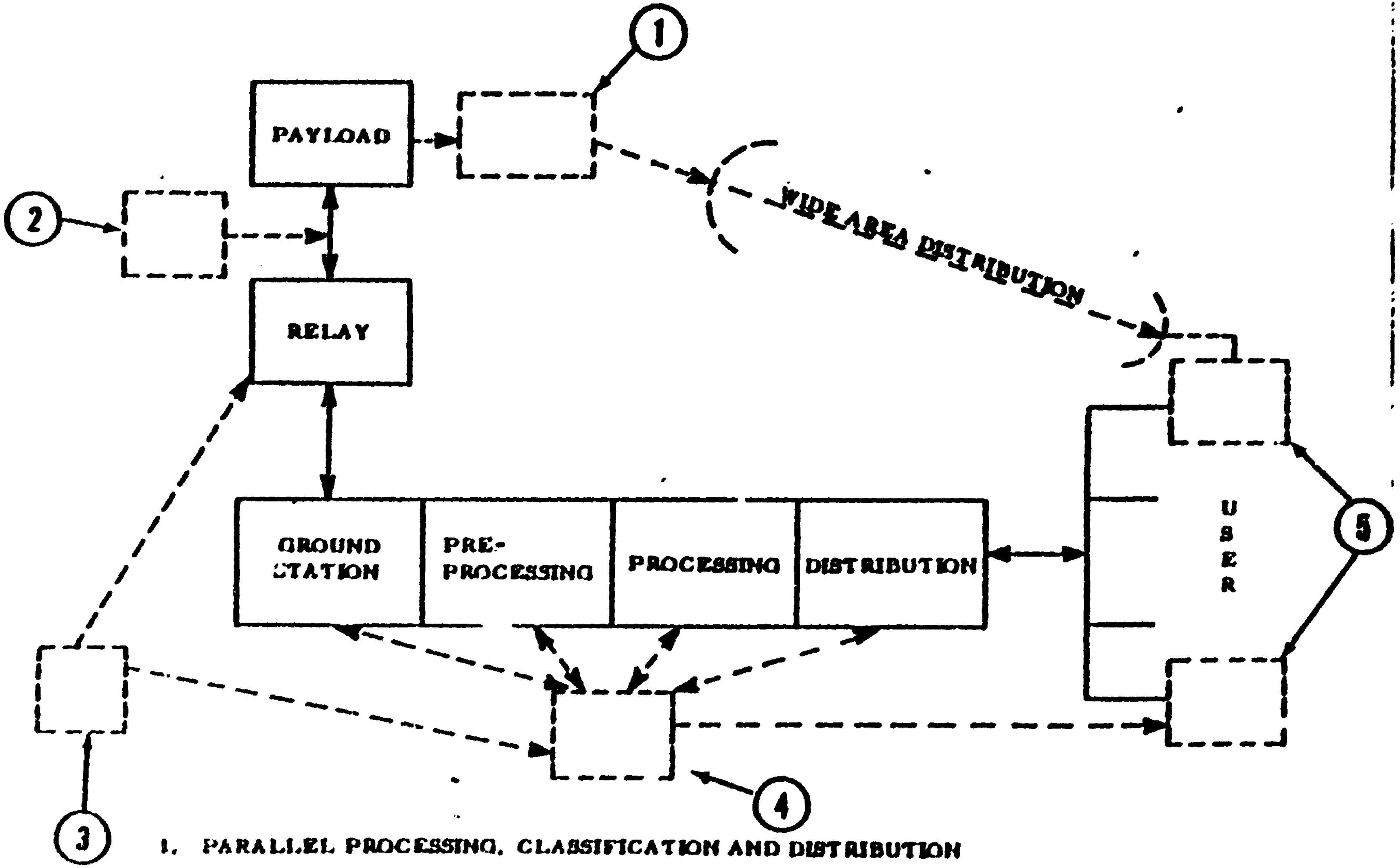
VII. APPENDICES A - I.

(SEE PREVIOUS PRESENTATION CHART.)

VOLUME II - FINAL REPORT APPENDIX B (PAYLOAD/SYSTEM ANALYSIS SHEETS).

VOLUME III - PAYLOAD SOFTWARE TECHNOLOGY DEVELOPMENT PLANS.

PAYLOAD SOFTWARE TECHNOLOGY



1. PARALLEL PROCESSING, CLASSIFICATION AND DISTRIBUTION
2. SENSOR CORRECTION, QUALITY ASSESSMENT, TARGET SELECTION
3. SECURITY AND CONTROL OF HIGH-RESOLUTION DATA
4. TARGET MODEL DATA BANK
5. LOW-COST USER SYSTEMS

ALL. SOFTWARE DEVELOPMENT AND ENGINEERING COST REDUCTION

PAYLOAD DATA SYSTEMS NEW TECHNOLOGY REQUIREMENTS

RTOP PRESENTATION

JANUARY 1978

OAST SPACE SYSTEMS STUDIES REVIEW

ROY STOKES/JSC FM

PRESENTED BY:

L. C. KRCHNAK/JSC AT2

CONTENTS

OBJECTIVES

DETERMINE THE DEPENDENCY OF THE SHUTTLE PAYLOAD DATA SYSTEM REQUIREMENTS UPON SCIENTIFIC OBJECTIVES (INCLUDING USER PRODUCTS), PAYLOAD CHARACTERISTICS, AND PAYLOAD OPERATIONAL PROCEDURES. IDENTIFY AND RANK BY RELATIVE POTENTIAL, AREAS OF NEW DATA SYSTEM TECHNOLOGY WHICH CONTRIBUTE TO THE EXPEDIENCY OF THE DATA SYSTEM AND/OR REDUCE THE OVERALL CAPITALIZATION AND OPERATION COST (LIFE CYCLE COST) OF THE DATA SYSTEM.

APPROACH

- DRIVER PAYLOADS/PAYLOAD GROUPINGS
  - REDUCTION OF PAYLOADS/PAYLOAD GROUPINGS TO A MANAGEABLE LEVEL
- END-TO-END SYSTEMS ANALYSIS
  - TO DETERMINE THE IMPACT OF VARIOUS PAYLOAD DEVELOPMENT PHASES ON A SPECIFIC PAYLOAD DATA SYSTEM SUPPORT FUNCTION; E.G., THE IMPACT OF SENSOR DESIGN AND/OR OPERATIONS ON THE DATA PROCESSING SYSTEM
  - TO DETERMINE THE DATA SYSTEM SUPPORT REQUIRED FOR ALL THE PAYLOAD DEVELOPMENT PHASES; E.G., DEVELOPMENT PHASES SUCH AS MISSION PLANNING, OPERATIONS, TRAINING, AND DATA PROCESSING
  - TO DETERMINE THE DATA SYSTEM HARDWARE AND SOFTWARE TRADEOFFS REQUIRED TO SUPPORT THE VARIOUS PAYLOAD DATA SYSTEM REQUIREMENTS (E.G., HARDWARE DRIVING SOFTWARE AND VICE VERSA)
- SENSITIVITY ANALYSIS
  - SENSITIVITY OF DATA SYSTEM LIMITATIONS TO STATE-OF-THE-ART ADVANCEMENT, TECHNOLOGY COSTS, AND PAYLOAD OBJECTIVES
- RISK ANALYSIS
  - GAUGE RISK FACTOR IN BOTH CREATION AND PREDICTED AVAILABILITY OF TECHNOLOGY

5

METHODOLOGY

THREE PHASES

- PHASE ONE

  DEVELOP A PAYLOAD MODEL FROM WHICH DRIVER PAYLOADS ARE TO BE SELECTED

- PHASE TWO

  RANKING PROCESS TO SELECT POSSIBLE DRIVER PAYLOADS/ PAYLOAD GROUPINGS

- PHASE THREE

  TOP LEVEL DATA SYSTEM CONFIGURATION AND EVALUATION OF PHASE TWO DRIVERS -- IDENTIFY AND RANK DATA SYSTEM TECHNOLOGY LIMITATIONS

FUNDING

Ø I	TPM DEVELOPMENT	JAN-DEC 1976 IBM AND FORD AEROSPACE	$160
Ø II	SELECTION OF PAYLOAD DRIVERS		
Ø III	PAYLOADS/DATA SYSTEMS ANALYSIS RTOP 790-40-15	JAN-OCT 1977 IBM ONLY	$ 90

PHASE ONE
TECHNOLOGY PAYLOAD MODEL (TPM) DEVELOPMENT

- GOAL
  - DEVELOP A PAYLOAD MODEL THAT WOULD REASONABLY REPRESENT THE TOTAL SPECTRUM OF PAYLOADS THAT COULD FLY BETWEEN THE YEARS 1981 AND 1991.
- PROCESS
  - REVIEW ALL EXISTING PAYLOAD MODELS
  - REVIEW SPECIAL STUDIES (I.E., "OUTLOOK FOR SPACE," AND THE "AEROSPACE" REPORT)
  - ACCUMULATE A LIST OF PAYLOADS WITH TRAFFIC RATES INTO ONE TOTAL MODEL--TPM

PHASE TWO
SELECTION OF DRIVER PAYLOADS

- GOALS
  - CURSORILY EXAMINE AND REDUCE THE 150 TPM PAYLOADS/PAYLOAD GROUPINGS TO A MANAGEABLE LEVEL
  - IDENTIFY GENERALLY THE SUSPECTED AREAS OF DATA SYSTEM TECHNOLOGY LIMITATIONS
- PROCESS
  - RANK ALL PAYLOADS IN EACH SCIENTIFIC DISCIPLINE AGAINST SPECIFIC CRITERIA
  - CRITERIA EXAMPLES
    - DATA ANALYSIS
    - OPERATIONS
    - QUALITY ASSURANCE
  - RANKING CONSIDERATIONS
    - COST FOR EACH CRITERIA
    - NEED FOR EACH CRITERIA
    - DATA RATE AND DATA VOLUME REQUIREMENTS FOR EACH PAYLOAD/PAYLOAD GROUPING - RANKING WEIGHT
  - SELECT HIGHEST RANKED PAYLOADS IN EACH SCIENTIFIC DISCIPLINE
    - 26 PAYLOADS

DRIVER PAYLOADS ANALYZED FOR NEW DATA SYSTEM TECHNOLOGY

PAYLOAD
LANDSAT/SEASAT PROGRAMS
GLOBAL EARTH AND OCEAN MONITORING SYSTEM
LUNAR ORBITER
PLANETARY IMAGERY ORBITERS
CRYOGENICALLY COOLED IR TELESCOPE-FREE FLYING
LARGE SOLAR OBSERVATORY
COSMIC RAY LABORATORY
LARGE HIGH ENERGY OBSERVATORY - B
LARGE X-RAY TELESCOPE
MICROCHANNEL SPECTROMETER
DEDICATED ASTRONOMY SORTIE
DEEP SKY ULTRAVIOLET SURVEY TELESCOPE (DUST)
MODIFIED ASTRONOMY SORTIE
VERY LONG BASELINE INTERFEROMETER (VLBI)
EARTH VIEWING APPLICATIONS LABORATORY (EVAL)
SOLAR SORTIE
ATMOSPH, MAGNETOSPH & PLASMAS IN SPACE (AMPS)
HIGH ENERGY ASTROPHSICS SORTIE
SOLAR POWER STATION (SPS) PROTOTYPE DEVELOPMENT
SOLAR POWER SPACE TEST ACTIVITY
PLANETARY SAMPLE RETURN
COMMERCIAL PROCESSING-CREW OPERATED
"LONG TERM" BIOLOGICAL MATERIALS RESEARCH
SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)
12-PERSON SPACE STATION IN SEO
DISEASE PROCESSES RESEARCH

PHASE THREE

RESULTS

PHASE THREE TASK OVERVIEW

- PAYLOADS ANALYSIS
  - DATA GATHERING AND INTERPRETATION FOR 26 PAYLOADS
  - DETERMINATION OF DATA SYSTEM FUNCTIONAL REQUIREMENTS FOR EACH PAYLOAD
- DATA SYSTEM ANALYSIS
  - EVALUATION OF PAYLOAD DATA SYSTEM FUNCTIONAL REQUIREMENTS
  - SUMMARY OF DATA SYSTEM STATE-OF-THE-ART AND PROJECTIONS
  - IDENTIFICATION AND RANKING OF NEW TECHNOLOGY AREAS

PAYLOAD DESCRIPTION GUIDELINES

- ADOPT DRIVER CONFIGURATION REPRESENTATIVE OF CLASS
- ASSUME MAXIMAL REALISTIC OPERATION
- PROJECT PAYLOAD TECHNOLOGY TO USE DATE
- TRADE-OFF ONBOARD/GROUND FUNCTIONS
- UTILIZE INPUT-PROCESS-OUTPUT FORMAT FOR FUNCTIONAL REQUIREMENTS
- UTILIZE SYSTEM COMMONALITIES ACROSS PAYLOAD SPECTRUM
- ACCOUNT FOR ALTERNATIVE TECHNOLOGICAL SOLUTIONS

Table 2: Payload Functional Requirements Summary

Processing Category	Processing Function	Earth And Planetary Viewing Free Flyers				Solar And Space Viewing Free Flyers					Sortie Payloads									Payloads Whose Major Products Are Materials, Energy, Or Actions					Exploratory Space Stations		
		LANDSAT/SEASAT	Glob Earth & Ocean Mon Sys	Lunar Orbiter	Planet Imagery Orbiters	Cryog Cooled IR Tel	Large Solar Obs	Cosmic Ray Lab	Large High Energy Obs - B	Large X-ray Tel Fac	Microchannel Sparks	Ded Astro Sortie	DUST	Med Astro Sortie	VLBI	EVAL	Solar Sortie	AMPS	High Energy Astro Sortie	Solar Power Station	Solar Power Test	Planet Sample Ret	Commercial Proc	"Long Term" Bio Maint	SETI	12 Pers Space Sta	Disease Pre Research
Preparation	Mission Planning														•	•				•	•		•	•			•
	Operations Training										•	•	•	•	•	•	•	•	•	•			•	•			•
	Payload System Design Support										•									•	•						
	Data System Development Support																			•		•	•	•			•
Real Time Operations	Operations Or Experiment Control					•	•				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•
	Pointing And Guidance					•	•			•	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•
Real Time Data Handling	Pre-Transm. Conditioning, Sequence	•	•	•	•	•		•	•	•	•	•		•		•	•	•				•				•	
	Post-Receipt Conditioning, Storage	•	•				•								•		•										
	A/D Conversion																								•		
	Coincidence Detection							•	•		•								•								
	R.T. Information Extraction																								•		
	R.T. Data Management																			•	•		•	•		•	•
Quick Look	Image Manipulation And Display					•	•									•	•	•							•	•	
	Statistics					•	•										•									•	
	Integral Transform					•												•									
Data Product Generation	A/D Conversion (Film)											•	•	•				•	•		•					•	
	Radiometric Correction/Scaling	•	•	•		•	•					•	•	•		•	•	•			•					•	•
	Geometric Correction/Registration	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•	•		•					•	•
	Integral Transform	•	•		•	•									•	•		•			•						•
	Filtering				•	•		•	•	•	•	•		•				•	•		•					•	
	Archival/Distribution				•	•	•	•	•	•		•	•	•	•		•	•	•		•					•	•
Information Extraction/Analysis	Image Manipulation	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•	•		•					•	•
	Image Display	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•	•		•					•	•
	Statistics	•	•	•	•		•	•	•	•		•	•	•	•	•	•	•	•		•					•	•
	Classification	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•		•					•	•
	Pattern Recognition	•	•	•	•	•	•	•	•	•		•	•		•	•	•	•	•		•				•	•	•
	Spectrum Analysis			•	•	•	•	•	•	•	•	•	•	•			•	•	•		•					•	
	Abundance Determination			•	•	•	•	•	•	•	•	•		•			•	•	•		•					•	

ORIGINAL PAGE IS
OF POOR QUALITY

NEW TECHNOLOGY

- MISSION ENABLING
- MISSION ENHANCING

ORIGINAL PAGE IS
OF POOR QUALITY

Table 3: Technology vs. Payload Summary

Technology \ Payload	Earth And Planetary Viewing Free Flyers				Solar And Space Viewing Free Flyers					Sortie Payloads									Payloads Whose Main Products Are Materials, Energy, Or Artifacts					Exploratory Space Sciences		
	LANDSAT/SEASAT	Grab Earth & Ocean Mon Sys	Lunar Orbiter	Planet Imagery Orbiters	Cryog Cooled IR Tel	Large Solar Obs	Cosmic Ray Lab	Large High Energy Obs - B	Large X-ray Tel Fac	Interstellar Space	Out. Astro Sortie	DUST	Med Astro Sortie	VLBI	EVAL	Solar Sortie	AMPS	High Energy Astro Sortie	Solar Power Station	Solar Power Test	Planet Sample Ret	Commercial Proc	"Long Term" Bio Mods	SETI	13 P/n Space Sta	Dreeam Pro Research
Space-Qualified Microprocessors	•	L	•	•	L	L	L	L	L	L	L	L	L	L	L	L	L	L	•	•	L	•	•	•	•	•
Mass Storage Systems	•	•	•	•	L	•	•	•	•	L	L	•	L	•	•	•	•	•	•	•		•	•	•	•	•
Onboard Data Compression Processor	•		•	•		•									•	•					•					
Image Processor	•	•	•	•											•						•			•		
Massively Parallel Processor	•	•		•											•						•			•		•
[illegible]	•	-	•	•		•									•	•					•			•		•
Automated Analyzer (For Pattern Recognition/Classification)	•	•				•									•						•			•		
Spectrum Analyzer					•	•																		L		
Onboard Data Recorder	L	•	•	•	•	•				•	•		•		L	•					•			L		L
A/D Converter																								M		
Communication Links	•	•			•	•									•	•								•		
Hardware Interface Standardization	•	•	•	•	L	L	L	L	L	L	L	L	L	L	L	L	L	L	•	•	•	•	•	•	L	•
Fault-Tolerant System Design	•	•	•	•		•	•		•						•				•		•			•	•	•
Autonomous System Design																			•		M			•		
[illegible] Computer System	•														•	•	•		•					•	•	•
End-To-End Data Base Management System	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•	•			•	•	•	•	•
Information Integration	L	L				•									L	•	•							L	•	L
Data Compression/Decompression Algorithms	•	•	•	•		•									•	•					•					
Image Processing Algorithms	•	•	•	•		•	•	•	•		•		•		•		•	•			•			•	•	•
Pattern Recognition/Classification Algorithms	•	•	•	•		•						•	•		•				•		L			•	•	•
On-Line Planning/Scheduling Algorithms																			•						•	•
Automated Data Selection/Thresholding Algorithms	•	•		•	•																			•		
Algorithm [illegible] Techniques	•	•																			•			•		
Data Networking S/W (Routing/Distribution)	•	•													•											
S/W Support To Microprocessors	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Procedure-Oriented High-Level Language	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
S/W Standardization	•	•			•	•			•		•	•	•	•	•	•	•	•	•		•			•	•	•
S/W Reliability	•	•	•	•															•		•			•	•	
Programming Methodology	•	•																	•		•			•		
S/W Implementation [illegible]	•	•																	•		•			•		
Programmer Productivity	•	•																	•					•		
Distributed S/W Operating System	•	•									•		•		•	•	•	•	•		•			•	•	•
Natural Language Command And Control S/W	•														•	•	•		•					•	•	•
[illegible] Control And Monitoring S/W																			•					•		
Robotics S/W																			•		M					
Simulation/Emulation Techniques											•		•		•	•	•	•	•	•	L	•	•	•		•

Legend:
H Mission Enabling Technology With High Risk
M Mission Enabling Technology With Medium Risk
L Mission Enabling Technology With Low Risk
• Mission Enhancing Technology

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

- GENERAL DRIVER PAYLOAD TECHNOLOGY REQUIREMENTS
  - LARGE PROGRAMS REQUIRE TECHNOLOGICAL IMPROVEMENTS.
  - STRUCTURES, PROPULSION, ETC., TECHNOLOGY ORIENTED PAYLOADS TEND TO REQUIRE LESS DATA SYSTEM TECHNOLOGY THAN LARGE INFORMATION ORIENTED PAYLOADS (LANDSAT/SEASAT, GLOBAL EARTH AND OCEAN MONITORING SYSTEM, ETC.).
  - REQUIREMENT FOR EFFICIENT END-TO-END DATA BASE MANAGEMENT SYSTEMS.
  - SPACE QUALIFIED MICROPROCESSORS, HIGH DENSITY MASS STORAGE SYSTEMS, AND STANDARDIZED HARDWARE INTERFACES ARE ESSENTIAL TO MOST FREE-FLYERS AND ALL SPACELAB-TYPE PAYLOADS.
  - PROCEDURE-ORIENTED HIGH LEVEL LANGUAGE DEVELOPMENT AND SOFTWARE SUPPORT TO MICROPROCESSORS ARE REQUIRED FOR ALL PAYLOADS.
  - ROBOTIC SYSTEM DESIGN, ROBOTIC SOFTWARE DEVELOPMENT, AND SIMULATION TECHNIQUES ARE THE DRIVING TECHNOLOGIES FOR THE PLANETARY SAMPLE RETURN MISSION.
  - A/D CONVERTER IS A HIGH RISK ENABLING TECHNOLOGY FOR THE SETI PROJECT.
  - MASSIVELY PARALLEL PROCESSORS APPEAR TO HAVE GREAT POTENTIAL IN MAKING FUTURE IMAGE PROCESSING REQUIREMENTS REALIZABLE.
  - JOSEPHSON TUNNELING DEVICE COULD REVOLUTIONIZE ONBOARD REAL TIME SYSTEM DESIGN AND OPERATION.

SUMMARY AND CONCLUSIONS
(CONTINUED)

- NEW TECHNOLOGY RANKING
  - MOST SIGNIFICANT
    - SPACE QUALIFIED MICROPROCESSORS
    - MASS STORAGE
    - SOFTWARE SUPPORT TO MICROPROCESSORS
    - PROCEDURE ORIENTED HIGH LEVEL LANGUAGE
    - HARDWARE INTERFACE STANDARDIZATION
  - LESS IMPORTANT THAN PREVIOUS GROUP
    - ONBOARD DATA RECORDER
    - COMMUNICATIONS LINKS
    - FAULT-TOLERANT SYSTEM DESIGN
    - END-TO-END DATA BASE MANAGEMENT
    - INFORMATION INTEGRATION
    - SOFTWARE STANDARDIZATION
    - SOFTWARE RELIABILITY

SUMMARY AND CONCLUSIONS
(CONCLUDED)

- NEW TECHNOLOGY RANKING
  - LESS IMPORTANT THAN PREVIOUS GROUP - EXTENSION OF EXISTING TECHNOLOGY
    - DATA COMPRESSION/DECOMPRESSION
    - IMAGE PROCESSING ALGORITHMS
    - PATTERN RECOGNITION/CLASSIFICATION ALGORITHMS
    - SIMULATION/EMULATION TECHNIQUES
  - LESS IMPORTANT THAN ITEMS IN PREVIOUS GROUPS
    - DEDICATED SOFTWARE OPERATING SYSTEMS
    - DATA NETWORKING SOFTWARE

SUPERCONDUCTING SENSORS IN SPACE

- FEASIBILITY STUDY BY CRYOGENICS DIVISION, NATIONAL BUREAU OF STANDARDS
- COMPLETION: APRIL 1978 COST: $50K 35% COMPLETE
- SIX STUDY AREAS
- SOME PRELIMINARY RESULTS
- 10 KELVIN CRYOGENIC SYSTEMS REQUIRED FOR ALL APPLICATIONS

NASA AMES
SPDO-08-06
JM:1-11-78

SUPERCONDUCTING LOW FREQUENCY SENSORS

APPLICATIONS

- MAGNETIC FIELD AND GRADIENT MEASUREMENTS
- AMPLIFICATION
- LOW LEVEL CURRENT AND VOLTAGE MEASUREMENTS
- SMALL DISPLACEMENT MEASUREMENTS
- SMALL ANGLE MEASUREMENTS
- BIOLOGICAL MEASUREMENTS

PRELIMINARY RESULTS

- SQUID, (SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE) -- MOST LIKELY SENSOR
- DEVELOPMENT OF HIGH SPEED LOCK IN AMPLIFIER REQUIRED

NASA AMES
SPDO-08-05
JM:1-11-78

SUPERCONDUCTING HIGH FIELD MAGNETS

APPLICATIONS

- Particle Physics
- Energy Storage
- Energy Conversion: Generators
- Fusion - MHD
- Propulsion
- Medical Applications
- Industrial Applications

PRELIMINARY RESULTS

Development required for higher critical current density materials

NASA AMES
SPDO-08-04
JM:1-11-78

SUPERCONDUCTING DIGITAL ELECTRONICS AND COMPUTERS

APPLICATIONS

- SIGNAL ACQUISITION
- ANALOG-TO-DIGITAL CONVERSION
- SAMPLE-AND-HOLD CIRCUITS
- SIGNAL PROCESSING - COMPUTER

PRELIMINARY RESULTS

AT PRESENT LEVEL OF DEVELOPMENT, WITHIN 10-20 YEARS, SPACECRAFT COMPUTERS CAN HAVE CAPABILITIES IN EXCESS OF ANY CURRENT GROUND BASED SYSTEM

NASA AMES
SPDO-08-03
JM:1-11-78

SUPERCONDUCTING MICROWAVE & INFRARED SENSORS

APPLICATIONS

- COMMUNICATIONS
- RADIO AND INFRARED ASTRONOMY
- UNIVERSE BACKGROUND TEMPERATURE MEASUREMENTS

PRELIMINARY RESULTS

- LARGE TECHNOLOGY DEVELOPMENT REQUIRED BEFORE SUPERCONDUCTING SENSORS CAN COMPETE WITH CONVENTIONAL DETECTORS

SUPERCONDUCTING HIGH Q CAVITIES

APPLICATIONS

- Gravitation Experiments - Red Shift, etc.
- Deep Space Navigation
- Ranging
- Small Displacement Measurements

PRELIMINARY RESULTS

- Superconducting Clocks - Most Likely Candidate for Significant Gain in Capability (10^2 Improvement Possible with Modest Development)

PRESENTATION TO OAST - CODE RX
STUDY, ANALYSIS AND PLANNING OFFICE

FINAL REPORT

TECHNOLOGY ENABLEMENT-SPACE POWER SYSTEMS

RTOP NO. 790-40-19
FUNDING: $50K

J. W. STEARNS
JANUARY 11, 1978

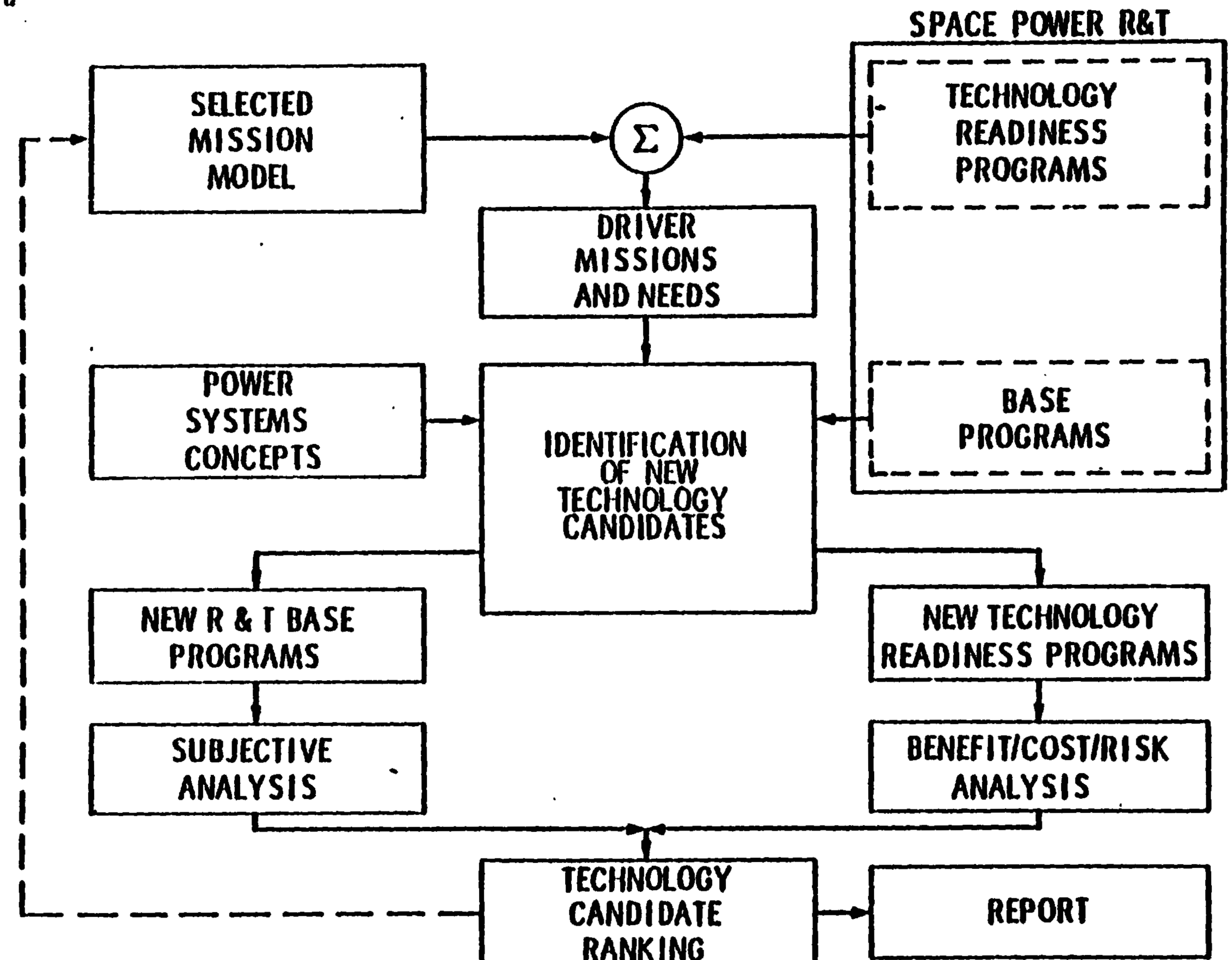
TECHNOLOGY ENABLEMENT - SPACE POWER
AGENDA

- OBJECTIVES AND WORK PLAN
- MISSION ESTIMATES
- TECHNOLOGY CANDIDATE IDENTIFICATION
- TECHNOLOGY RECOMMENDATIONS

TECHNOLOGY ENABLEMENT - SPACE POWER
OBJECTIVES

- ASSESS LONG-LIFE SPACE POWER SYSTEM TECHNOLOGY NEEDS WITH EMPHASIS ON:
  - SHUTTLE LAUNCH
  - MODERATE (UP TO KW) SCALE POWER NEEDS
  - AUTOMATED MISSIONS
- DEFINE TECHNOLOGIES THAT SUPPORT POTENTIAL FUTURE MISSIONS
  - ENABLING
  - SIGNIFICANTLY ENHANCING
- EVALUATE AND PRIORITIZE TECHNOLOGY CANDIDATES FOR PRESENTATION OF RESULTS
  - BENEFIT/COST/RISK (B/C/R) ANALYSIS
  - OTHER DISCRIMINATORS

TECHNOLOGY ENABLEMENT - SPACE POWER
WORK PLAN



TECHNOLOGY ENABLEMENT - SPACE POWER
SELECTED MISSIONS
(LUNAR AND PLANETARY)

MISSION	RECONNAISSANCE	EXPLORATION	INTENSIVE STUDY	UTILIZATION
LUNAR AND INNER PLANETS	1980-1982 VENUS	1984-1990 MERCURY ORBIT MARS PENETRATOR VENUS ORBIT/LANDER	1985-2000 LUNAR POLAR ORBIT LUNAR LABORATORY MARS ROVER AND SSR MERCURY ROVER AND SSR VENUS ROVER AND SSR	1992-2000 LUNAR BASE[a]
OUTER PLANETS AND SOLAR ESCAPE	1982-1988 SATURN/URANUS JUPITER/NEPTUNE SOLAR ESCAPE COMETS AND ASTEROIDS	1982-1998 JUPITER ORBIT SATURN ORBIT PLUTO ORBIT ASTEROID SSR SOLAR ESCAPE COMET SR	1993-1998 ORBIT, LANDERS, ROVERS, SSR AT JUPITER, SATURN, URANUS, AND NEPTUNE	1993-2000 NUCLEAR WASTE DISPOSAL

[a]AUTOMATED TECHNOLOGY WITH MANNED SYSTEMS.

TECHNOLOGY ENABLEMENT - SPACE POWER
SELECTED MISSIONS
(LUNAR AND PLANETARY)

MISSION	RECON-NAISSANCE	EXPLORATION	INTENSIVE STUDY	UTILIZATION
LUNAR AND INNER PLANETS	1980-1982 VENUS*	1984-1990 MERCURY ORBIT MARS PENETRATOR* VENUS ORBIT/ LANDER	1985-2000 LUNAR POLAR ORBIT* LUNAR LABORATORY MARS ROVER AND SSR* MERCURY ROVER AND SSR VENUS ROVER AND SSR	1992-2000 LUNAR BASE[a]
OUTER PLANETS AND SOLAR ESCAPE	1982-1988 SATURN/ URANUS JUPITER/ NEPTUNE SOLAR ESCAPE* COMETS AND ASTEROIDS*	1982-1998 JUPITER ORBIT* SATURN ORBIT* PLUTO ORBIT ASTEROID SSR SOLAR ESCAPE COMET SR	1993-1998 ORBIT, LANDERS, ROVERS, SSR AT JUPITER, SATURN, URANUS, AND NEPTUNE	1993-2000 NUCLEAR WASTE DISPOSAL

* (hatched box) DENOTES MISSION COVERED BY PRESENT PROGRAMS

[a]AUTOMATED TECHNOLOGY WITH MANNED SYSTEMS.

TECHNOLOGY ENABLEMENT - SPACE POWER
SELECTED MISSIONS
(EARTH ORBIT AND SOLAR)

MISSION	RECON-NAISSANCE	EXPLORATION	INTENSIVE STUDY	UTILIZATION
EARTH ORBIT AND SOLAR		1979-1985	1984-1993	1980-2000[b]
		SPACE TELESCOPE	LARGE TELESCOPE	EARTH RESOURCES
		SOLAR MAX.	SOLAR OBSERVATORY	EARTH OBSERVATIONS
		SOLAR PROBE	SPACELAB[a]	COMMUNICATIONS
		LAND/SEA OBSERVATIONS	EARTH SURVEY	NAVIGATION
		HIGH ENERGY OBSERVATIONS	ATMOSPHERIC PHYSICS	CLIMATE/WEATHER
		CLIMATE/WEATHER	GRAVITY/MAGNETICS	SPACE POWER
		COMMUNICATION	LARGE ANTENNAS	INDUSTRIALIZATION
		RADIO ASTRONOMY	POWER TRANSMISSION	COLONIZATION
		EXTRA ECLIPTIC		

[a] AUTOMATED TECHNOLOGY WITH MANNED SYSTEMS.
[b] SEPARATE STUDIES BEING ACCOMPLISHED

TECHNOLOGY ENABLEMENT - SPACE POWER

SELECTED MISSIONS

(EARTH ORBIT AND SOLAR)

MISSION	RECON-NAISSANCE	EXPLORATION	INTENSIVE STUDY	UTILIZATION
EARTH ORBIT AND SOLAR		1979-1985	1984-1993	1980-2000[b]
		SPACE TELE-SCOPE SOLAR MAX. SOLAR PROBE LAND/SEA OBSERVA-TIONS HIGH ENERGY OBSERVA-TIONS CLIMATE/WEATHER COMMUNICA-TION RADIO ASTRONOMY EXTRA ECLIPTIC	LARGE TELESCOPE SOLAR OBSERVA-TORY SPACELAB[a] EARTH SURVEY ATMOSPHERIC PHYSICS GRAVITY/MAGNETICS LARGE ANTENNAS POWER TRANS-MISSION	EARTH RESOURCES EARTH OBSERVATIONS COMMUNICATIONS NAVIGATION CLIMATE WEATHER SPACE POWER INDUSTRIALIZATION COLONIZATION

[hatched box] DENOTES MISSION COVERED BY PRESENT PROGRAMS

[a]AUTOMATED TECHNOLOGY WITH MANNED SYSTEMS.

[b]SEPARATE STUDIES BEING ACCOMPLISHED

TECHNOLOGY ENABLEMENT - SPACE POWER

POTENTIAL DRIVER MISSIONS AND TECHNOLOGY CANDIDATES

MISSION (LUNAR AND INNER PLANETS)	FEATURE DRIVING THE TECHNOLOGY	POWER TECHNOLOGY CANDIDATE	CANDIDATE TYPE (SEE NOTE)	POWER LEVEL (kWe)
MERCURY	HIGH TEMPERATURE,	HIGH TEMPERATURE COMPONENTS	2	1-5
ORBITER (SEP)	SOLAR CORONA	ELECTROMAGNETIC SHIELDING,	•	
LANDER/ROVER/SSR		LASER POWER BEAMING,	1 - a	
		RADIOISOTOPE THERMIONICS,	1 - a	
		ADVANCED RTG,	1 - a	
		THIN FILM Ga As	1 - a	
VENUS	HIGH TEMPERATURE,	RADIOISOTOPE THERMIONICS,	1 - a	2-5
LANDER/ROVER/SSR	HIGH PRESSURE,	ADVANCED RTG,	1 - a	
BUOYANT STATION	CO_2 ATMOSPHERE	STIRLING REFRIGERATION,	1 - b	
		FUSED SALT BATTERIES	2	
AUTOMATED LUNAR BASE	LONG LUNAR NIGHT,	NUCLEAR-ELECTRIC POWER,	•	~500
	POWER NETWORK	LASER POWER BEAMING,	1 - a	
		THIN FILM Ga As,	1 - a	
		FLYWHEEL ENERGY STORAGE	2	

NOTE:

CANDIDATE TYPE	DEFINITION
1 - a	TECHNOLOGY READINESS WITH DIRECT POWER APPLICATION
1 - b	TECHNOLOGY READINESS WITH TANGENTIAL APPLICATION
2	R AND T BASE
•	NO PROGRAM AUGMENTATION NEEDED

TECHNOLOGY ENABLEMENT - SPACE POWER

POTENTIAL DRIVER MISSIONS AND TECHNOLOGY CANDIDATES

MISSION (OUTER PLANETS AND SOLAR ESCAPE)	FEATURE DRIVING THE TECHNOLOGY	POWER TECHNOLOGY CANDIDATE	CANDIDATE TYPE (SEE NOTE)	POWER LEVEL (kWe)
URANUS/NEPTUNE/ SOLAR ESCAPE (SEP)	LONG RADIO DISTANCE, LONG FLIGHT TIME	RADIOISOTOPE THERMIONICS, ADVANCED RTG	1 - a 1 - a	~0.5
PLUTO ORBITER/PROBE/ SOLAR ESCAPE (NEP)	NEP INTERFACE, LONG RADIO DISTANCE	NUCLEAR-ELECTRIC POWER, RADIOISOTOPE THERMIONICS, ADVANCED RTG, INDUCTIVE ENERGY STORAGE	• 1 - a 1 - a •	1-50
NUCLEAR WASTE DISPOSAL (NEP)	EARTH ORBIT LOGISTICS, NUCLEAR SAFETY, RENDEZVOUS AND DOCKING	NUCLEAR-ELECTRIC POWER, RADIATION HARD COMPONENTS, INDUCTIVE ENERGY STORAGE	• 2 •	1-20
AUTOMATED PLANETARY STATION ORBITAL MAPPERS, PROCESSORS, BEAMING, PROBES, PENETRATORS, LANDERS, ROVERS, SSR	EXTREME ENVIRONMENTS, JUPITER RADIATION, SATURN/URANUS RINGS, NEPTUNE REMOTENESS, RENDEZVOUS AND DOCKING	NUCLEAR-ELECTRIC POWER, RADIATION HARD COMPONENTS, LASER POWER BEAMING, RADIOISOTOPE THERMIONICS, ADVANCED RTG, INDUCTIVE ENERGY STORAGE	• 2 1 - a 1 - a 1 - a •	10-400

NOTE:

CANDIDATE TYPE	DEFINITION
1 - a	TECHNOLOGY READINESS WITH DIRECT POWER APPLICATION
1 - b	TECHNOLOGY READINESS WITH TANGENTIAL APPLICATION
2	R AND T BASE
•	NO PROGRAM AUGMENTATION NEEDED

TECHNOLOGY ENABLEMENT - SPACE POWER

POTENTIAL DRIVER MISSIONS AND TECHNOLOGY CANDIDATES

MISSION (EARTH ORBIT AND SOLAR)	FEATURE DRIVING THE TECHNOLOGY	POWER TECHNOLOGY CANDIDATE	CANDIDATE TYPE (SEE NOTE)	POWER LEVEL (kWe)
SOLAR PROBE/ ORBITER (0.01 AU)	HIGH SOLAR IRRADIANCE (14 MW/m^2), SOLAR CORONA	HIGH TEMPERATURE COMPONENTS SYSTEM WITH HEAT SHIELD, HEAT SHIELD/HEAT PIPES, ELECTROMAGNETIC SHIELDING, STIRLING REFRIGERATION	2 1 - a 1 - b • 1 - b	0.5-50
EARTH OBSERVATION AND RADIO ASTRONOMY	CRYOGENIC COOLING OF SENSORS (10 YRS, 2 W, 5^{0}K)	STIRLING REFRIGERATION, THIN FILM Ga As	1 - b 1 - a	1-10
ELECTRIC ORBIT TRANSFER VEHICLE	PROTON BELT DWELL (MULTI-ROUND TRIP)	THIN FILM Ga As, RADIATION HARD COMPONENTS, ELECTROMAGNETIC SHIELDING, FLYWHEEL ENERGY STORAGE, INDUCTIVE ENERGY STORAGE	1 - a 2 • 2 •	100-1,000
SPACELAB PROCESSING	HIGH TEMPERATURE FURNACE (>2800^{0}K, 6 kWt)	SOLAR FURNACE (~15 kWt), THERMIONIC BOTTOMING	1 - b •	REPLACES 50 kWe

NOTE; <u>CANDIDATE TYPE</u> <u>DEFINITION</u>

CANDIDATE TYPE	DEFINITION
1 - a	TECHNOLOGY READINESS WITH DIRECT POWER APPLICATION
1 - b	TECHNOLOGY READINESS WITH TANGENTIAL APPLICATION
2	R AND T BASE
•	NO PROGRAM AUGMENTATION NEEDED

NEW TECHNOLOGY READINESS PROGRAM
TECHNOLOGY CANDIDATE RECOMMENDATIONS
(TECHNOLOGIES DIRECTLY APPLICABLE TO SPACE POWER NEEDS)

PRIORITY	CANDIDATE TECHNOLOGY	FLIGHTS	B/C RATIO	QTY ENABLED FLIGHTS	QTY ENHANCED FLIGHTS	SPINOFF	
						EARTH ORBIT POWER	TERR. POWER
1	THIN FILM Ga As PHOTOVOLTAICS	1 4 7	4 13 20	>10	>10	YES	YES
2	RADIOISOTOPE THERMIONIC GENERATOR OR ADVANCED RTG		∞	>2	>10		
3	SYSTEMS WITH HEAT SHIELD/HEAT PIPES		∞	>1			
4	LASER POWER BEAMING	1 4 7	0.4 1.1 1.4		5-10	YES	

NEW TECHNOLOGY READINESS PROGRAM
TECHNOLOGY CANDIDATE RECOMMENDATIONS
(TECHNOLOGIES TANGENTIALLY APPLICABLE TO SPACE POWER NEEDS)

PRIORITY	CANDIDATE TECHNOLOGY	FLIGHTS	B/C RATIO	QTY ENABLED FLIGHTS	QTY ENHANCED FLIGHTS	SPINOFF	
						EARTH ORBIT POWER	TERR. POWER
1	SOLAR FURNACE (REPLACES 50 kWe SUPPLY)		∞	1-3		YES	YES
2	HEAT SHIELD/HEAT PIPES		∞	1-2			
3	FIBER OPTICS CABLING (GSE REQUIREMENT)	1 4 7	1.0 3.3 5.1		>10		
4	STIRLING REFRIGERATOR (10 YEAR CRYOGENICS)	1 4 7	0.4 1.2 1.7		>10	YES	

TECHNOLOGY ENABLEMENT - SPACE POWER

R & T PROGRAM TECHNOLOGY CANDIDATE RECOMMENDATIONS

		TYPE		APPLICATION		COMPLEXITY	
PRIORITY	CANDIDATE TECHNOLOGY	ENABLE	ENHANCE	NEAR	FAR	LOW	HIGH
1	PRIMARY FUSED SALT BATTERY (WITH INDIGENOUS MATERIALS)	X			X	X	
2	HIGH TEMP. POWER COMPONENTS FOR INNER PLANET OPERATIONS		X	X			X
3	RAD. HARD. POWER COMPONENTS FOR OPERATION IN OUTER-PLANET RADIATION BELTS		X	X			X
4	• FLYWHEEL ENERGY STORAGE FOR LONG LIFE, MANY DUTY CYCLES		X		X		X

• POTENTIALLY IMPORTANT TO LARGE POWER SYSTEMS

DEFINITION OF TERMS USED IN THE TECHNOLOGY ENABLEMENT STUDY

PLANNING ELEMENT	DEFINITION
SELECTED MISSION MODEL	AN ALL-INCLUSIVE MISSION SET FOR MAXIMUM REASONABLE EXERCISE OF POWER SYSTEMS TECHNOLOGY CONCEPTS
TECHNOLOGY READINESS PROGRAMS	TECHNOLOGY DEVELOPMENT PROGRAMS THAT ARE TO HAVE DEMONSTRATED FLIGHT READINESS BY A SPECIFIED DATE (PART OF SPACE POWER R&T)
R & T BASE PROGRAMS	TECHNOLOGY STUDIES OF AN EXPLORATORY NATURE, INVESTIGATING BASIC PHENOMENA AND PRINCIPLES OF CONCEPTS HAVING POTENTIAL SPACE APPLICATIONS (PART OF SPACE POWER R&T)
DRIVER MISSIONS	POTENTIAL MISSIONS WHICH, IF THEY ARE TO BE ACCOMPLISHED, REQUIRE TECHNOLOGY ADVANCE
NEW TECHNOLOGY CANDIDATES	TECHNOLOGY CONCEPTS THAT OFFER POTENTIAL FOR MEETING TECHNOLOGY NEEDS OF DRIVER MISSIONS
BENEFIT/COST/RISK (B/C/R) ANALYSIS	AN ANALYTICAL MANAGEMENT TOOL TO QUANTIZE THE VALUE OF A GIVEN TECHNOLOGY PROGRAM
TECHNOLOGY CANDIDATE RANKING	A PRIORITY LISTING OF TECHNOLOGY CANDIDATES ON THE BASIS OF B/C/R ANALYSIS AND OTHER MORE-SUBJECTIVE VALUES

TECHNOLOGY ENABLEMENT - SPACE POWER

TECHNOLOGY ENABLEMENT MISSIONS
PRINCIPAL DATA SOURCES

- NASA PAYLOAD MODEL (HQ)
- NASA 5-YEAR PLAN (HQ)
- OUTLOOK FOR SPACE (HQ)
- COMPLEX 1976 (JPL)
- REPORT ON SPACE SCIENCE (NAS)
- PAYLOAD DESCRIPTIONS (MSFC)
- TECHNOLOGY PAYLOAD MODEL (JSC)
- COMPOSITE NASA PAYLOAD MODEL (GDC)
- OUTSIDE USERS PAYLOAD MODEL (BMI)
- OAST SPACE SYSTEMS TECHNOLOGY MODEL (GRC)
- FUTURE STS ANALYSIS STUDY (BAC)
- MMS SPACECRAFT PLAN (GSFC)
- APSS AT JUPITER (GENERIC) (JPL)
- PROBE & PENETRATOR STUDIES (ARC)
- ADVANCED PLANNING STUDIES (AEROSPACE)
- UTILITY OF STS (HAC)
- SURVEYING EARTH'S ENVIRONMENT (JPL)

TECHNOLOGY ENABLEMENT - SPACE POWER

PRESENT SPACE POWER TECHNOLOGY DEVELOPMENTS

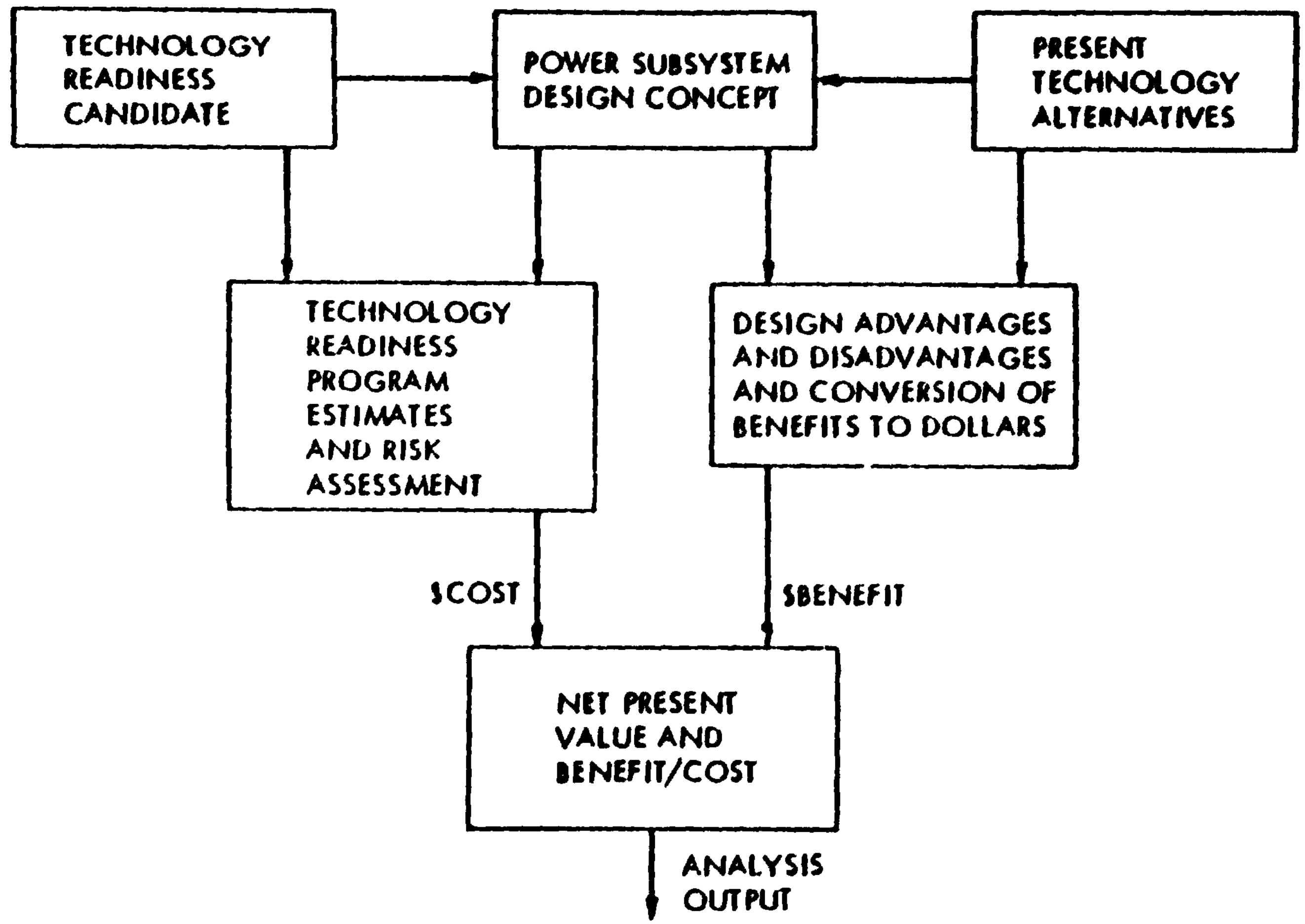
TECHNOLOGY	READY DATE
• POWER CONVERSION	
• LIGHTWEIGHT PHOTOVOLTAICS	1980
• SELENIDE RTG (SIG)	1980
• BIPS/KIPS	1981
• THERMIONICS	1990
• SOLAR THERMOELECTRIC GENERATOR (STG)	1982
• ENERGY STORAGE	
• BATTERIES (NiCd, NiH, AgH)	1980
• FUEL CELLS	1978
• LITHIUM BATTERIES	1982
• POWER PROCESSING AND MANAGEMENT	
• MODULAR REGULATORS	1978
• PULSED BATTERY CHARGERS	1978
• SOLID STATE SWITCHING AND PROTECTION	1982
• MULTI-PHASE INVERTERS	1978
• SPECIAL-PURPOSE TRANSFORMERS	1977
• MICROLOGIC/PROCESSOR	1979
• AUTOMATED POWER SYSTEMS MANAGEMENT	1981

TECHNOLOGY ENABLEMENT - SPACE POWER

ONGOING SPACECRAFT SYSTEMS TECHNOLOGY PROGRAMS

- ONGOING
  - JUPITER ORBITER/PROBE (JPL/ARC)
  - VENUS ORBITER IMAGING RADAR (JPL)
  - MULTIMISSION MODULAR SPACECRAFT (GSFC)
  - ION DRIVE (JPL/LeRC)
  - MARS PENETRATOR (ARC)
  - ATMOSPHERIC ENTRY PROBES (ARC)
- PLANNED
  - MARS SURFACE SAMPLE RETURN (JPL)

BENEFIT/COST/RISK ANALYSIS PROCESS



TECHNOLOGY ENABLEMENT - SPACE POWER

AREAS OF ANALYSIS FOR CONVERSION C: BENEFITS TO DOLLARS

DIRECT BENEFITS

- EQUIPMENT COST SAVINGS
- LAUNCH COST SAVINGS
- COST AVOIDANCE
- STANDARDIZED DESIGN SAVINGS
- INCREASED DATA

SESSION 'M' - MULTIPROGRAM TECHNOLOGY

Advanced Automation Needs Analysis (E. Heer, JPL)

DISCUSSION: JSC workshop will use results from the various space utilization studies and will also provide an opportunity for the workshop participants to assist the individuals working in space utilization in the areas of automation and machine intelligence. Point was made that NEEDS is the first step in automation to increase productivity per person.

In addition, Stan Sadin discussed the anticipated new initiatives for the next five years, one of which is automated operations.

Technology Enablement - Multiple Requirements for Pointing and Control (W. Bachman, JPL)

DISCUSSION: LSST pointing and control requirements were mentioned.

Payload Software Technology (P. Rose, M&S Computing, for J. Capps, MSFC)

DISCUSSION: The "free flier" software study part of the contract has just begun; contact will be made with GSFC for information. In addition, it was suggested that J. Capps meet directly with D. Blanchard (GSFC) of the NEEDS project. It was also suggested that JPL be contacted for information on DSN software.

It was mentioned that this study complements the automation study. Mr. Rose stated that it appeared that the primary driver found in this effort was software development. He suggested that a software experiment be proposed for Spacelab I.

Payload Data Systems New Technology Requirements (L. Krchnak, JSC)

DISCUSSION: The only high risk technology item identified during the study was the 800 Mbs A/D converter for SETI.

Superconducting Sensors in Space (J. Murphy, ARC)

DISCUSSION: Utilization of Josephson effect is a key element of future computer advances.

Technology Enablement - Space Power Systems (J. Stearns, JPL)

DISCUSSION: The most important requirement for space power appears to be radiation hardness, which points to developments in thin film GaAs or similar technologies. D. Aviv stated that microwaves may be size competitive with laser power beaming to planetary probes, but others disputed this. Stan Sadin made the point that value of present technology efforts should be included in studies so that "new stops" can be identified. Mr. Stearns mentioned that the final report on this study details candidate technologies examined.

Discussion of FY 79 Plans in Multiprogram Technology

Stan Sadin mentioned that these are the "hardest" studies because they are so broad and require mission models. However, they are particularly useful to the divisions; for this reason, joint funding should be considered. J. Mullin commented that these type studies should be repeated periodically for each discipline to help identify high and low priority technologies. He felt they are also valuable because they are an objective look at OAST activities.

The possibility of doing joint studies with OSTDS in end-to-end data systems, software technology, and cryogenics was raised. It was pointed out that the technology model was valuable in doing multiprogram technology studies.

SECTION 6

SESSION 'A'

REVIEW OF APPLICATIONS STUDY PROGRAMS

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRESENTATION OVERVIEW

- STUDY OBJECTIVES
- GUIDELINES
- PRODUCTS
- STATUS

STUDY OBJECTIVES

<u>GENERAL</u>

- PROVIDE INFORMATION USEFUL TO NASA IN PLANNING THE ADVANCED DEVELOPMENT PROGRAM AND INSURING ITS RELEVANCE TO AGENCY NEEDS

JLW

STUDY OBJECTIVES

GENERAL

- PROVIDE INFORMATION USEFUL TO NASA IN PLANNING THE ADVANCED DEVELOPMENT PROGRAM AND INSURING ITS RELEVANCE TO AGENCY NEEDS

STUDY OBJECTIVES (contd)

SPECIFIC

- PERFORM READINESS ASSESSMENT OF THE VOIR AND SEASAT-B MISSIONS
  - PROVIDES AN EVALUATION OF THE MATURITY AT PROJECT START AND RISKS OF UTILIZATION OF THE TECHNOLOGIES UPON WHICH USER-PROGRAM-OFFICE-DEVELOPED DESIGNS FOR THESE MISSIONS DEPEND
  - PROVIDES A COMPARISON OF THE MATURITY OF THESE TECHNOLOGIES WITH THE MATURITY OF THE TECHNOLOGIES AT PROJECT START OF PREVIOUS JPL MISSIONS TO PLACE IDENTIFIED RISKS IN HISTORICAL PERSPECTIVE
- PERFORM BENEFITS ASSESSMENT FOR THE VOIR AND SEASAT FOLLOW-ON MISSIONS
  - IDENTIFIES, FOR MUTUAL OAST/USER PROGRAM OFFICE CONSIDERATION, POSSIBLE TECHNOLOGY ALTERNATIVES WHICH MAY REDUCE RISK FOR AND/OR ENHANCE THE USER-PROGRAM-OFFICE-DEVELOPED BASELINE DESIGNS
  - PROVIDES MEASURES OF THE INCREMENTAL BENEFITS, RISK, AND COST OF THESE ALTERNATIVES

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

GUIDELINES

AREA	GUIDELINE	
	VOIR	SEASAT-B
SOURCE OF BASELINE MISSION AND SPACECRAFT DESCRIPTIONS	• JPL FY '77 AND '78 PRE-PROJECT ACTIVITY SPONSORED BY NASA OSS/SL	• JPL FY '77 PRE-PROJECT ACTIVITY SPONSORED BY NASA OA
SOURCE OF TECHNOLOGY OPTIONS/ALTERNATIVES	• JPL (WITH EMPHASIS) • INDUSTRY • GOVERNMENT (TO INCLUDE CONSIDERATION OF NASA-RELATED DOD TECHNOLOGIES IDENTIFIED BY THE AEROSPACE CORP IN AN FY '76 OAST/RX-SPONSORED STUDY*)	(SAME AS VOIR)
EMPHASIS OF TECHNOLOGY OPTIONS/ALTERNATIVES	• ALL SPACECRAFT ENGINEERING SUBSYSTEMS (EMPHASIS ON OPTIONS WHICH MIGHT PROVE BENEFICIAL FOR SUPPORT OF THE SYNTHETIC APERTURE RADAR (SAR)) • NO SCIENCE SUBSYSTEMS/INSTRUMENTS • NO GROUND SUPPORT EQUIPMENT	(SAME AS VOIR)

*"TECHNOLOGY ASSESSMENT AND NEW OPPORTUNITIES - STUDY 2.3", THE AEROSPACE CORPORATION, D.G. AVIV

VOIR / SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRODUCTS+

PRODUCT	TITLE	DESCRIPTION
1	IDENTIFICATION OF BASELINE DESIGN TECHNOLOGY COMPONENTS	LIST OF SUBSYSTEM COMPONENTS UTILIZED IN USER-PROGRAM OFFICE GENERATED BASELINE DESIGN
2	IDENTIFICATION OF TECHNOLOGY OPTIONS	LIST OF SUBSYSTEM TECHNOLOGY OPTIONS WHICH MAY REDUCE RISK AND/OR ENHANCE THE BASELINE MISSION
3	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION STATE OF DEVELOPMENT ASSESSMENT	IDENTIFICATION OF COMPONENT STATE-OF-DEVELOPMENT AT PROJECT START ON A STANDARD 7-DEVELOPMENT LEVEL SCALE (FOR SCALE, SEE APPENDIX)
4	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION COMMITMENT CONDITION ASSESSMENT	EVALUATION OF COMPONENT SATISFACTION OF 7 CONDITIONS ESSENTIAL FOR COMPONENT COMMITMENT TO A PROJECT AT LOW RISK (FOR CONDITIONS, SEE APPENDIX)
5	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION RISK ASSESSMENT	EVALUATION OF COMPONENT RISK (HIGH, MEDIUM, LOW) IN THE AREAS OF TECHNOLOGY, ENGINEERING, PERSONNEL, AND FORESEEABLE PROBLEMS (FOR CRITERIA, SEE APPENDIX)
6	TECHNOLOGY MATURITY COMPARISON	COMPARISON OF THE MATURITY AT PROJECT START, BASED ON THE SCALE OF PRODUCT 3, OF THE TECHNOLOGIES OF WHICH THE BASELINE DESIGN IS COMPRISED WITH THE MATURITY AT PROJECT START OF THE TECHNOLOGIES OF PREVIOUS JPL MISSIONS
7	TECHNOLOGY OPTION BENEFIT RATING	PRIORITIZATION OF TECHNOLOGY OPTIONS BY THE DEGREE TO WHICH THEY PROVIDE MISSION BENEFITS (i.e., INCREASED SCIENCE INFORMATION QUANTITY AND/OR QUALITY AT REDUCED COST) FOR THE MISSION OF INTEREST
8	DEVELOPMENT PROGRAM RECOMMENDATIONS	RECOMMENDED NEW INITIATIVES, INITIATIVE AUGMENTATIONS, AND/OR INITIATIVE REVISIONS WHICH MAY REDUCE RISK TO AN ACCEPTABLE LEVEL FOR, AND/OR ENHANCE, THE BASELINE MISSION

+FOR APPROACH, SEE APPENDIX

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VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

STATUS

PRODUCT	STATUS / EXPECTED COMPLETION DATE	COMMENTS
1	COMPLETE	ALL BASELINE COMPONENTS DEFINED IN OA-SPONSORED FY '77 PRE-PROJECT ACTIVITY AT JPL
2	IN PROGRESS / MARCH 1978	• KEY OPTIONS: ON-BOARD SAR PROCESSOR, UNIFIED DATA SYSTEM • INVESTIGATION OF NASA-RELATED DOD TECHNOLOGIES JUST BEGINNING • HEADQUARTERS REVIEW/AUGMENTATION OF PRESENT OPTIONS LIST IS REQUESTED (FOR LIST, SEE APPENDIX)
3	IN PROGRESS / MARCH 1978	BASELINE TECHNOLOGY COMPONENT STATE-OF-DEVELOPMENT ASSESSMENT NEARLY COMPLETE. OPTIONS ASSESSMENT ONGOING
4	IN PROGRESS / MARCH 1978	BASELINE COMPONENT COMMITMENT CONDITION ASSESSMENT NEARLY COMPLETE. OPTIONS ASSESSMENT ONGOING
5	IN PROGRESS MARCH 1978	BASELINE COMPONENT RISK ASSESSMENT NEARLY COMPLETE. OPTIONS ASSESSMENT ONGOING
6	IN PROGRESS / JANUARY 1978	TECHNOLOGY MATURITY COMPARISON NEARLY COMPLETE
7	IN PROGRESS / FEBRUARY 1978	IDENTIFICATION/WEIGHTING OF CRITERIA FOR ASSIGNMENT OF OPTION BENEFIT RATINGS JUST UNDERWAY
8	IN PROGRESS / APRIL 1978	DEVELOPMENT PROGRAM RECOMMENDATIONS CURRENTLY EMERGING

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[illegible]/1[illegible]6

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

APPENDIX

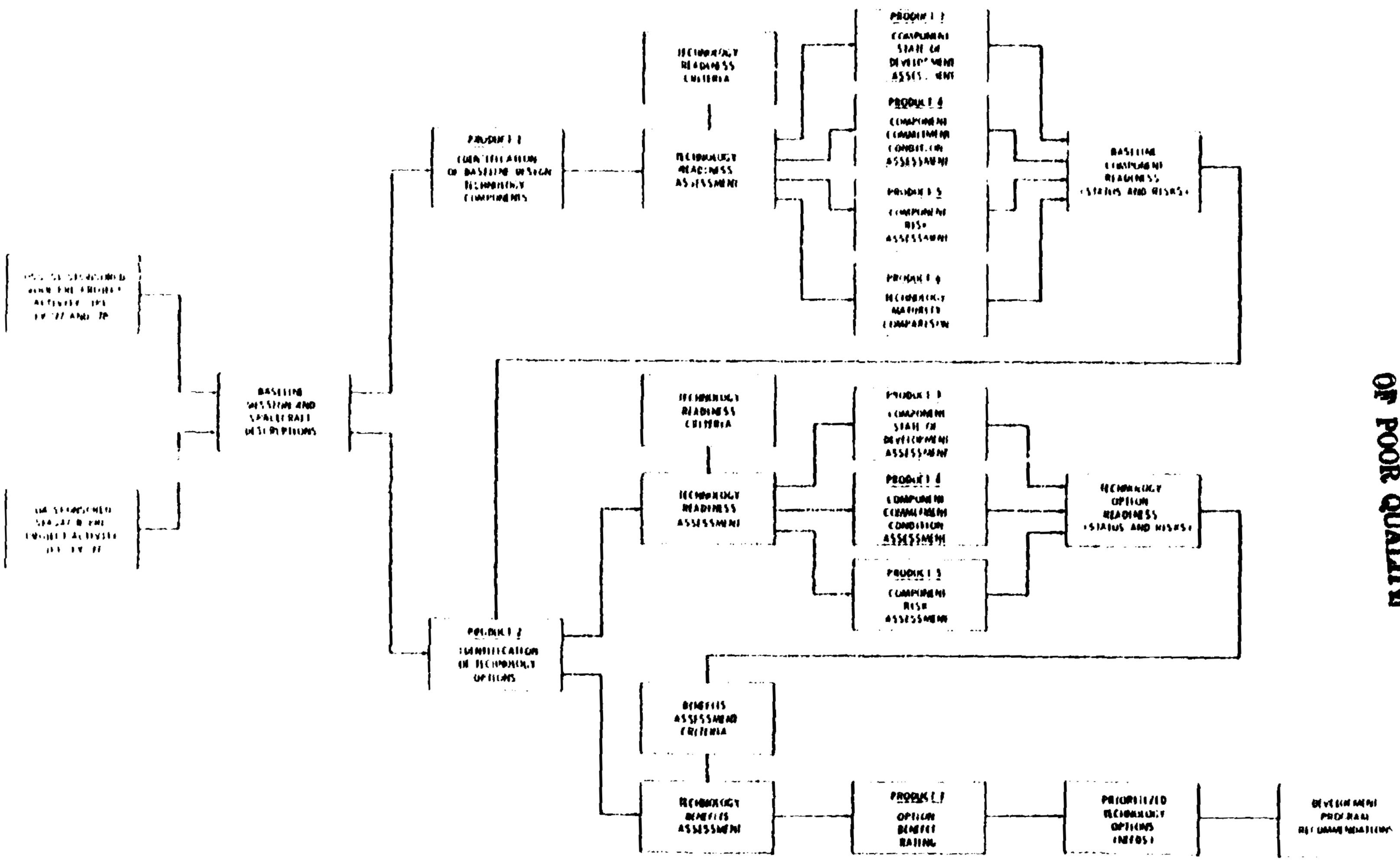
VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

APPENDIX CONTENT

- STUDY APPROACH
- PRODUCT 2 - TECHNOLOGY OPTIONS LI…
- PRODUCT 3 CRITERIA - COMPONENT STATE-OF-DEVELOPMENT SCALE
- PRODUCT 4 CRITERIA - CRITERIA FOR COMPONENT COMMITMENT TO A PROJECT
- PRODUCT 5 CRITERIA - CRITERIA FOR COMPONENT RISK ASSESSMENT

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

STUDY APPROACH



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VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRODUCT 2 - TECHNOLOGY OPTIONS LIST

TECHNOLOGY OPTIONS*	MISSION APPLICABILITY: VOIR	MISSION APPLICABILITY: SEASAT FOLLOW-ON	ENGINEERING SUBSYSTEM APPLICABILITY — VOIR: ENGINEERING MECHANICS	VOIR: POWER	VOIR: PROPULSION	VOIR: ATTITUDE AND ARTICULATION CONTROL	VOIR: TELECOMMUNICATIONS	VOIR: DATA HANDLING AND CONTROL	SEASAT FOLLOW-ON: ENGINEERING MECHANICS	SEASAT FOLLOW-ON: THERMAL CONTROL	SEASAT FOLLOW-ON: POWER	SEASAT FOLLOW-ON: ATTITUDE CONTROL AND DETERMINATION	SEASAT FOLLOW-ON: COMMUNICATIONS AND DATA HANDLING	FUNDING STATUS: FUNDED	FUNDING STATUS: UNFUNDED
MULTIDISCIPLINARY RESEARCH (NO OPTIONS IDENTIFIED)															
MATERIALS R&T (NO OPTIONS IDENTIFIED)															
STRUCTURE R&T															
• METAL-LINED COMPOSITE PROPELLANT TANKS	X				X									X	
SENSING & DETECTION R&T (NO OPTIONS IDENTIFIED)															
GUIDANCE & CONTROL R&T (TO BE INVESTIGATED)															
DATA REDUCTION & DISTRIBUTION R&T															
• ON-BOARD SAR IMAGE PROCESSOR	X	X						X					X	X	
• DIGITAL DATA SYSTEMS (UNIFIED DATA SYSTEM)	X	X						X							
• DIGITAL RADIO	X	?					X						?	X	
• Ku-BAND PLANAR ARRAY ANTENNA		X											X	X	
• OTHER															
CHEMICAL PROPULSION R&T															
• FLOURINE-HYDRAZINE RETRO-PROPULSION TECHNOLOGIES	X				X									X	
ELECTRIC PROPULSION R&T															
• ELECTRIC PROPULSION	X				X									X	

* CLASSIFIED BY OAST SPACE R&T PROGRAM/DISCIPLINE OBJECTIVE. SOURCES INCLUDE "SR&T TECHNOLOGY PROGRAM AND SPECIFIC OBJECTIVES," OAST, FY '78; "VOIR 1983 MISSION AND SYSTEM STUDY," OCT 1978; "SEASAT-B OPTIONS PHASE FINAL REPORT," JUNE 1977

X INDICATES MISSION/SUBSYSTEM APPLICABILITY AND FUNDING STATUS

PRODUCT 2 - TECHNOLOGY OPTIONS LIST (contd)

TECHNOLOGY OPTIONS*	MISSION APPLICABILITY: VOIR	MISSION APPLICABILITY: SEASAT FOLLOW-ON	VOIR: ENGINEERING MECHANICS	VOIR: POWER	VOIR: PROPULSION	VOIR: ATTITUDE AND ARTICULATION CONTROL	VOIR: TELECOMMUNICATIONS	VOIR: DATA HANDLING AND CONTROL	SEASAT FOLLOW-ON: ENGINEERING MECHANICS	SEASAT FOLLOW-ON: THERMAL CONTROL	SEASAT FOLLOW-ON: POWER	SEASAT FOLLOW-ON: ATTITUDE CONTROL AND DETERMINATION	SEASAT FOLLOW-ON: COMMUNICATIONS AND DATA HANDLING	FUNDING STATUS: FUNDED	FUNDING STATUS: UNFUNDED
SPACE ENERGY SYSTEMS R&T															
• BRAYTON ISOTOPE POWER SYSTEM (BIPS)	X			X										X	
• KILOWATT ISOTOPE POWER SYSTEM (KIPS)	X			X										X	
• AUTOMATED POWER SYSTEM MANAGEMENT	X	X		X							X			X	
• OTHER															
NUCLEAR ENERGY R&T (NO OPTIONS IDENTIFIED)															
HIGH POWER LASERS & ENERGETICS R&T (TO BE INVESTIGATED)															
ENTRY R&T (TO BE INVESTIGATED)															
ELECTRONIC SYSTEMS TECHNOLOGY (TO BE INVESTIGATED)															
MATERIALS AND STRUCTURES SYSTEMS TECHNOLOGY (TO BE INVESTIGATED)															
PROPULSION AND POWER SYSTEMS TECHNOLOGY															
• FLUORINE - HYDRAZINE RETRO PROPULSION (SPACE STORABLE BIPROPELLANT PROPULSION)	X				X									X	
• AEROBRAKE	X				X										X

* CLASSIFIED BY OAST SPACE R&T PROGRAM/DISCIPLINE OBJECTIVE. SOURCES INCLUDE "SR&T TECHNOLOGY PROGRAM AND SPECIFIC OBJECTIVES," OAST, FY '78; "VOIR 1983 MISSION AND SYSTEM STUDY," OCT 1978; "SEASAT-B OPTIONS PHASE I FINAL REPORT," JUNE 1977

X INDICATES MISSION/SUBSYSTEM APPLICABILITY AND FUNDING STATUS

ORIGINAL PAGE IS OF POOR QUALITY

PRODUCT 3 CRITERIA - COMPONENT STATE-OF-DEVELOPMENT SCALE

STATE-OF-DEVELOPMENT LEVEL	DEFINITION	
	HARDWARE*	SOFTWARE
1	BASIC PRINCIPLES OBSERVED AND REPORTED	BASIC THEORY DEVELOPED AND PUBLISHED
2	CONCEPTUAL DESIGN FORMULATED	APPLICABILITY TO SPECIFIC PROBLEMS PROPOSED
3	CONCEPTUAL DESIGN SUBJECTED TO ANALYTICAL INVESTIGATION AND/OR EXPERIMENTAL TEST	USED TO IDENTIFY PARTS OF EXISTING MISSION DESIGN
4	CRITICAL FUNCTION OR CHARACTERISTIC DEMONSTRATED (i.e., GROSS DESIGN FEASIBILITY ESTABLISHED)	FAVORABLE COMPARISON WITH AVAILABLE MISSION RESULTS ATTAINED
5	PROTOTYPE/BREADBOARD SUCCESSFULLY TESTED (i.e., PERFORMANCE AND LIFETIME REQUIRED BY THE MISSION OF INTEREST DEMONSTRATED) IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	ANALYSES REQUIRED FOR REFERENCE FUTURE MISSION PERFORMED
6	ENGINEERING MODEL SUCCESSFULLY TESTED IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	DEMONSTRATION THAT ALL FUNCTIONS REQUIRED FOR REFERENCE FUTURE MISSION CAN BE PERFORMED TO THE REQUIRED ACCURACY
7	ENGINEERING MODEL SUCCESSFULLY FLIGHT TESTED OR SUCCESSFULLY FLOWN IN THE SPACE ENVIRONMENT	SOFTWARE USED IN SUPPORT OF AT LEAST ONE PREVIOUS MISSION

*ABSTRACTED FROM GD CONVAIR RPT. No. CASD-NAS-75-016, "FUTURE PAYLOAD TECHNOLOGY REQUIREMENTS STUDY," JUNE 1975.

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRODUCT 3 CRITERIA - COMPONENT STATE-OF-DEVELOPMENT SCALE

STATE-OF-DEVELOPMENT LEVEL	DEFINITION	
	HARDWARE*	SOFTWARE
1	BASIC PRINCIPLES OBSERVED AND REPORTED	BASIC THEORY DEVELOPED AND PUBLISHED
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3	CONCEPTUAL DESIGN SUBJECTED TO ANALYTICAL INVESTIGATION AND/OR EXPERIMENTAL TEST	USED TO IDENTIFY PARTS OF EXISTING MISSION DESIGN
4	CRITICAL FUNCTION OR CHARACTERISTIC DEMONSTRATED (i.e., GROSS DESIGN FEASIBILITY ESTABLISHED)	FAVORABLE COMPARISON WITH AVAILABLE MISSION RESULTS ATTAINED
5	PROTOTYPE/BREADBOARD SUCCESSFULLY TESTED (i.e., PERFORMANCE AND LIFETIME REQUIRED BY THE MISSION OF INTEREST DEMONSTRATED) IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	ANALYSES REQUIRED FOR REFERENCE FUTURE MISSION PERFORMED
6	ENGINEERING MODEL SUCCESSFULLY TESTED IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	DEMONSTRATION THAT ALL FUNCTIONS REQUIRED FOR REFERENCE FUTURE MISSION CAN BE PERFORMED TO THE REQUIRED ACCURACY
7	ENGINEERING MODEL SUCCESSFULLY FLIGHT TESTED OR SUCCESSFULLY FLOWN IN THE SPACE ENVIRONMENT	SOFTWARE USED IN SUPPORT OF AT LEAST ONE PREVIOUS MISSION

*ABSTRACTED FROM GD CONVAIR RPT. No. CASD-NA5-75-016, "FUTURE PAYLOAD TECHNOLOGY REQUIREMENTS STUDY," JUNE 1975.

VOIR/SEASAT FOLLOW-ON TECHNOLOGY
READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRODUCT 4 CRITERIA - CRITERIA FOR COMPONENT COMMITMENT TO A PROJECT

COMMITMENT CONDITION	DEFINITION
1.	THE COMPONENT STATE OF DEVELOPMENT MUST CORRESPOND TO A LEVEL OF 5 OR HIGHER ON THE APPROPRIATE HARDWARE OR SOFTWARE COMPONENT STATE-OF-DEVELOPMENT SCALE
2.	THE COMPONENT MUST NOT PLACE REQUIREMENTS ON OTHER SUBSYSTEMS WHICH REQUIRE THEIR ADVANCEMENT BEYOND THE STATE-OF-THE-ART
3.	COMPONENT PIECE PARTS (OR THEIR EQUIVALENTS) MUST BE AVAILABLE (AND REMAIN SO) AND MUST MEET PROJECT QUALITY REQUIREMENTS
4.	THERE MUST BE NO UNSOLVABLE PROBLEMS TO THE COMPONENT SURVIVING AND FUNCTIONING IN THE EXPECTED ENVIRONMENTS
5.	COMPONENT MASS, POWER, AND VOLUME ESTIMATES MUST BE COMPATIBLE WITH SYSTEM PERFORMANCE CAPABILITIES
6.	COMPONENT DEVELOPMENT COSTS AND SCHEDULE MUST BE CONSISTENT WITH THE PROJECT PLAN AND ANTICIPATED RESOURCES
7.	COMPONENT MANUFACTURING REQUIREMENTS MUST NOT EXCEED INDUSTRY CAPABILITY IN QUALITY OR QUANTITY

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 2: SEASAT FOLLOW-ON

PRODUCT 5 CRITERIA - CRITERIA FOR COMPONENT RISK ASSESSMENT

AREA	LEVELS OF RISK		
	LOW	MEDIUM	HIGH
TECHNOLOGY	TECHNOLOGY EXISTS AND HAS DEMONSTRATED THE PERFORMANCE AND LIFETIME REQUIRED BY THE MISSION OF INTEREST, CORRESPONDING TO A STATE OF DEVELOPMENT LEVEL OF 5 OR HIGHER.	TECHNOLOGY EXISTS ONLY AS A CONCEPTUAL DESIGN UNDERGOING EVALUATION, CORRESPONDING TO LEVELS 2-4.	TECHNOLOGY DOES NOT EXIST AND MUST BE DEVELOPED FROM BASIC PRINCIPLES, CORRESPONDING TO LEVEL 1.
	TECHNOLOGY OPTIONS OR ALTERNATIVES EXIST.	TECHNOLOGY OPTIONS OR ALTERNATIVES EXIST ONLY AS CONCEPTUAL DESIGNS.	TECHNOLOGY OPTIONS OR ALTERNATIVES DO NOT EXIST.
	PARALLEL TECHNOLOGY DEVELOPMENTS ARE FEASIBLE WITHIN ANTICIPATED RESOURCES AND SCHEDULE.	ANTICIPATED RESOURCES AND SCHEDULE ARE MARGINAL FOR PARALLEL TECHNOLOGY DEVELOPMENTS.	PARALLEL TECHNOLOGY DEVELOPMENTS ARE NOT FEASIBLE.
ENGINEERING	PROBLEM IS COMMONPLACE AND MAY BE SOLVED BY THE APPLICATION OF ANY ONE OF A NUMBER OF ROUTINE DESIGN APPROACHES.	PROBLEM IS SOMEWHAT NOVEL AND REQUIRES A DESIGN APPROACH SHOWING SOME INGENUITY AND CREATIVITY.	PROBLEM IS NOVEL, ALTHOUGH SOLUTIONS BASED ON EXISTING TECHNOLOGY DO EXIST, AND REQUIRES A DESIGN APPROACH OF CONSIDERABLE INGENUITY AND CREATIVITY.
PERSONNEL	PERSONNEL WHO ARE CONSIDERED EXPERTS IN THEIR FIELDS AND WHO HAVE SUCCESSFULLY SUPPORTED SIMILAR PROJECTS ARE AVAILABLE.	PERSONNEL OF HIGH QUALITY, BUT LIMITED APPLICABLE EXPERIENCE, ARE AVAILABLE.	PERSONNEL OF UNKNOWN OR QUESTIONABLE CAPABILITIES ARE AVAILABLE.
	COMMITMENT OF ABOVE PERSONNEL TO PROJECT FOR ITS DURATION WOULD BE FIRM.	PERSONNEL COMMITMENT TO PROJECT IS CONDITIONAL.	PERSONNEL COMMITMENT TO PROJECT IS UNDETERMINED.
FORESEEABLE PROBLEMS	ENOUGH IS KNOWN TO FORESEE ALL MAJOR PROBLEMS AND ACCURATELY ASSESS RISKS.	ENOUGH IS KNOWN TO FORESEE MOST MAJOR PROBLEMS AND ASSESS RISKS WITH SOME ACCURACY.	NOT ENOUGH IS KNOWN TO FORESEE MAJOR PROBLEMS OR ASSESS RISKS
	ENOUGH IS KNOWN TO FORESEE MOST MINOR PROBLEMS.	ENOUGH IS KNOWN TO FORESEE SOME MINOR PROBLEMS.	NOT ENOUGH IS KNOWN TO FORESEE MINOR PROBLEMS.

TECHNOLOGY READINESS FOR A GLOBAL SERVICE MISSION

OAST SPACE SYSTEMS REVIEW

NASA HEADQUARTERS
WASHINGTON, D.C.

JANUARY 11-12, 1978

W. RAY HOOK
LANGLEY RESEARCH CENTER

TECHNOLOGY READINESS STUDY PLAN

OBJECTIVE

- TO IDENTIFY AND EVALUATE TECHNOLOGY ALTERNATIVES FOR A PLANNED AGENCY FLIGHT PROGRAM IN GLOBAL SERVICES

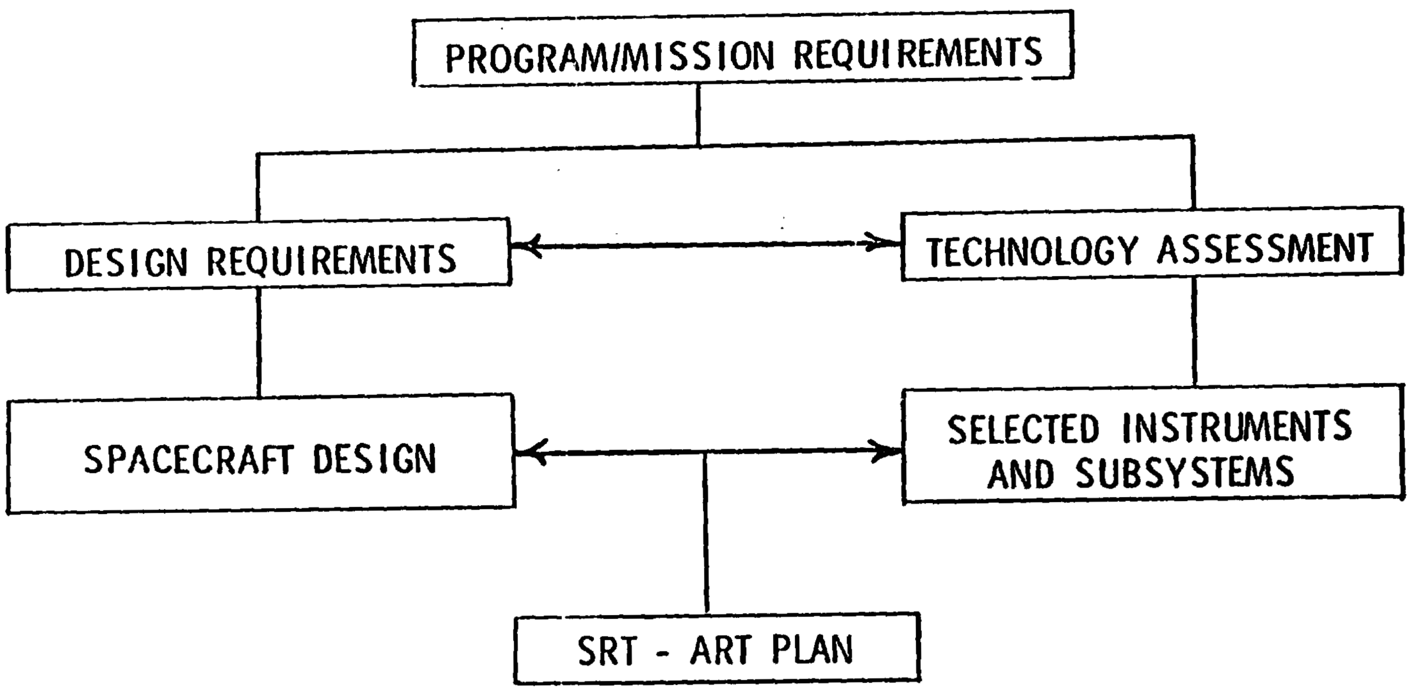
TECHNIQUE

- REVIEW PLANNED PROGRAM
- SMALL INTERDISCIPLINARY TEAM WORKING WITH THE PRELIMINARY DESIGN TEAM
- PROMISING SENSOR AND SUBSYSTEM AREAS SELECTED FOR ECONOMIC ASSESSMENT

RESULTS

- TECHNOLOGY ASSESSMENT AND UPDATED ART-SRT PLAN

TECHNOLOGY READINESS ASSESSMENT



TECHNOLOGY READINESS STUDY ACTIVITY

- o ENVIRONMENTAL MONITORING SATELLITE - MISSION STUDIES UNDERWAY
- o EARTH RADIATION BUDGET SATELLITE - PROGRAM PLAN BEING DEVELOPED -

  THREE INSTRUMENT SETS:
  - o TIROS
  - o AEM

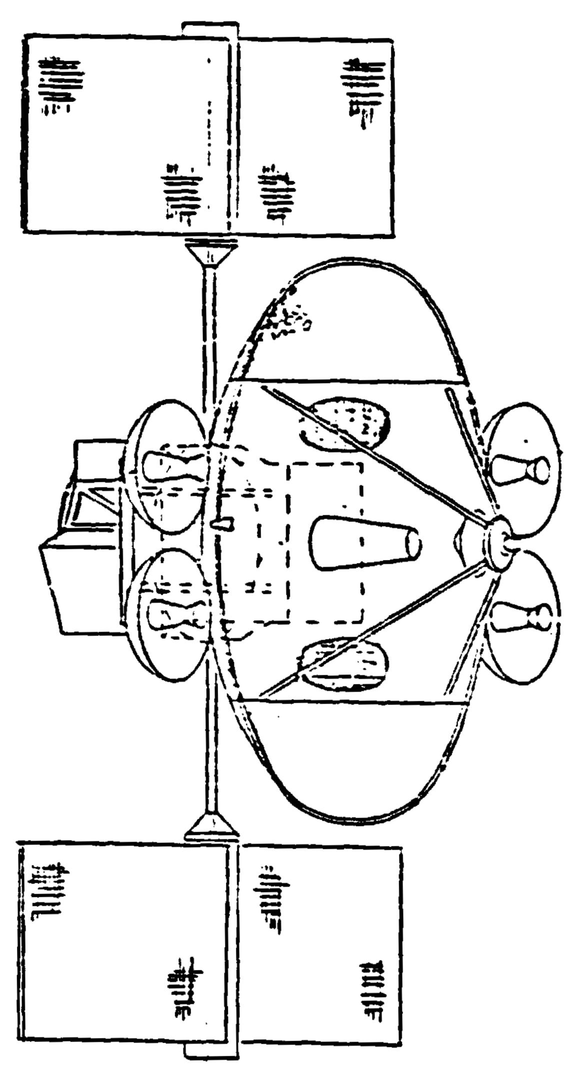
PUBLIC SERVICE PLATFORM

BACKGROUND

- PRELIMINARY SYSTEM DESIGN FOR A PUBLIC SERVICE COMMUNICATIONS TECHNOLOGY SATELLITE DEVELOPED AT GSFC IN 1977.
- DESIGN WAS TECHNOLOGY CONSTRAINED - PRIMARILY FOR COST REASONS.

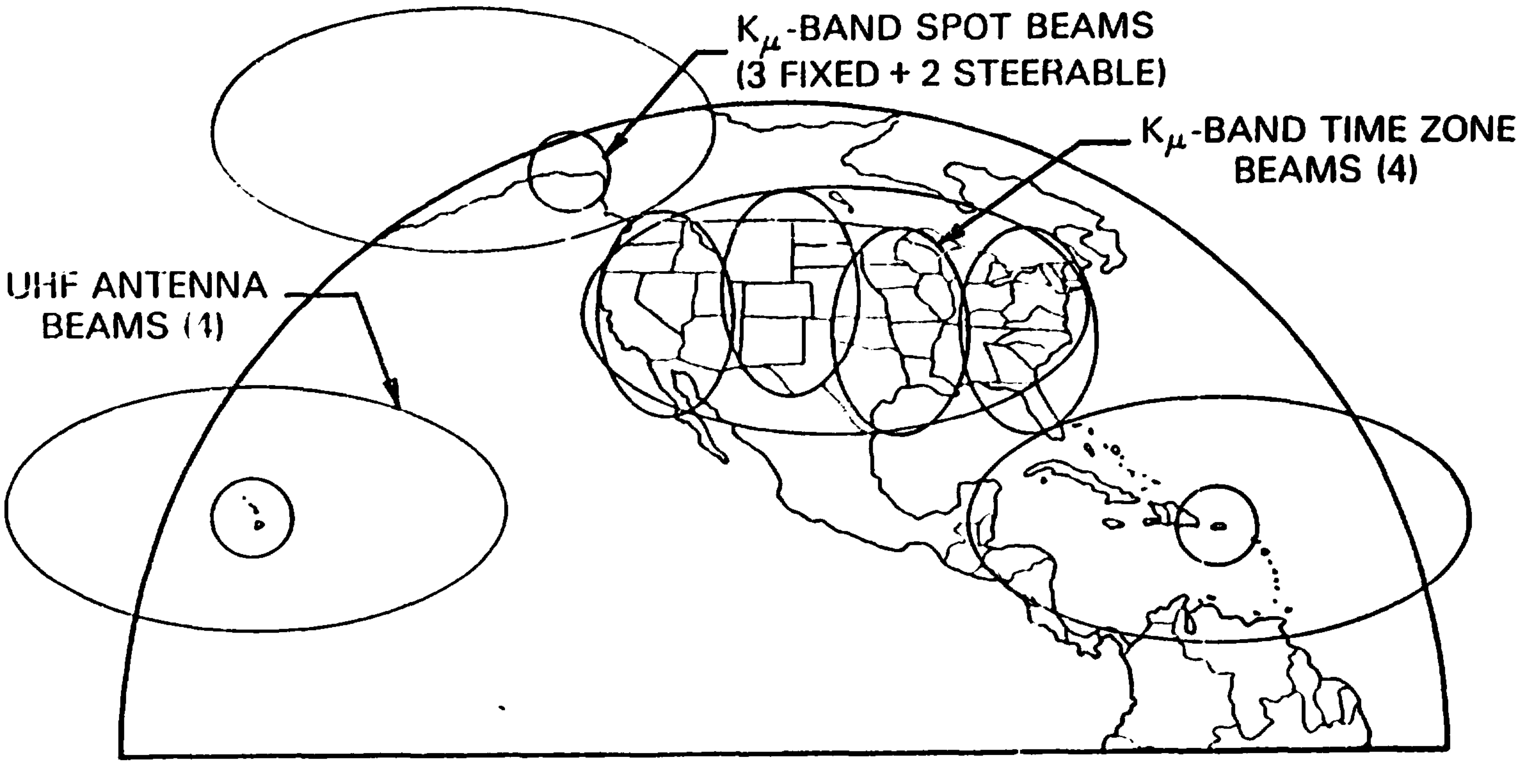
OBJECTIVES

- USE PSCTS CONSTRAINED DESIGN AS A BASELINE FOR DEVELOPMENT OF UNCONSTRAINED TECHNOLOGY CONCEPT.
- USE CONCEPT TO IDENTIFY TECHNOLOGY DRIVERS FOR PUBLIC SERVICE PLATFORMS IN ~1985 TIME-FRAME.



PSCTS CONCEPT

PSCTS CONCEPT - ANTENNA BEAM COVERAGE



PUBLIC SERVICE PLATFORM

- REVIEW REQUIREMENTS BASIS FOR PSCTS SYSTEM DESIGN CONCEPT.
- EXTEND/EXTRAPOLATE CURRENT DESIGN CONCEPT TO "OPTIMIZE" CAPABILITIES.
- IDENTIFY TECHNOLOGY REQUIREMENT OPTIONS FOR OPTIMIZED DESIGN CONCEPT.
- EVALUATE IDENTIFIED TECHNOLOGIES FOR READINESS IN ~1985 TIME-FRAME.

TECHNOLOGY READINESS

- IDENTIFY TECHNOLOGY ALTERNATIVES FOR MEETING MISSION REQUIREMENTS (OPTIONS, EXTRAPOLATION, ETC.)

- EVALUATE INCREMENTAL BENEFIT TO MISSION FROM EACH TECHNOLOGY ALTERNATIVE (BENEFITS MAY LIE IN PERFORMANCE, RELIABILITY, COST, SYSTEM FLEXIBILITY, ETC.)

- TO MAX. EXTENT POSSIBLE EXPRESS INCREMENTAL MISSION BENEFITS IN COMMON ($) TERMS.

- ASSESS COST AND RISK FOR EACH INCREMENTAL BENEFIT (E.G., COST - HIGH >2M, MED 0.5 - 2.0M, LOW <0.5M: RISK - FUNCTION OF FLIGHT DATE AND LEVEL OF DEMONSTRATION REACHED)

- RECOMMEND TECHNOLOGY AREAS FOR R&D ON BASIS OF COST/BENEFIT EVALUATION.

SCHEDULE, FUNDING, MANPOWER

SCHEDULE

- START 3 JAN 78
- SOW/PR PACKAGE COMPLETE 3 FEB 78
- TASK ORDER AWARD 3 MAR 78
- FINAL REPORT COMPLETE 8 SEP 78

FUNDING 35K

-

MANPOWER

- 0.5MY

EVALUATE USE OF PENETRATOR CONCEPT FOR FUTURE EARTH EXPLORATION

Objectives

Phase I
- Define the resource parameters that must be measured
- Conceptually identify the type of sensors capable of making the measurements
- Convene workshop with Geosat Committee and government participants to evaluate concept

Phase II
- Determine future sensor and system technology requirements
- Perform case studies for penetrator simulation
- Prepare final report and recommendations

EVALUATE USE OF PENETRATOR CONCEPT FOR FUTURE EARTH EXPLORATION

Contacts

Working Staff: Ames Research Center

Space Science Division
Space Projects Division

University Grant

San Jose State University,
Department of Geology

On-Site Contractor

LFE Corporation - Geologists

Workshop: Geosat Committee President (Fred Henderson III)

Participating Industry Corps

Mineral
Oil & Gas
Geothermal
Environmental & Engineering

Government Agencies

NASA
USGS
ERDA
NSF

Universities and Consultants

EVALUATE USE OF PENETRATOR CONCEPT FOR FUTURE EARTH EXPLORATION

Phase I Activities

- Determine characteristics to be measured:

  Mineral Deposits
  Oil & Gas Accumulations
  Geothermal Resources
  Environmental & Engineering Applications

- Conceptually identify methods of measurement:

  Geochemical
  Biological
  Geophysical

- Convene workshop with Geosat Committee and Government participants to exchange ideas:

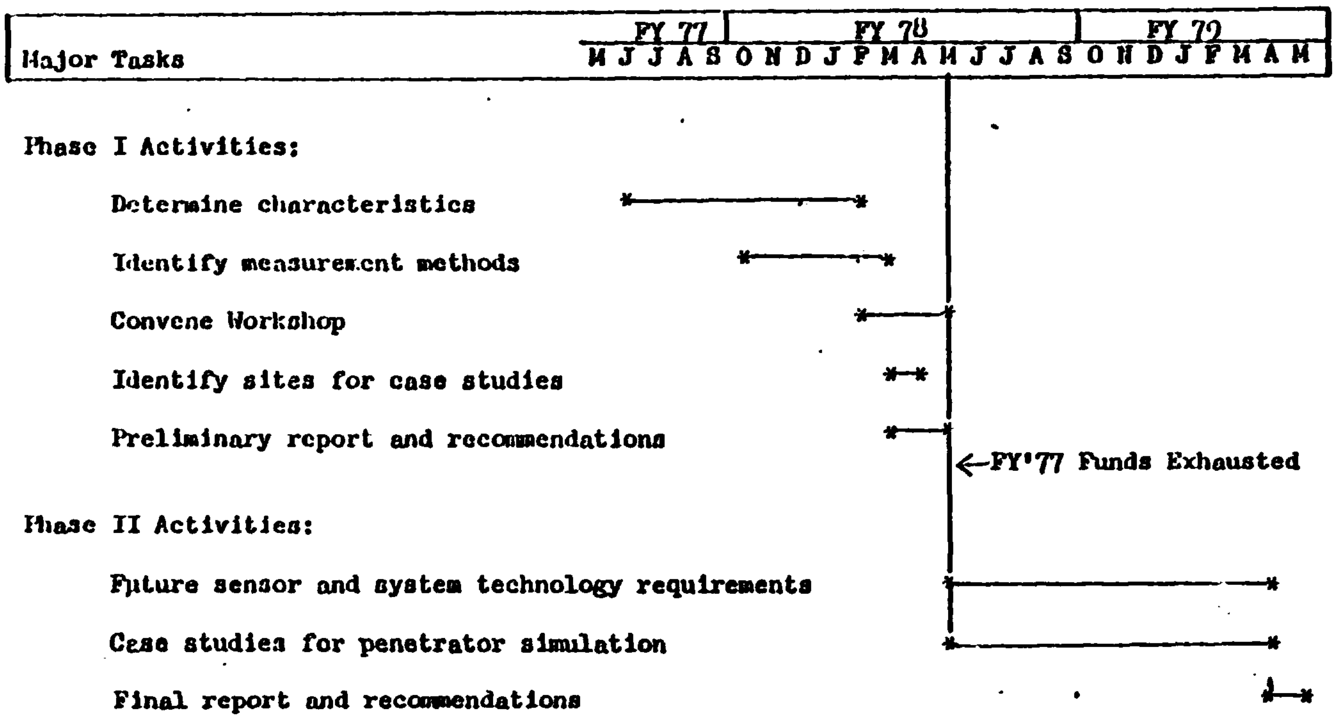
  Evaluate potential uses
  Determine important measurements
  Identify demonstration project(s)

- Identify sites for case studies to simulate penetrator application(s) for important potential uses:

  Reconstrust actual ore deposit site(s) to a pre-mined condition
  Simulate use in both reconnaissance and site survey modes, if possible

EVALUATE USE OF PENETRATOR CONCEPT FOR FUTURE EARTH EXPLORATION

Schedule and Cost



Activity	Item	Cost
Phase I(FY 77)	University Grant	20 K
	LFE Contract	40 K
Phase II(FY 78)	University Grant	75 K (University Grant, LFE Contract and Technology Innovations Contract together)
	LFE Contract	
	Technology Innovations Contract	

POST LANDSAT D
ADVANCED CONCEPT EVALUATION

PLACE OBJECTIVES

- TO IDENTIFY THE KEY TECHNOLOGIES OF EARTH RESOURCES SATELLITE SYSTEMS OF THE POST '84 TIME PERIOD (1985-2000)
- TO PROVIDE A COMPREHENSIVE 'SPACE SYSTEMS TECHNOLOGY MODEL' FOR EARTH RESOURCES PROGRAMS FOR THIS PERIOD
- TO DEVELOP A TOOL TO ALLOW FOR PRIORITY STRUCTURING OF THESE KEY TECHNOLOGIES AS A DECISION AID

PLACE STUDY

ORGANIZATION

MANAGEMENT:	S. SADIN (RX) -- PROGRAM MANAGER F. FLATOW (GSFC) -- STUDY MANAGER
CONTRACTOR:	G.E.
FUNDING:	$176K (OAST/OA)
PERIOD OF PERFORMANCE:	JULY 1977 TO JULY 1978

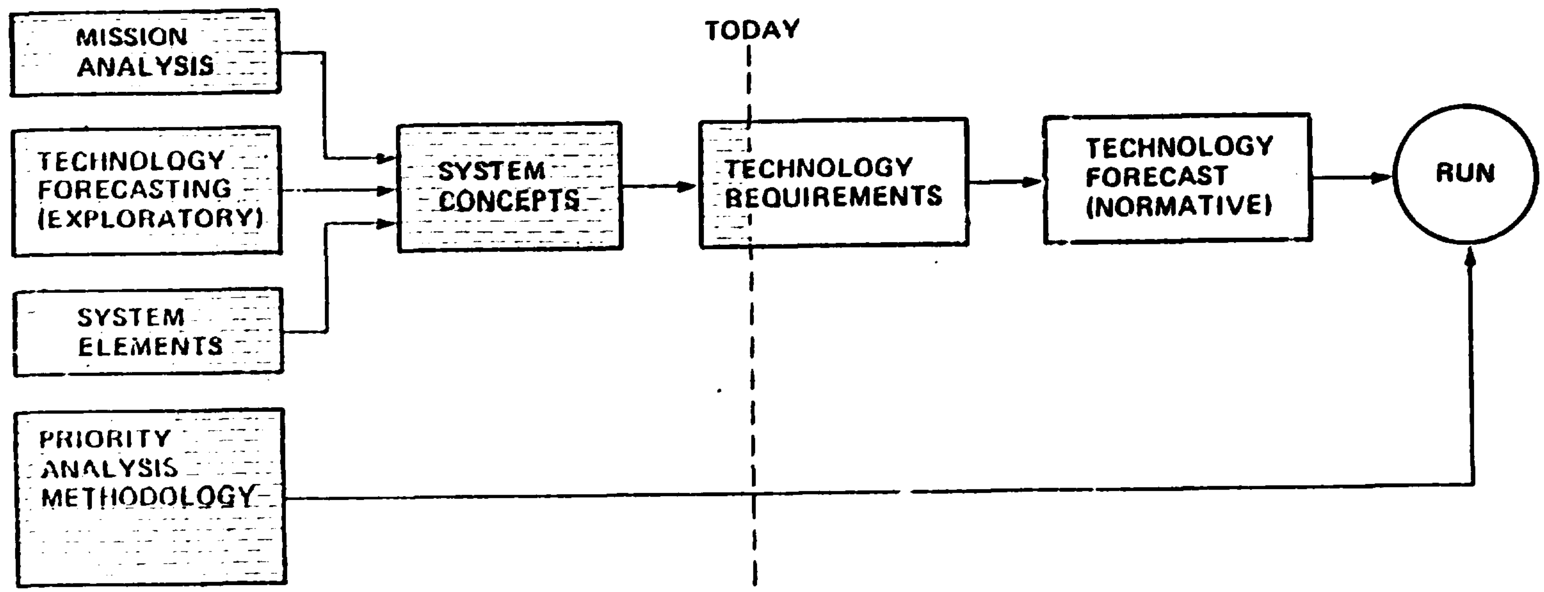
NASA MANDATE FOR VISION

- STUDY SHOULD ATTEMPT TO EMPLOY IMAGINATION, VISION AND INSPIRATION. SEEK TO GO BEYOND THE CREDIBLE TO THE 'SEMI-CREDIBLE'
- IN BOTH MISSION ANALYSIS AND TECHNOLOGY FORECASTING — ASK WHAT 'CAN BE' RATHER THAN WHAT 'WILL BE.'

APPLIED AS

	CREDIBLE	SEMI-CREDIBLE	INCREDIBLE
OBJECTIVES	GLOBAL CROP PRODUCTION FORECASTING	MONITOR GRAZING POTENTIAL	TRAFFIC MONITORING NAVIGATION HAZARDS
		SATCLOUD (1000 SATS)	SOIL COMPOSITION SYSTEM
SYSTEMS	LANDSAT E SHUTTLE CALIBRATION LAB	MICROSAT (600 X 1300 M ARRAY) FERRIS WHEEL (30 KM ARRAY)	SIMULTANEOUS EVENT DETECTING SYSTEM
TECHNOLOGIES	2-D ARRAY DETECTOR/ PROCESSORS	LARGE STRUCTURES APPLICATIONS MODELS	GRAVITY WAVE SENSORS NEUTRINO DETECTOR

PLACE STUDY METHODOLOGY



PLACE MISSION CATEGORIES

INCLUDED	EXCLUDED
AGRICULTURE	WEATHER
RANGE MANAGEMENT	CLIMATE
FORESTRY	ATMOSPHERIC SENSING(EXCEPT CALIBRATION)
GEOLOGICAL RESOURCES	EARTH AND OCEAN DYNAMICS
LAND USE	
WATER RESOURCES	ENERGY/COMM/NAV
ENVIRONMENTAL QUALITY	MILITARY
DISASTER ASSESSMENT	AIRCRAFT/D.C.P.'S
	EXTRATERRESTRIAL
	CRIMINAL ACTIVITIES(EXCEPT POLLUTION)

DERIVATION OF MISSION OBJECTIVES

- GE FORMULATION OF KEY MISSION OBJECTIVES
  - -- LITERATURE SEARCH
  - -- PREVIOUS STUDY RESULTS
  - -- MISSION REQUIREMENTS BOARD
- SELECTION CRITERIA
  - -- ECONOMIC AND OTHER SOCIAL IMPORTANCE
  - -- DIVERSITY: OBJECTIVES, TECHNOLOGY REQUIREMENTS
- OBJECTIVES APPROVED BY NASA FOR PURPOSE OF THIS STUDY

KEY OBJECTIVES

- AGRICULTURE – CROP PRODUCTION FORECASTING
  - IDENTIFY CROPS
  - MEASURE ACREAGE
  - ESTIMATE YIELD
  - MEASURE PRODUCTION
- RANGE MANAGEMENT – GRAZING POTENTIAL DETERMINATION
  - EVALUATE STATUS AND MEASURE CARRYING CAPACITY
  - ESTIMATE LIVESTOCK COUNT
  - ESTIMATE FORAGE PALATABILITY
- FORESTRY – TIMBER STAND VOLUME ESTIMATION
  - IDENTIFY TREES
  - EVALUATE QUANTITY AND QUALITY OF TIMBER
- GEOLOGY – GEOLOGICAL RESOURCES LOCATION
  - LOCATE ORES
  - LOCATE FOSSIL FUELS
  - LOCATE CONSTRUCTION MATERIALS
  - LOCATE GEOTHERMAL RESOURCES

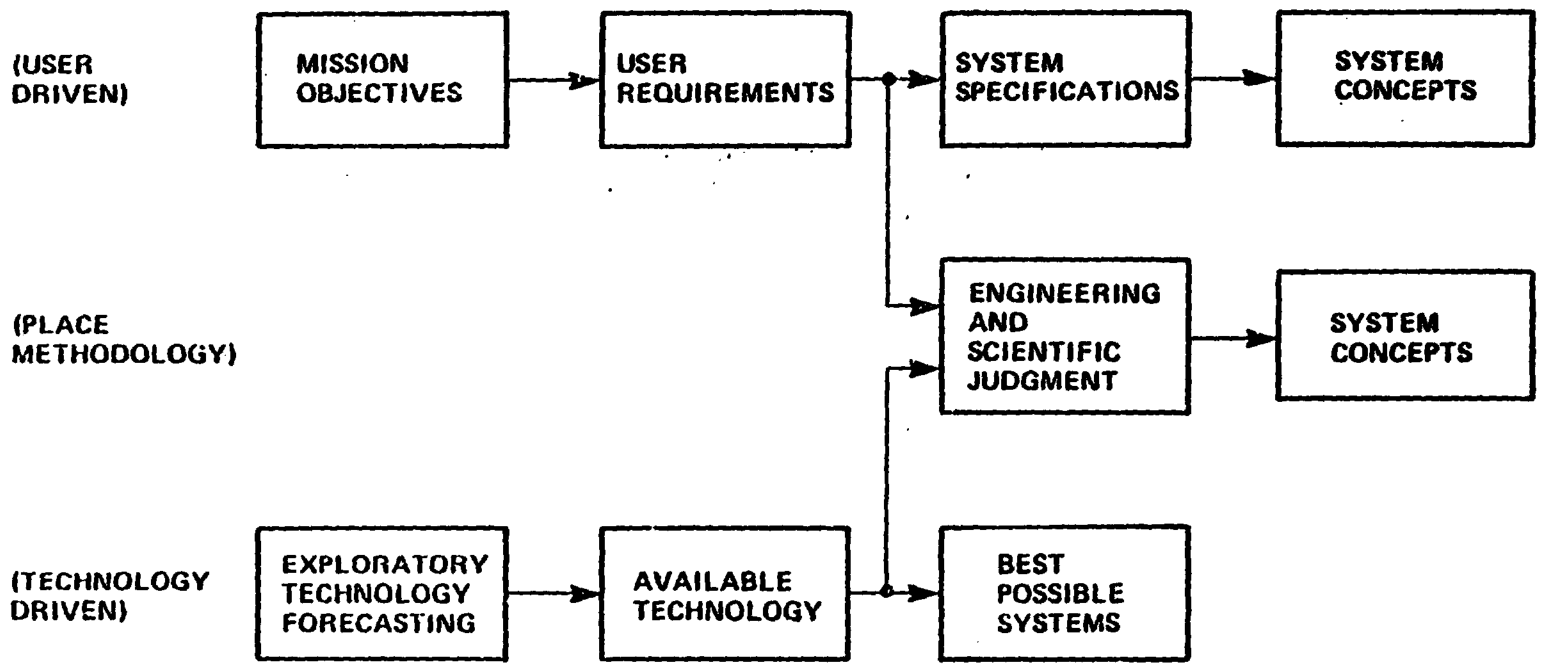
KEY OBJECTIVES

- LAND USE — LAND USE AND CENSUS ENUMERATION
  - CREATE THEMATIC AND LAND USE MAPS
  - DETECT CHANGE IN LAND USE
  - ESTIMATE POPULATION
- WATER RESOURCES — WATERSHED MONITORING
  - MONITOR SURFACE SUPPLY OF FRESH WATER
  - MEASURE GROUNDWATER FLOW AND STORAGE
  - INTEGRATE RAINFALL AND EVAPORATION DATA
- ENVIRONMENTAL QUALITY — WATER POLLUTION DETECTION
  - DETECT, MONITOR, AND TRACE FRESH WATER POLLUTANTS
  - MONITOR EUTROPHICATION
  - MEASURE SALT WATER INCURSION
- DISASTER ASSESSMENT — ABRUPT EVENT EVALUATION
  - MONITOR AND ASSESS DISASTERS
  - MONITOR NON-CALAMITOUS ABRUPT EVENTS

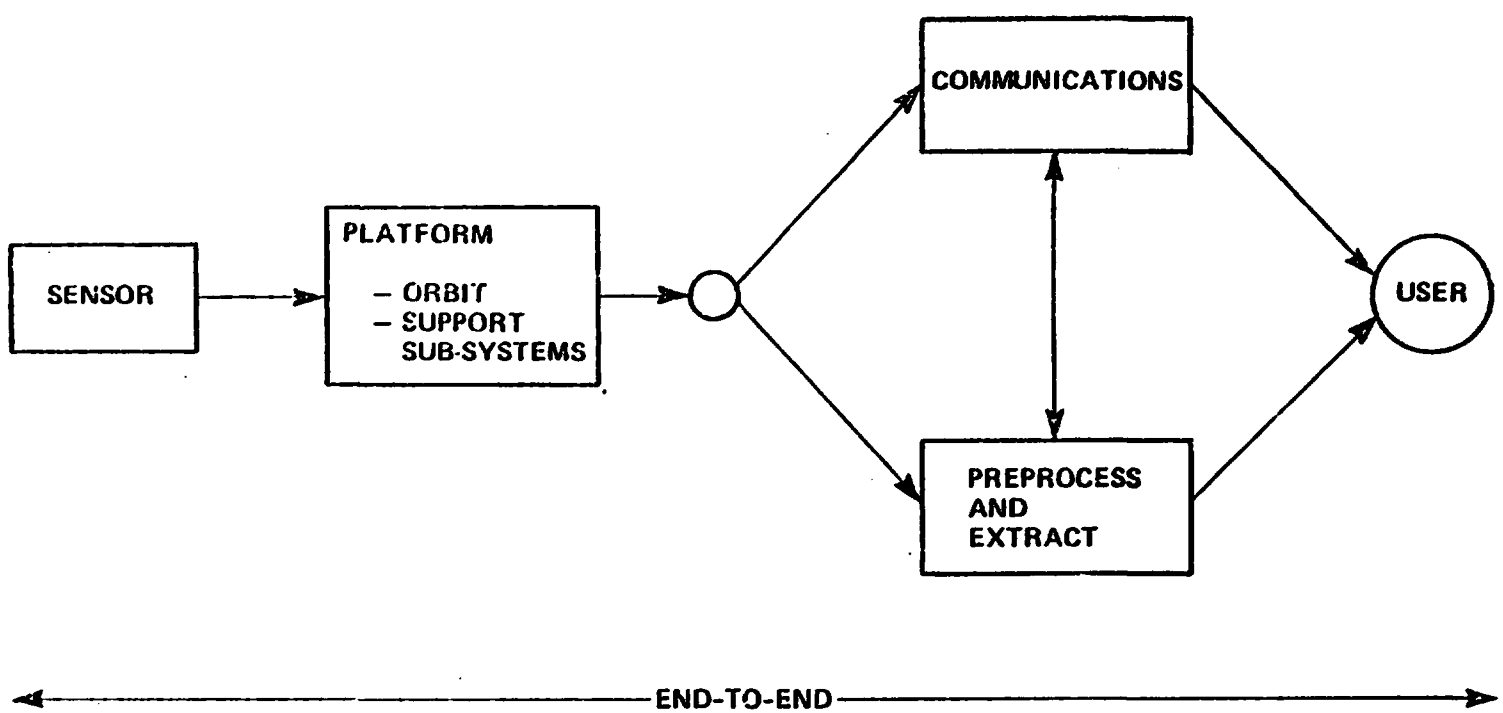
TRENDS IN REQUIREMENTS AND CAPABILITIES

- IFOV DOWN TO 5-10 METER
- AMPLITUDE RESOLUTION TO 0.1-0.5% (8-10 BITS).
- DATA RATE TO GIGABIT/SEC RANGE
- VARIABLE RESOLUTION/ZOOM CAPABILITY
- MAKE OBSERVATIONS IN ANY WEATHER, DAY OR NIGHT, UP TO REAL TIME
- MORE USE OF MODELS AND DATA BANKS

FORMATION OF SYSTEM CONCEPTS



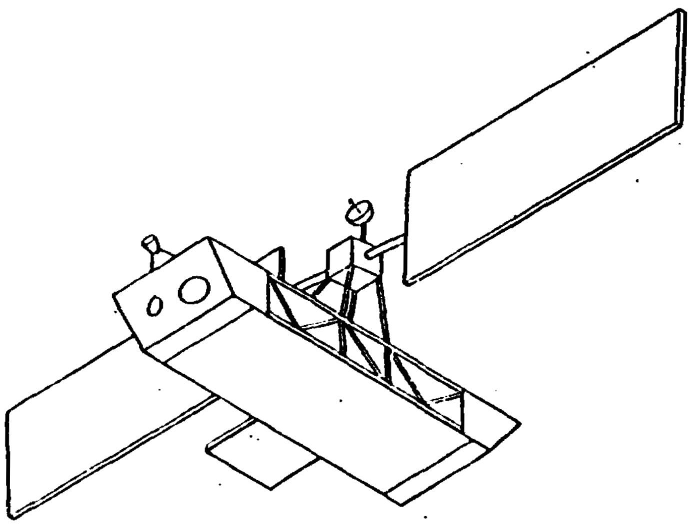
SYSTEM ELEMENTS



SENSOR & PLATFORM CONCEPTS

*1. LANDSAT H
2. EARTHWATCH
3. SEOS
4. TEXTUROMETER
5. HCMM FOLLOW-ON
6. NITE-LITE
*7. MICROSAT
8. PARASOL RADIOMETER
9. RADAR ELLIPSOMETER
*10. FERRIS WHEEL RADAR
11. SATCLOUD
12. RADAR ALTIMETER
13. SWEEP FREQUENCY RADAR
14. GEOSYNCHRONOUS SAR
15. RADAR HOLOGRAPHER
16. FARADAY MAGSAT
17. TETHERSAT
18. SHUTTLE CALIBRATION FACILITY
19. OPERATIONAL SHUTTLE FLIGHTS

LANDSAT H — SYSTEM CONCEPT



- EXTENSION OF OPERATIONAL LANDSAT PROGRAM (APPROX. 1995)
- INCORPORATES OPTICAL AND SAR DEVELOPMENTS OF LANDSAT F AND G
- SMART OPTICAL SENSOR ALLOWS FOR INTELLIGENT ON-BOARD EDITING/DATA REDUCTION
- SYNTHETIC APERTURE RADAR PROVIDES MULTI-FREQUENCY, ALL WEATHER IMAGING CAPABILITY
- ON-BOARD PROCESSING AND STORAGE ALLOWS FOR CHANGE DETECTION AND OR INFORMATION EXTRACTION
- HIGH RESOLUTION POINTABLE IMAGER PROVIDES GREATER DETAIL IN SELECTED TARGET AREAS
- ACTIVE VISIBLE SENSOR PROVIDES ATMOSPHERIC CALIBRATION, LUMINESCENCE, NIGHT IMAGING

LANDSAT H – SYSTEM CONCEPT (CONTINUED)

PERFORMANCE PARAMETERS

- SMART VISIBLE/IR SENSOR
  - FORWARD/BACKWARD LOOKING
  - 10 M RESOLUTION
  - 3 FORWARD BANDS/7 BACKWARD
  - 1.25 GBPS DATA RATE
  - 185 KM SWATH WIDTH
- SYNTHETIC APERTURE RADAR
  - L, C, X-BAND
  - 25 METER RESOLUTION
- HIGH RESOLUTION POINTABLE IMAGER
  - 5 M RESOLUTION
  - 5 KM x 5 KM TARGETS
  - 4 SPECTRAL BANDS
- LASER ATMOSPHERIC CALIBRATION
  - ALSO USED FOR LUMINESCENCE, NIGHT IMAGING
- ORBIT-SUN SYNCHRONOUS – (700 - 900 KM)
  - 3 SPACECRAFT CONSTELLATION
  - 6 DAY REPEAT CYCLE

SYSTEM CONSIDERATIONS

OBJECTIVES CONTRIBUTED TO: ALL

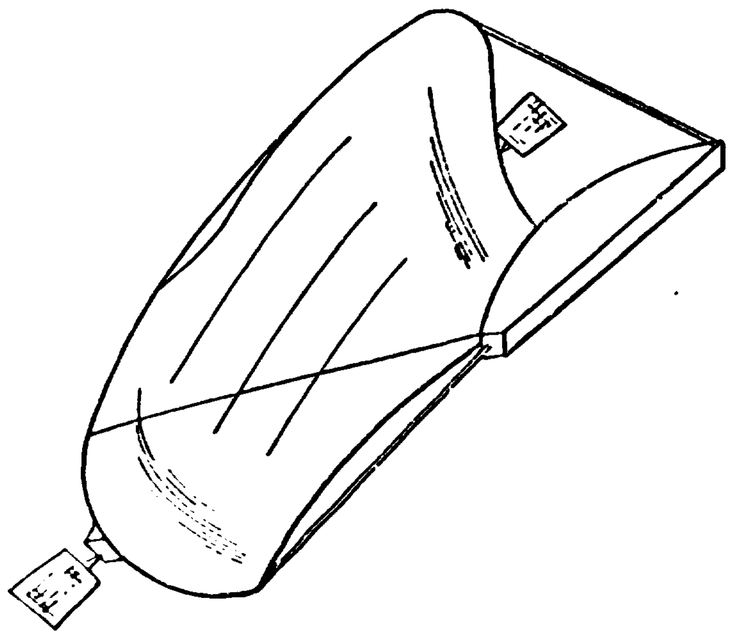
RELATED SPACECRAFT: EARTHWATCH

GEOSYNCHRONOUS SAR
RADAR HOLOGRAPHER

TIME PROJECTION: 1992 - 1997

MEASURE OF RISK: MEDIUM

MICROSAT – SYSTEM CONCEPT



- L-BAND PASSIVE RADIOMETER
- PARABOLIC TORUS ANTENNA WITH CLUSTER OF FEED HORNS IN A FOCAL ARC
- WOULD REQUIRE PREVIOUS COMMITMENT TOWARD LARGE STRUCTURES IN SPACE

MICROSAT — SYSTEM CONCEPT (CONTINUED)

PERFORMANCE PARAMETERS

- FREQUENCY IS 1.4 GHZ (L BAND)
- ANTENNA SIZE APPROXIMATELY 600M X 1300M
- GROUND RESOLUTION — 1KM, ORBIT — 1000KM, REPEAT CYCLE — 3 DAYS (2 SPACECRAFT), RADIOMETRIC TEMP. RES. — 1°K
- DATA RATE (PEAK) — 59 KBPS
- SWATH WIDTH - 535 KM

SYSTEM CONSIDERATIONS

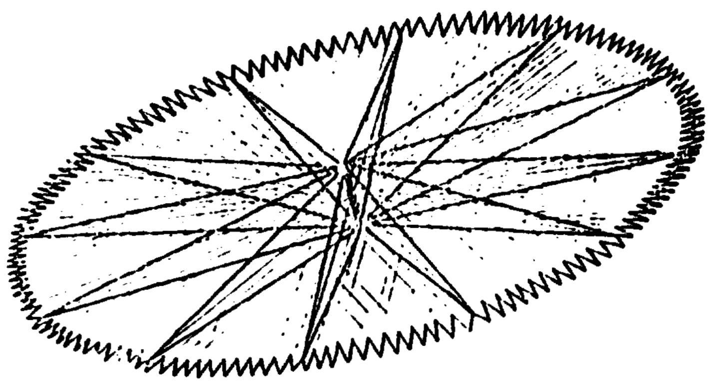
OBJECTIVE CONTRIBUTED TO:
SOIL MOISTURE

RELATED SPACECRAFT:
ALL MICROWAVE SYSTEMS
EXCEPT TEXTURE SYSTEMS

TIME PROJECTION: 1988-1992

MEASURE OF RISK: MEDIUM

FERRIS WHEEL RADAR – SYSTEM CONCEPT



- LARGE (30 KM DIAMETER) ROTATING CABLE STRUCTURE THAT RELIES ON CABLE TENSION FOR SUPPORT. PRESUMES PREVIOUS COMMITMENT TO ASSEMBLY OF LARGE STRUCTURES IN SPACE
- REAL APERTURE RADAR OPERATES AT LOW FREQUENCY (30-300 MHZ) FOR GROUND PENETRATION
- RESULTANT RETURN SIGNAL CAN MAP MATERIALS (BOUNDARY LAYERS AND GROUNDWATER)
- SPACECRAFT SPIN VECTOR IS FIXED IN INERTIAL SPACE
- PROBLEM AREA TO BE EXAMINED IS THE ATTENUATION EFFECTS OF THE IONOSPHERE.
- IC CHIPS FORM ELEMENTS OF A RANDOM SPARSE PHASED ARRAY
- TRADE BETWEEN CW AND PULSED IMPLEMENTATION YET TO BE PERFORMED

FERRIS WHEEL RADAR – SYSTEM CONCEPT (CONTINUED)

PLACE

NASA

PERFORMANCE PARAMETERS

- 30 KM DIAMETER
- DEPTH OF 1 TO > 75 METERS, DEPENDING ON SOIL TYPE, MOISTURE
- 300 M GROUND RESOLUTION
- VERTICAL TARGET RESOLUTION BELOW GROUND SURFACE – APPROXIMATELY 2M
- FREQUENCY – 30-300 MHZ
- SPIN RATE APPROXIMATEL 1 REV/HR
- 900 KM ORBIT

SYSTEM CONSIDERATIONS

OBJECTIVES CONTRIBUTED TO:

GEOLOGIC RESOURCES LOCATION
GROUNDWATER MAPPING
SOIL MOISTURE

COMPETING SPACECRAFT: NONE

TIME PROJECTION: 1995-2000

MEASURE OF RISK: HIGH

PLACE

TECHNOLOGY REQUIREMENTS ANALYSIS OUTPUT

- INSTRUMENTS
- SUPPORT SUBSYSTEMS
- SPACE PLATFORMS
- COMMUNICATION LINKS
- PREPROCESSING SYSTEMS (SPACE AND GROUND)
- INFORMATION EXTRACTION PROCESSING SYSTEMS (SPACE AND GROUND)
  - -- USER MODELS
  - -- LARGE DATA BASES
  - -- DATA ACCESSING TECHNIQUES
- DATA DISSEMINATION
- SPACE TRANSPORTATION PROSPECTS
- LARGE STRUCTURES

PRIORITY STRUCTURING METHODOLOGY

OBJECTIVE: TO HELP DECISION MAKERS IN ALLOCATING LIMITED AMOUNTS OF MONEY FOR DEVELOPMENT OF TECHNOLOGIES SO AS TO MAXIMIZE BENEFITS

APPLICATION: EXPERIMENTAL, INTERNAL TO STUDY ONLY AT THIS TIME

METHODOLODY: TWO METHODS DEVELOPED

- "TOP-DOWN": SIMPLE, FAST, DOES NOT GUARANTEE OPTIMUM RESULTS
- "BOTTOM-UP": THOROUGH, GOOD VISIBILITY, LONG-RUNTIME.

ENABLING TECHNOLOGY FOR GLOBAL SERVICE MISSIONS

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ENABLING TECHNOLOGY STUDIES

1/10/78

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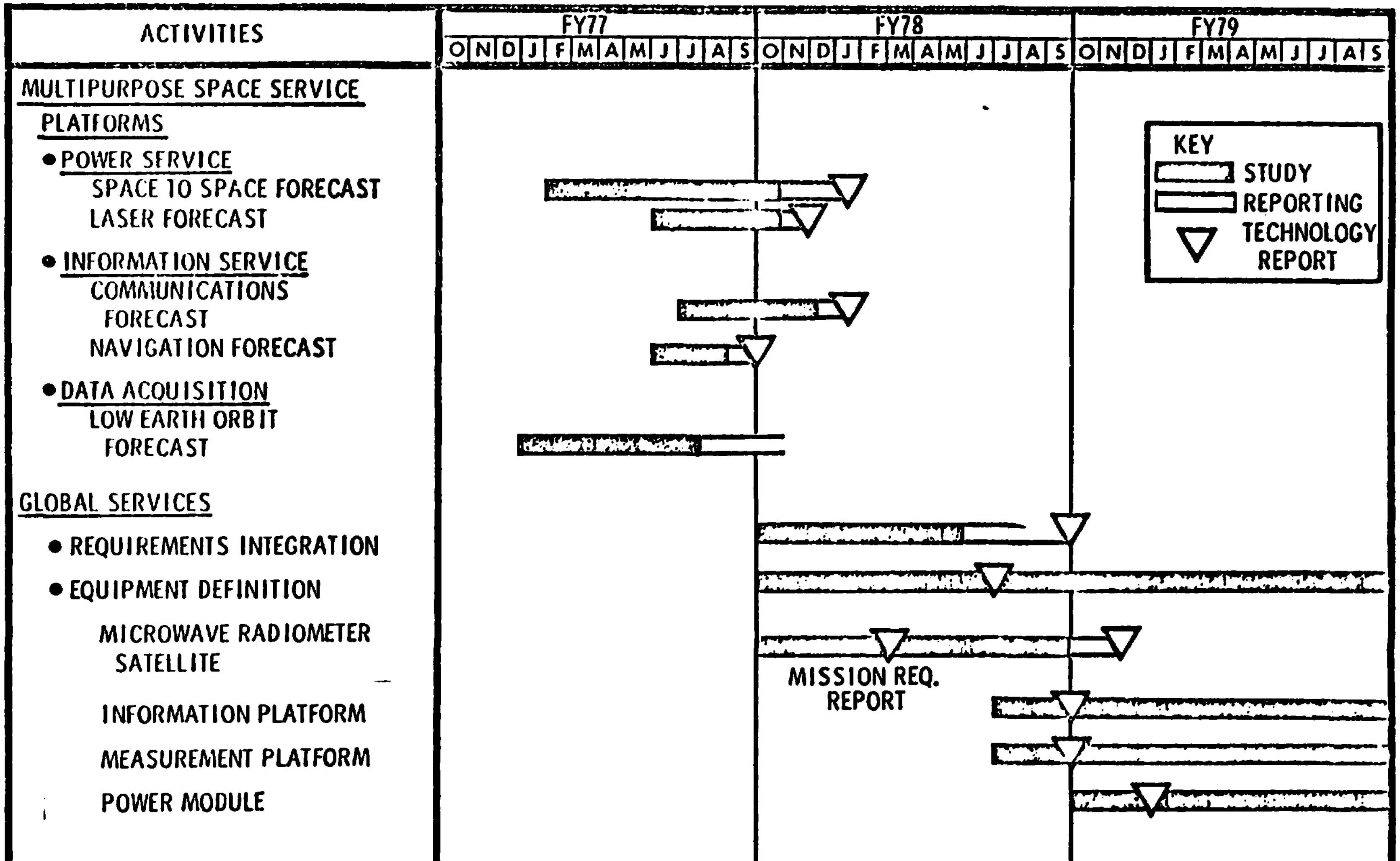
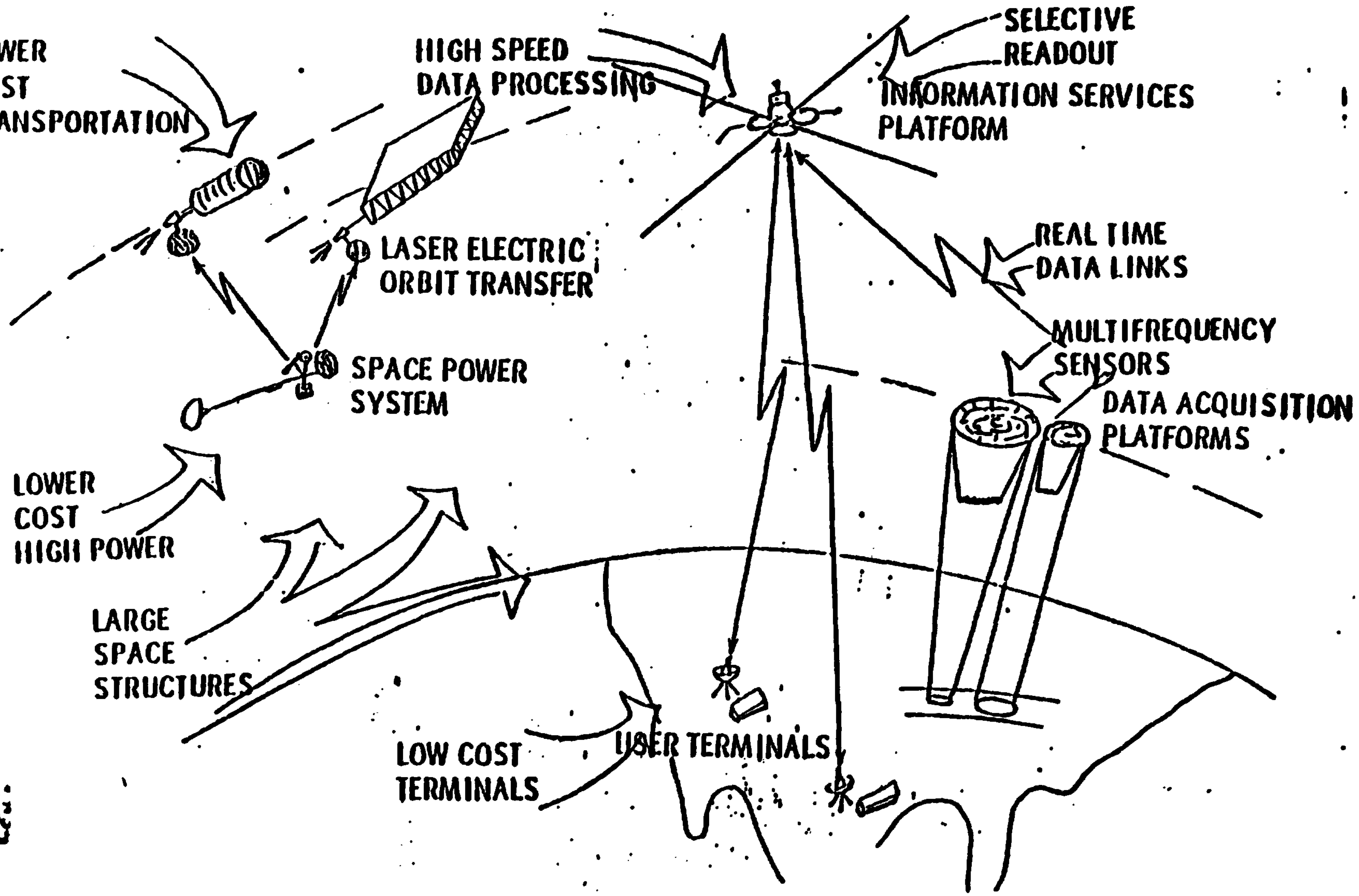


SPACE SERVICE PLATFORMS

- MULTIPURPOSE SPACE SYSTEMS

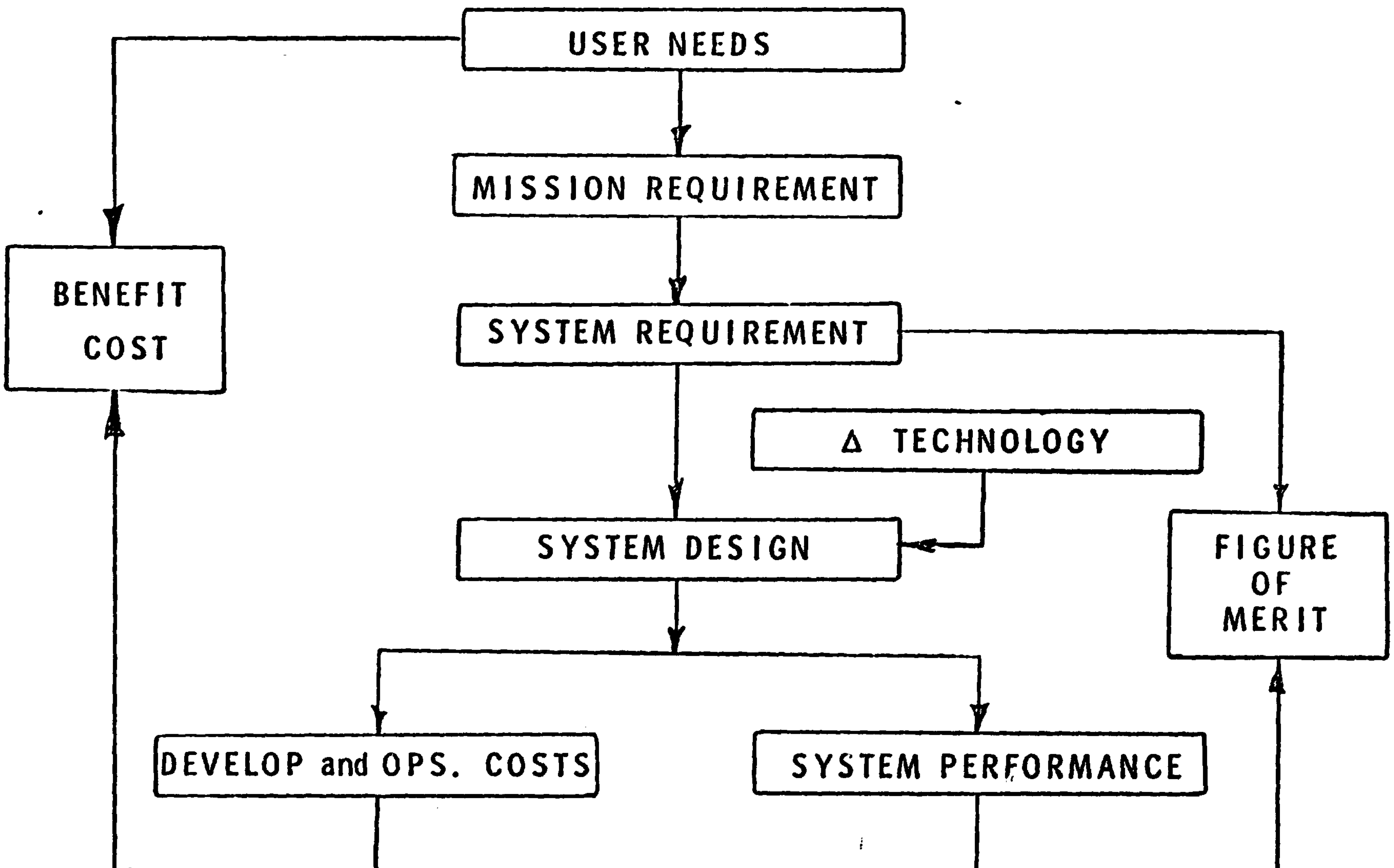


SPACE SERVICE PLATFORM CONFIGURATIONS

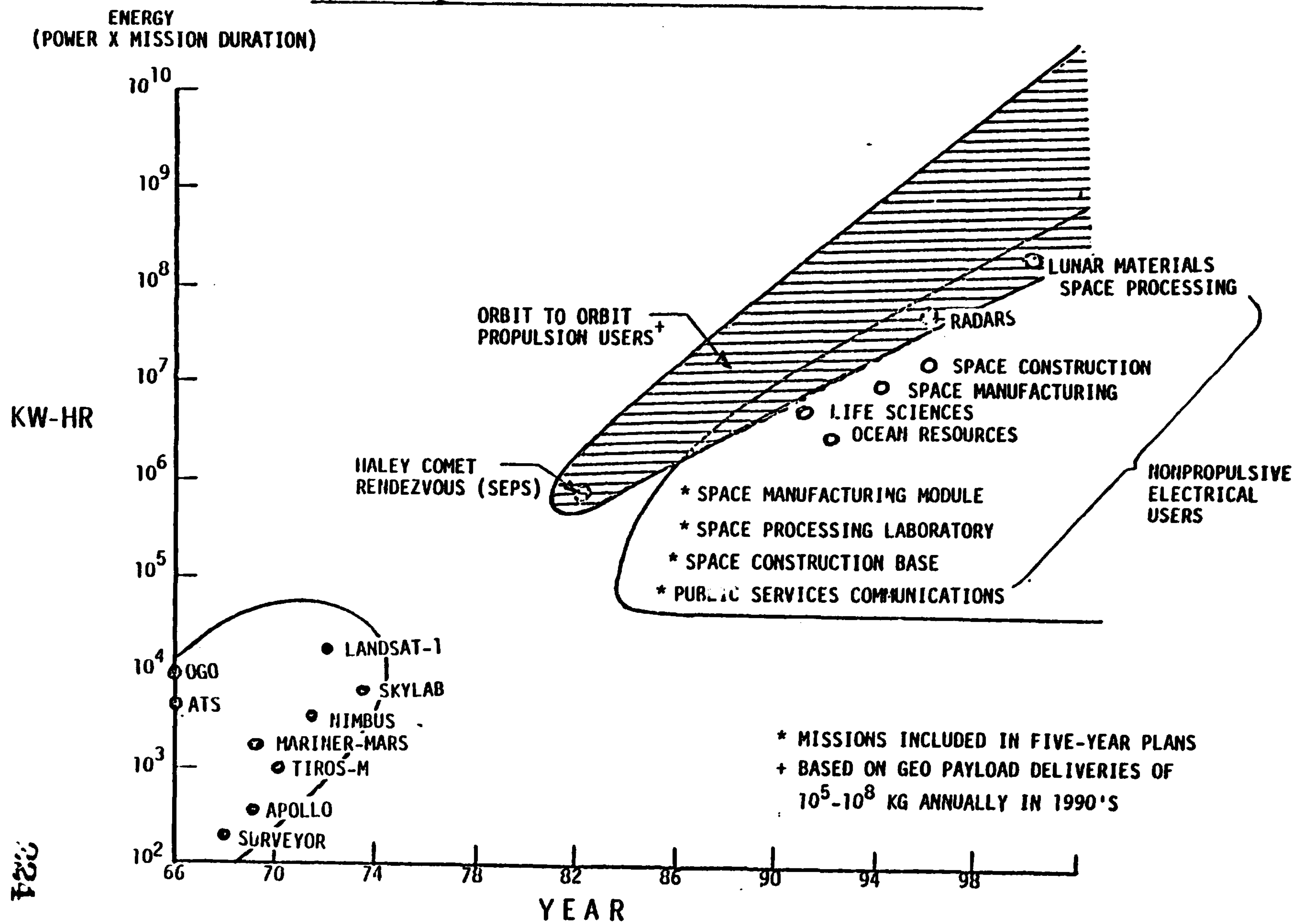
THE SPACE SERVICE PLATFORM MISSION PROFILE IDENTIFIES THE FOLLOWING PLATFORM CONFIGURATION:

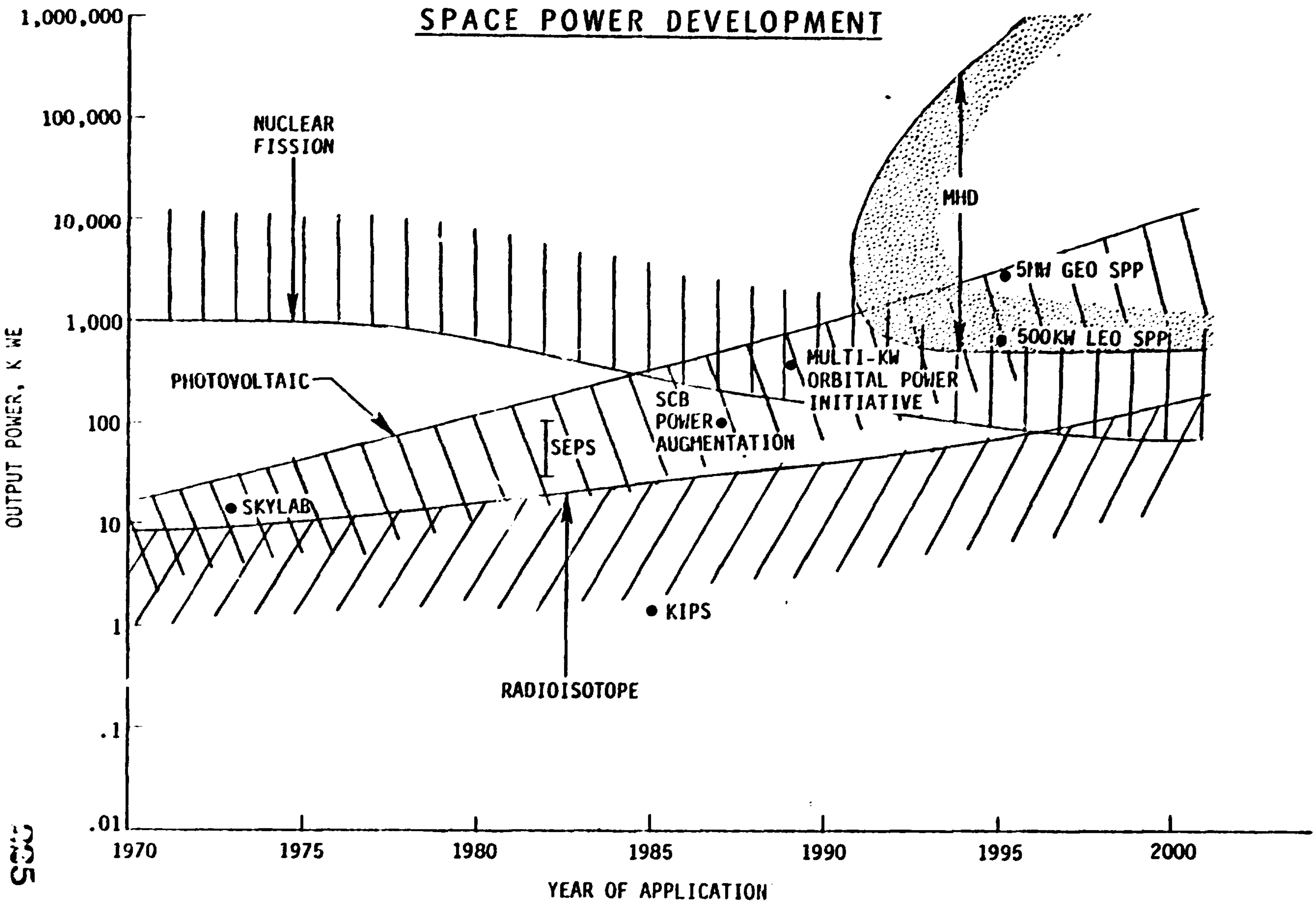
1. INFORMATION SERVICE PLATFORM (ISP)
   - LARGE COMMUNICATION ANTENNA ARRAYS
   - HOUSES LARGE AMOUNT OF COMPUTER/DATA PROCESSING AND COMMUNICATION EQUIPMENT
2. DATA ACQUISITION PLATFORM (DAP)
   - 15 TO 300 METER ANTENNAS - RADIOMETRIC, IR, OPTICS
   - MULTIPLE SENSORS EACH WITH MICROPREPROCESSING CAPABILITY
3. POWER SERVICE PLATFORM (PSP)
   - LARGE NUCLEAR POWER PLANT
   - LASER FOR TRANSMITTING ENERGY

SYSTEM DESIGN AND ANALYSIS

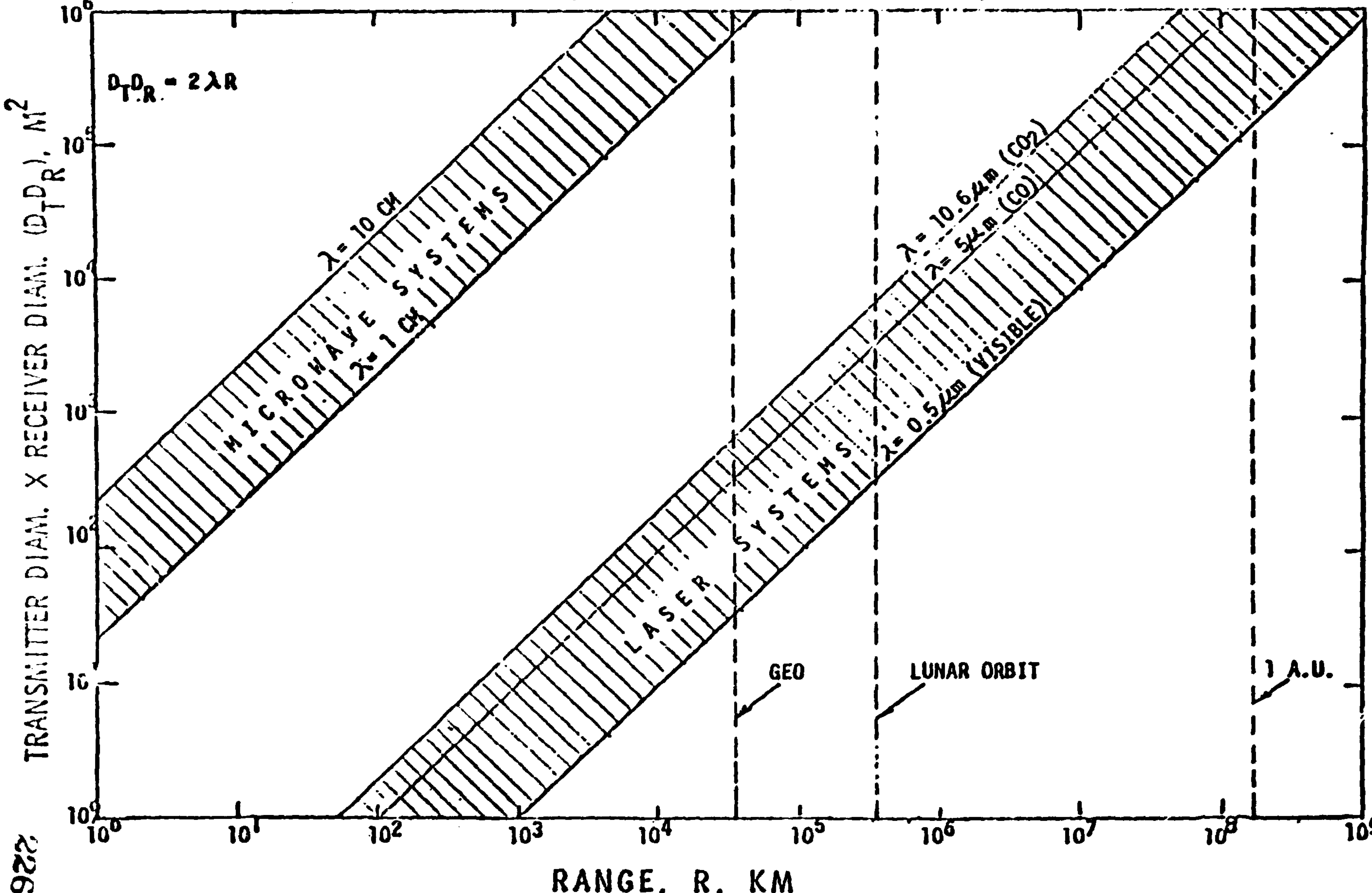


FUTURE NEAR EARTH SPACE ENERGY NEEDS

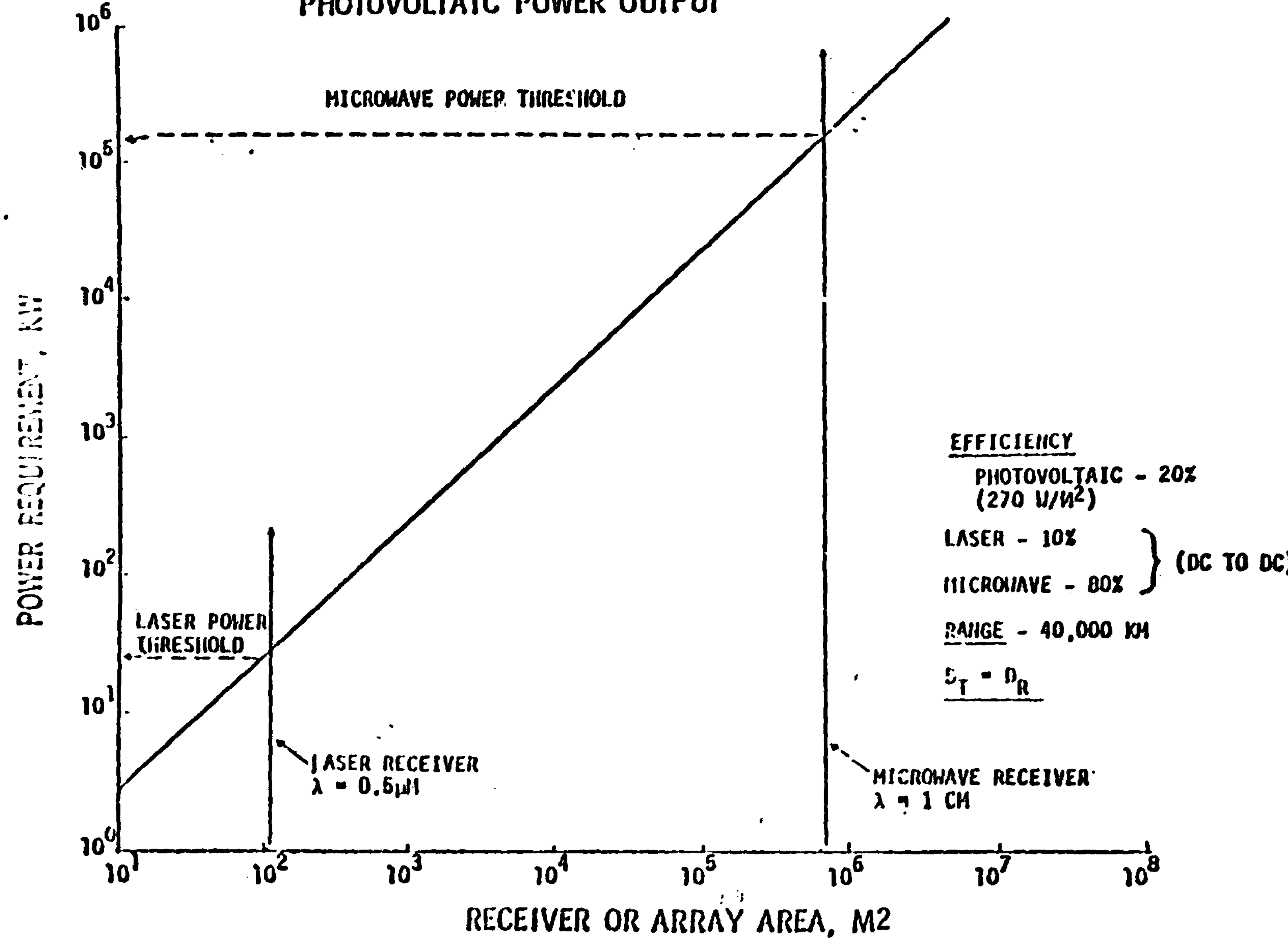



SPACE POWER DEVELOPMENT
1,000,000
100,000
10,000
1,000
100
10
1
.1
.01
OUTPUT POWER, K WE
NUCLEAR FISSION
PHOTOVOLTAIC
SKYLAB
SEPS
SCB POWER AUGMENTATION
MULTI-KW ORBITAL POWER INITIATIVE
MHD
5MW GEO SPP
500KW LEO SPP
KIPS
RADIOISOTOPE
1970
1975
1980
1985
1990
1995
2000
YEAR OF APPLICATION

TRANSMITTER/RECEIVER SIZES VS RANGE



ON-BOARD VS REMOTE POWER TRADEOFF
PHOTOVOLTAIC POWER OUTPUT

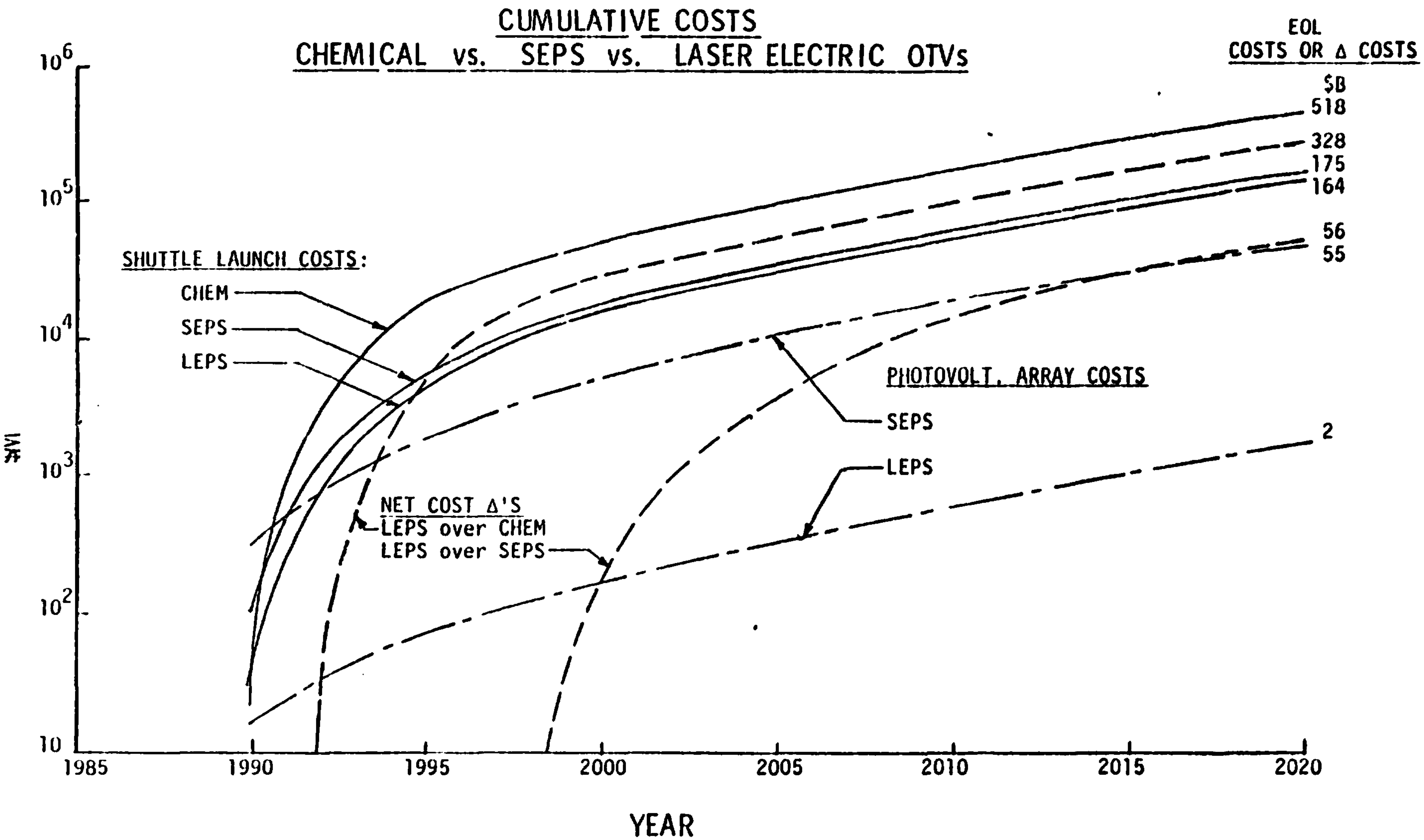


SPACE TO SPACE POWER SYSTEM EFFICIENCIES

POWER XMISSION SYSTEM	DC to DC EFFICIENCY, %		OVERALL SYSTEM EFFICIENCY, %	
	PRESENT	PROJECTED (1990)	PRESENT	PROJECTED (1990)
MICROWAVE	55 *	65	6 (Si Cells) 0.1 (Nuclear Gas Core Reactor)	12 (GaAs Cells) 10-30 (MHD Nuclear Gas Core Reactors)
CONVENTIONALLY POWERED LASERS	2-10 *	5-35	.1 - 3 (Si Cells) .01 (Nuclear Gas Core Reactor)	1 - 6 (GaAs Cells) 4 - 23 (MHD Nuclear Gas Core Reactors)
DIRECT PUMPED LASERS				
o SOLAR CONCENTRATOR	NOT APPLICABLE		NOT ESTIMATED **	1 - 2
o NUCLEAR	NOT APPLICABLE		0.1 - 0.2	25– 35 (Gas Core Reactors)

* MEASURED

** INSUFFICIENT DATA AVAILABLE ON LAZANTS COMPATIBLE WITH SOLAR RADIATION FREQUENCY SPECTRUM



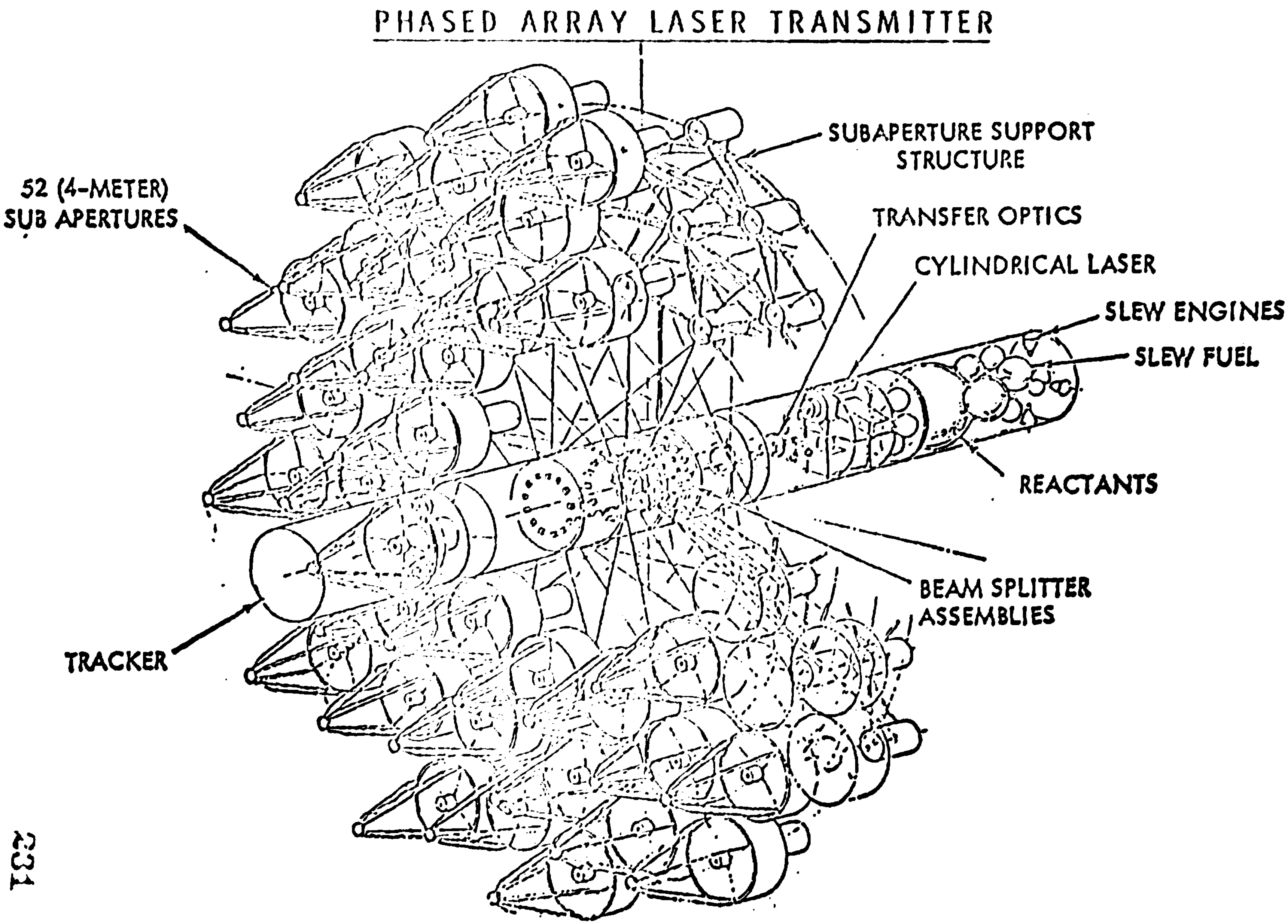
CUMULATIVE COSTS
CHEMICAL vs. SEPS vs. LASER ELECTRIC OTVs
EOL
COSTS OR Δ COSTS
$B
518
328
175
164
56
55
2
SHUTTLE LAUNCH COSTS:
CHEM
SEPS
LEPS
PHOTOVOLT. ARRAY COSTS
SEPS
LEPS
NET COST Δ'S
LEPS over CHEM
LEPS over SEPS
$M
10
10^2
10^3
10^4
10^5
10^6
1985
1990
1995
2000
2005
2010
2015
2020
YEAR

LASER VS SOLAR ELECTRIC PROPULSION

COSTING AND PERFORMANCE DATA

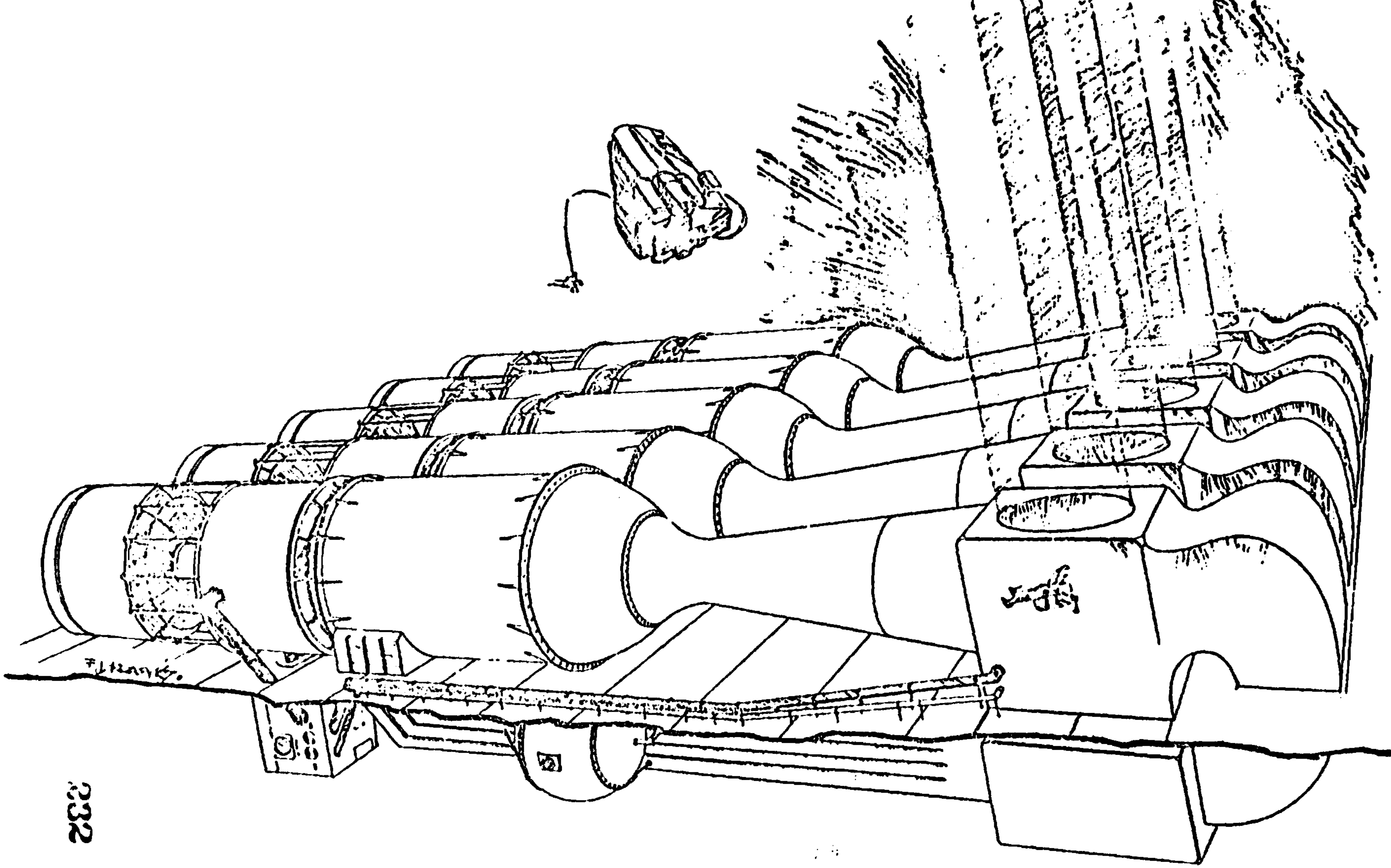
SHUTTLE LAUNCH COSTS	$20M/FLIGHT
PHOTOVOLTAIC ARRAY (GaAs) COSTS ($20-50/WATT)	$25/$\mathrm{WATT}_e$
POWER PLANT R and D COSTS	$1,500M
LASER R and D COSTS	$500M
SPACE BASED POWER SYSTEM COSTS (1 GWe OUTPUT):	
o CONSTRUCTION	$5,000M
o OPERATIONAL (ANNUAL)	$10M
o MAINTANENCE (ANNUAL)	$30M
EFFICIENCIES:	
o SOLAR PHOTOVOLTAIC	20 PERCENT
o LASER PHOTOVOLTAIC	50 PERCENT

LASER FLUX IS 10 TIMES SOLAR FLUX


PHASED ARRAY LASER TRANSMITTER
SUBAPERTURE SUPPORT STRUCTURE
52 (4-METER) SUB APERTURES
TRANSFER OPTICS
CYLINDRICAL LASER
SLEW ENGINES
SLEW/ FUEL
REACTANTS
BEAM SPLITTER ASSEMBLIES
TRACKER

BANK OF HIGH POWER LASERS

(ARTIST'S CONCEPT)



SPACE POWER PLATFORM
CONCLUSIONS

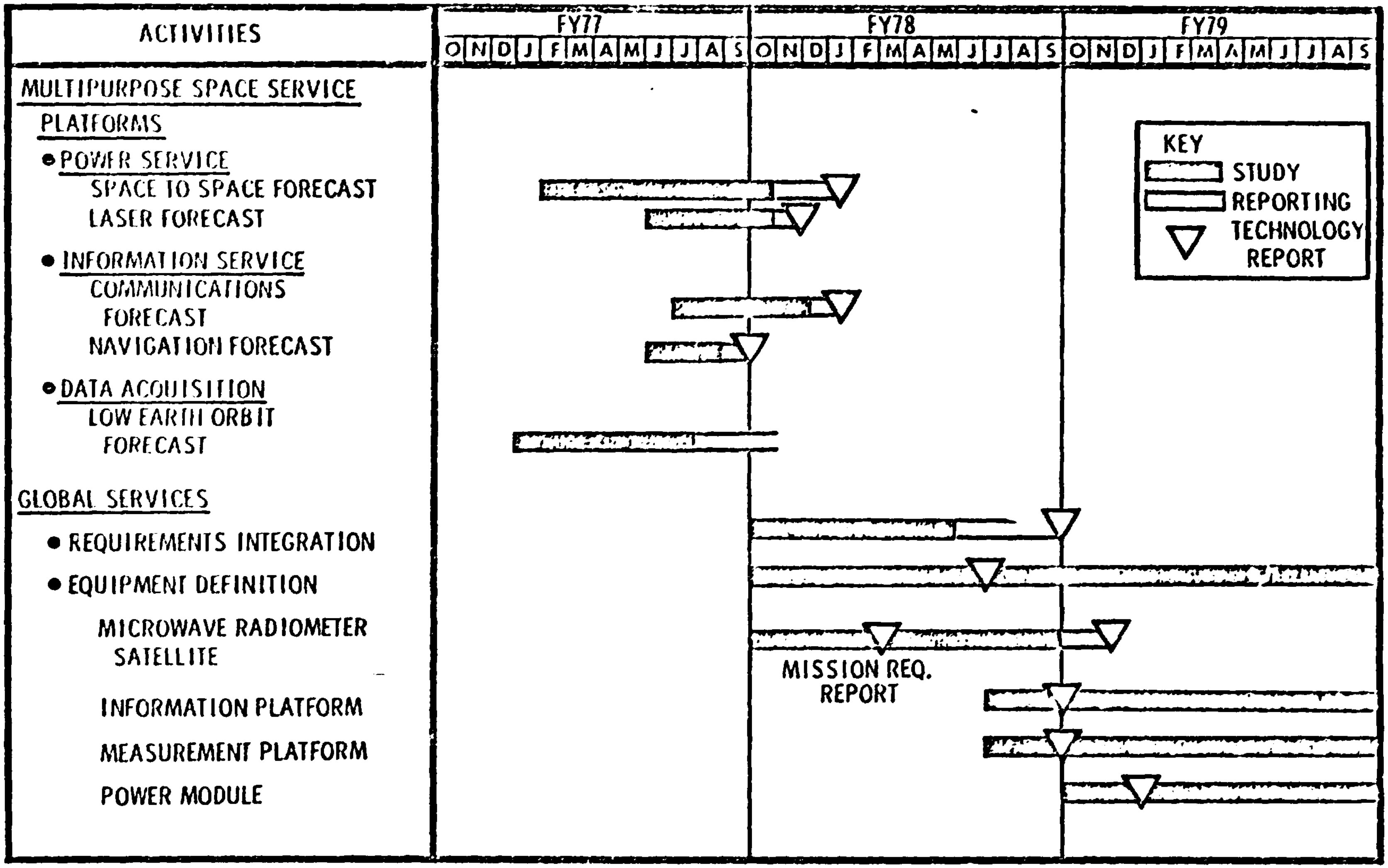
- SYSTEMS ANALYSIS
  - ACCELERATING SYSTEMS: BEST CASE FOR SPACE-TO-SPACE POWER
  - UTILITY SYSTEM: MARKET NOT THERE IN 1995
  - POWER MODULE FOR LARGE (APPROX. 250 KW) ZERO G USERS NEEDS STUDY
  - NEED INTEGRATED TRANSPORTATION SYSTEM STUDY
- STRUCTURES
  - LARGE STRUCTURES WITH LARGE MASS CONCENTRATION
  - FIGURE CONTROL MIRROR ARRAYS
  - RADIATOR DESIGNS
- MATERIALS
  - RADIATION RESISTANT STRUCTURAL MATERIAL
  - HIGH TEMPERATURE MATERIALS MHD AND LASER APPLICATIONS
- CONTROLS
  - POINTING AND FIGURE CONTROL: LASER TRANSMITTER AND RECEIVER
  - ENERGY MANAGEMENT
- POWER
  - LASER: CLOSED CYCLE - LONG LIFE - HIGH POWER
  - NUCLEAR POWER: GAS CORE REACTOR - MHD
  - SOLAR CELLS: HIGH EFFICIENCY - COST REDUCTION-RADIATION RESISTANCE
- PROPULSION
  - LASER POWER THERMAL ENGINE

CONCLUSIONS

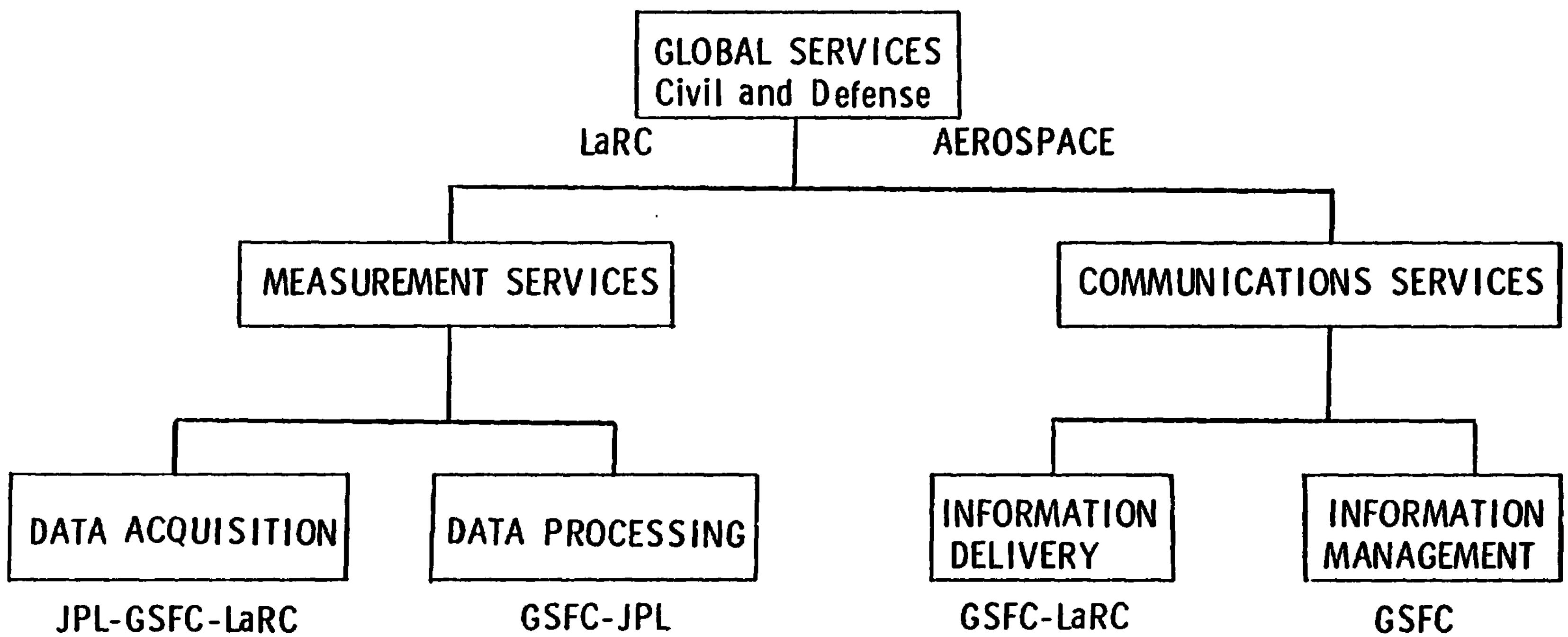
- MAJOR INCREASES IN SPACE POWER LEVELS AND ENERGY NEEDS PROJECTED IN THE 1990'S
- CENTRAL UTILITY CONCEPT ATTRACTIVE ALTERNATIVE TO SOME ON-BOARD SPACE POWER SYSTEMS - HOWEVER, BENEFITS/RISKS/COSTS ASSESSMENTS REQUIRED
- MATURING MICROWAVE TECHNOLOGY; EMERGING LASER TECHNOLOGY
- MAJOR TECHNOLOGY DEVELOPMENT BUDGETS FOR LASERS AND HIGH POWER SYSTEMS ARE IN DOD AND ERDA; HOWEVER, SYSTEMS ARE NOT AIMED AT NASA'S POTENTIAL NEEDS
- LASER TRANSMITTER/RECEIVER SMALL SIZE/MASS COMPARED WITH MICROWAVE
- DIRECT PUMPED NUCLEAR LASER WOULD ENHANCE OVERALL SYSTEMS EFFICIENCY
- LASER GENERATION AND COLLECTION SYSTEMS MAY BE DIFFERENT FOR PROPULSION AND FOR REMOTE ELECTRICAL USERS (E.G., CO, CO_2 FOR THERMAL ENGINES, VISIBLE FOR PHOTOVOLTAIC LASER RECEIVERS)
- POTENTIAL FOR POWER TRANSMISSION IN SPACE

ENABLING TECHNOLOGY STUDIES

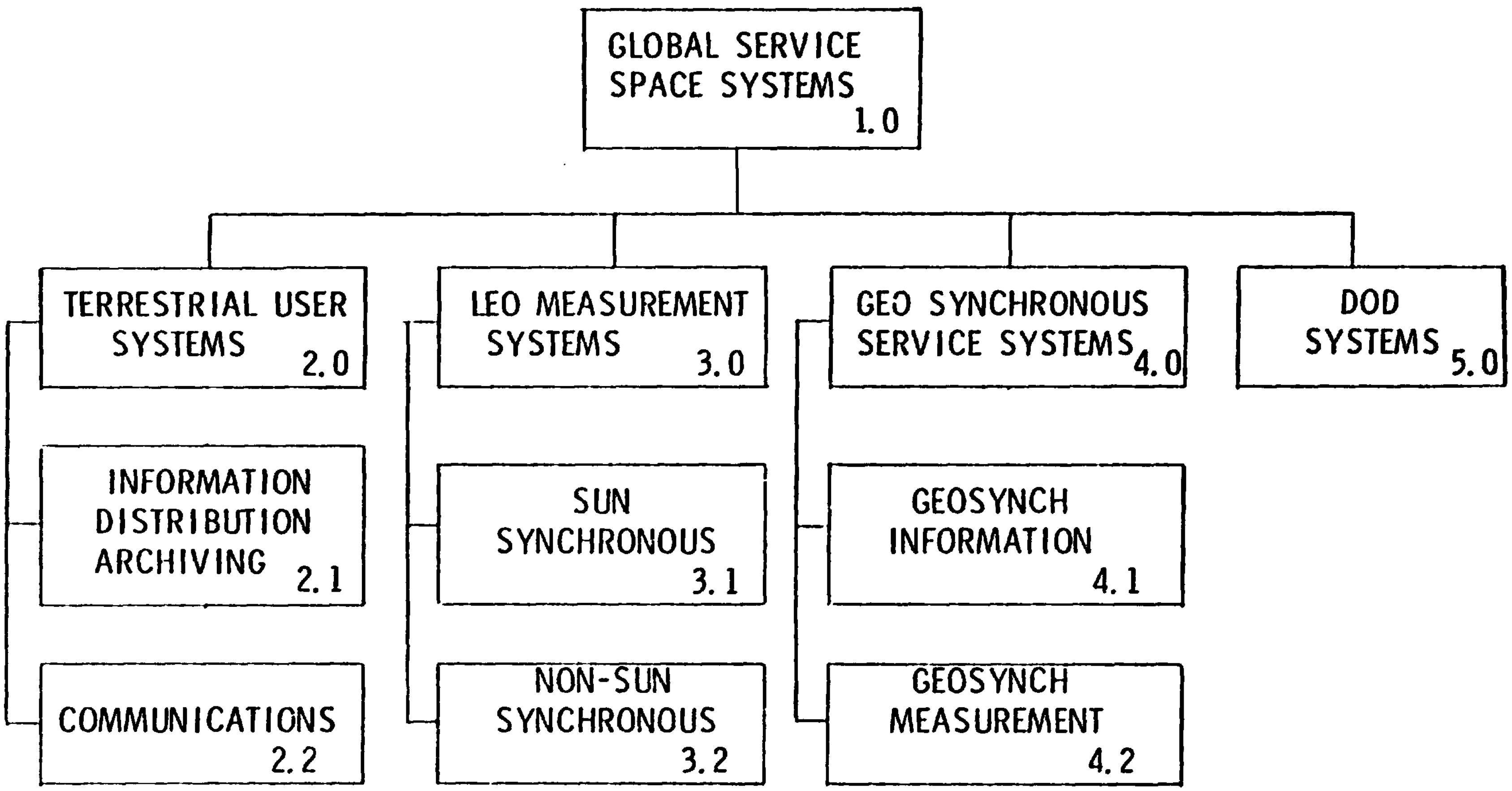
1/10/78



REQUIREMENTS MODEL



EQUIPMENT MODEL



PUBLIC INFORMATION
MANAGEMENT SERVICES SYSTEM, CIRCA 1995

JOINT CENTER STUDY

SPONSORED BY

TECHNOLOGY PLANNING OFFICE

STATUS REVIEW

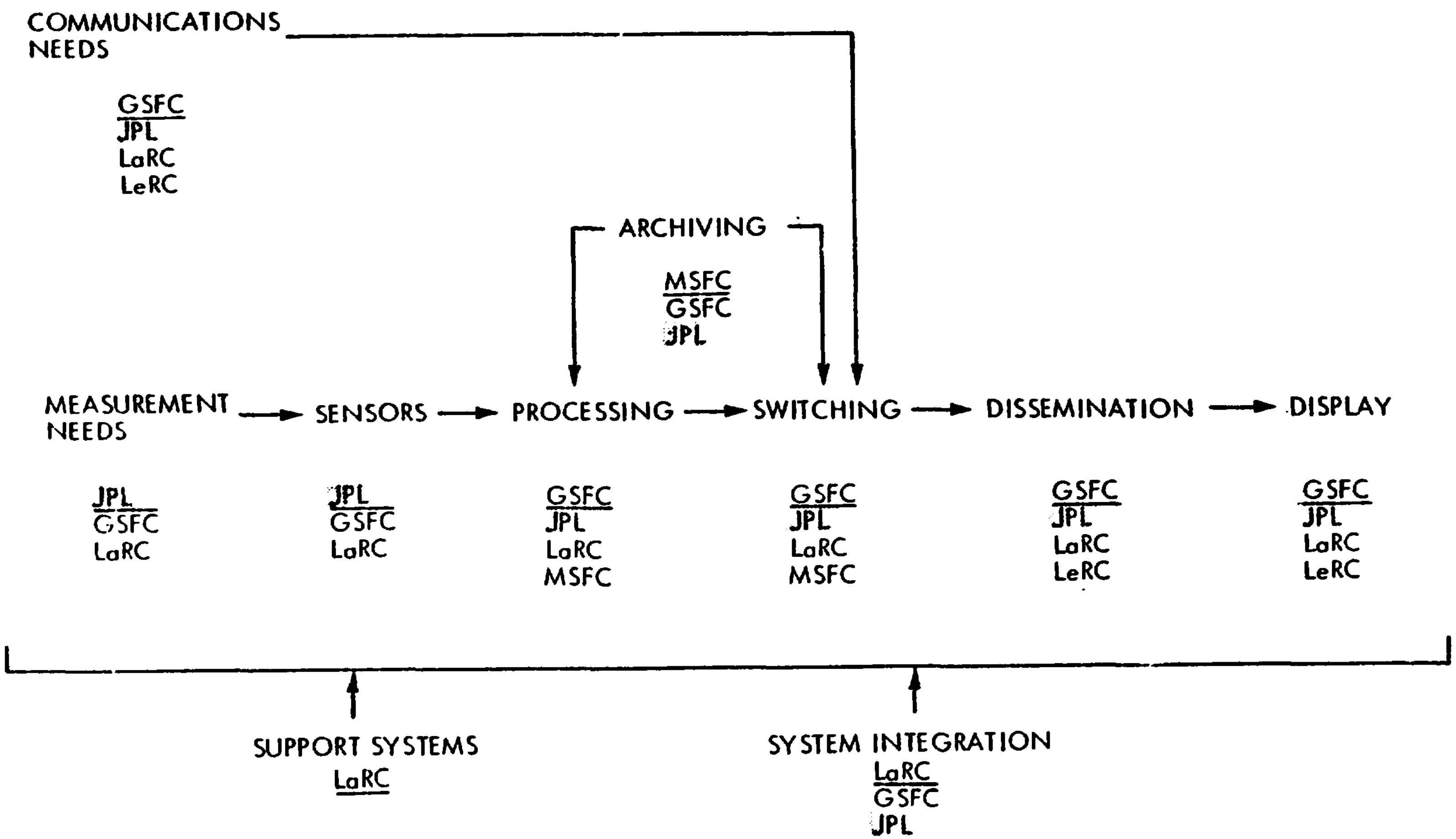
JPL CONTRIBUTIONS

R.G. NAGLER / E.J. SHERRY

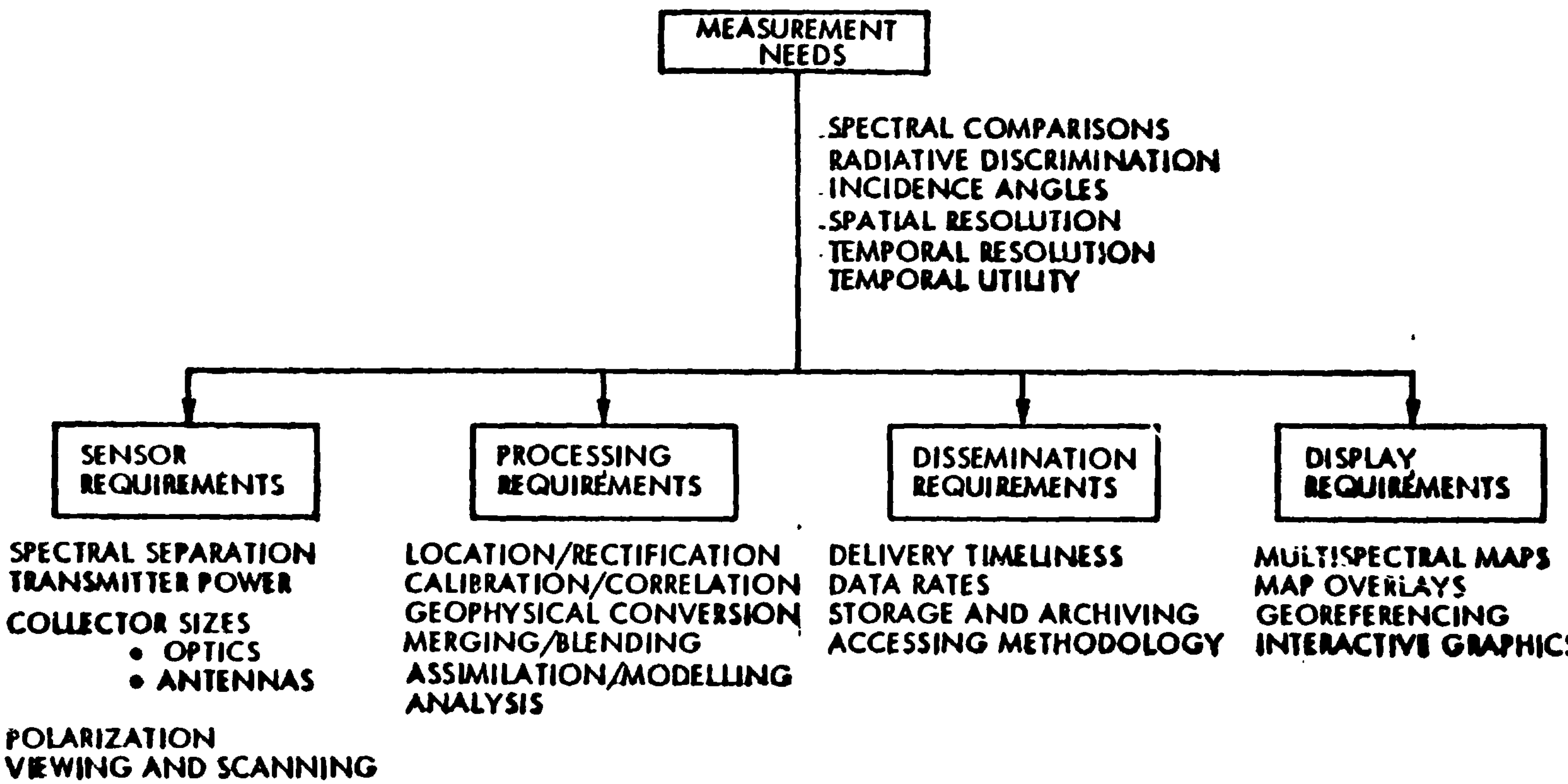
JANUARY 1978

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

STUDY RESPONSIBILITIES



PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM
MAJOR PRESENT JPL ACTIVITIES



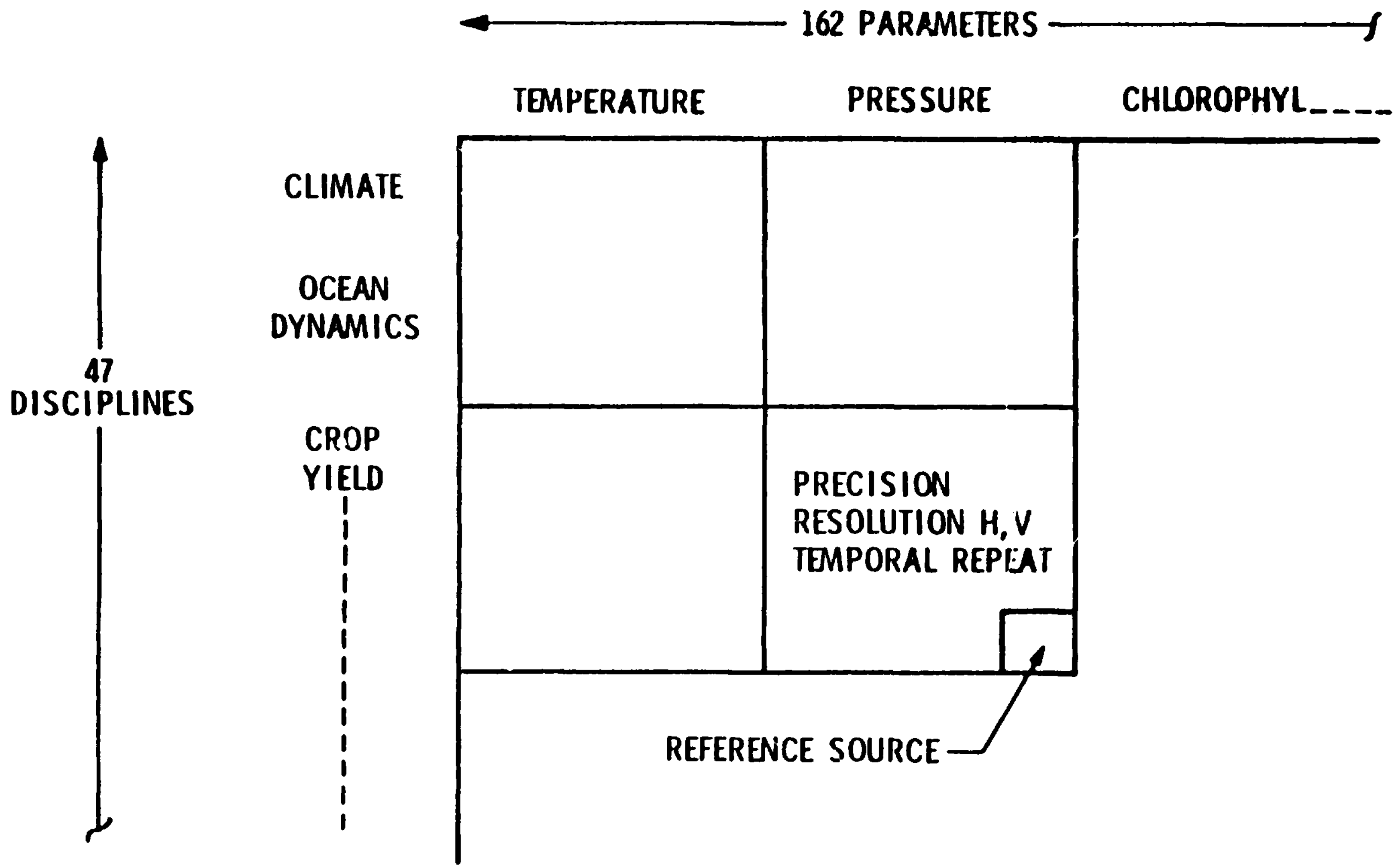
PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

JPL APPROACH

DISCIPLINES ↓	47 IDENTIFIED IN 5 TERRESTRIAL REGIMES
PARAMETERS ↓	162 IDENTIFIED IN 7 MEASUREMENT TYPES
MEASUREMENT NEEDS ↓	MOST DEMANDING CAPABILITY SPECIFIED/ MINIMUM USEFUL VALUE
APPLICABLE SENSORS ↓	46 IDENTIFIED IN 5 X 7 MATRIX
SENSOR REQUIREMENTS ↓	PRESENT CAPABILITY/PROJECTED NEED
PROCESSING, DISSEMINATION & DISPLAY FUNCTIONS	36 FUNCTIONS IDENTIFIED IN 4 FLOW ORIENTATIONS

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

EACH DISCIPLINE HAS DIFFERENT MEASUREMENT REQUIREMENTS



PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

SUMMARIZING MEASUREMENT

RANGE	PRECISION	RESOLUTIONS		
		HORIZONTAL	VERTICAL	TEMPORAL

MOST DEMANDING CAPABILITY REQUESTED/MINIMUM USEFUL VALUE

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

MEASUREMENT OPTIMIZATION DEPENDS ON TYPE OF BALANCE OR TEXTURE PROBLEM UNDER STUDY

	THERMAL BALANCE	CONVECTIVE VALANCE	WATER BALANCE	CHEMICAL BALANCE	BIOLOGICAL BALANCE	TEXTURE	SPECIAL FEATURES
SPACE							
ATMOSPHERE							
WATER							
ICE/SNOW							
LAND							

1. ASSIGN MEASUREMENTS
2. IDENTIFY APPLICABLE SENSING METHODS
3. SELECT IMPLEMENTATION CONCEPTS

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

SELECTING SENSOR IMPLEMENTATIONS WITH AT LEAST SOME CONCEPTUAL BASE

SPECTRAL BANDS	BAND WIDTH	INCIDENCE ANGLES	RESOLUTIONS		SWATH WIDTH	TEMPORAL REPEAT	ORBIT
			HORIZONTAL	VERTICAL			

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

POST-SENSING INFORMATION SERVICES REQUIREMENTS

SERVICE	FUNCTION	CHARACTER
ENGINEERING PREPARATION	DATA PROCESSING	• ONBOARD • ARCHITECTURE • SIZING
EXTRACTION OF GEOPHYSICAL MEANING	INFORMATION EXTRACTION	• GROUND/ONBOARD • ARCHITECTURE • SIZING • FUTURE ORIENTED
INFORMATION DELIVERY	TRANSFER & DESSIMINATION	• DATA RATES • LINK TYPES/NUMBERS
INFORMATION MANAGEMENT	ARCHIVING & ACCESSORY	• DYNAMIC ASSIMILATION • MASS STORAGE • ACCESSIBLE • EFFICIENT SWITCHING
DECISION AID	INFORMATION DISPLAY	• USER PECULIAR

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM
FUTURE JPL ACTIVITIES

REMAINDER OF FISCAL YEAR (100K-1.5 MY)

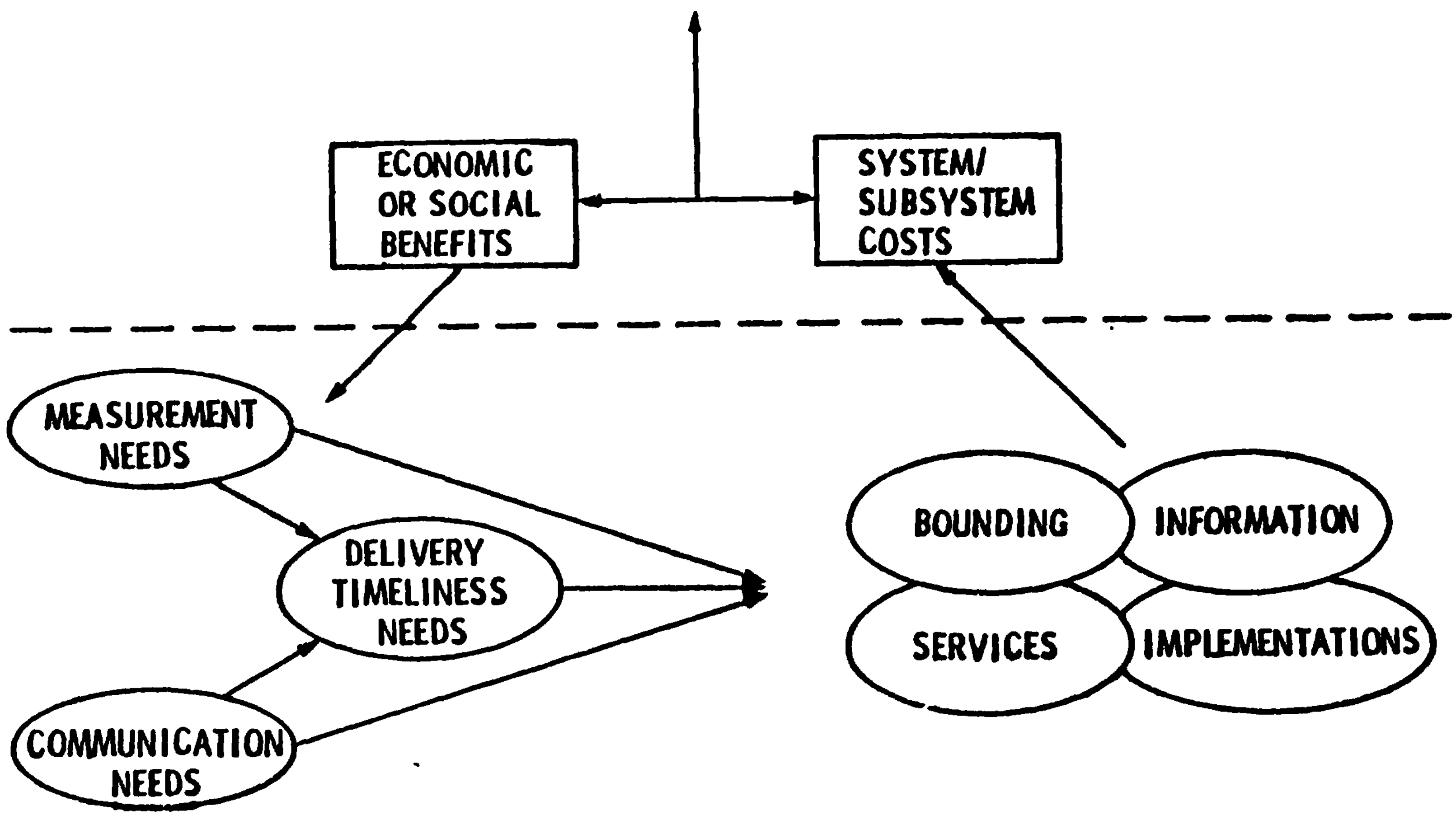
• COMPLETE NEEDS PACKAGE - MEASUREMENT/SENSORS	- BY FEBRUARY
-PROCESSING/DELIVERY	- BY MARCH
• PRELIMINARY SENSOR DESCRIPTIONS	- BY APRIL
• SUPPORT TO DESIGNING/SCOPING SUPPORT CAPABILITIES PROCESSING, SWITCHING, DISSEMINATION, DISPLAY	- JANUARY → APRIL
• TECHNOLOGY OPPORTUNITIES ASSESSMENT	- MARCH → JULY
• INTERIM REPORT	- SEPTEMBER

NEXT FISCAL YEAR (200K-2.0MY + CONTRACT)

• IMPLEMENTATION OPTIONS SELECTION	- OCTOBER
• ALTERNATIVE SYSTEM DESIGN	- OCTOBER → MARCH
• TECHNOLOGY DEVELOPMENT STRATEGIES	- JANUARY → JUNE
• FINAL REPORT	- SEPTEMBER

PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM

TECHNOLOGY DEVELOPMENT STRATEGIES



MEASUREMENT PARAMETERS
MAJOR EARTH APPLICATIONS DISCIPLINES

ATMOSPHERE AND ICE

CLIMATE
UPPER ATMOSPHERE RESEARCH
STRATOSPHERIC CONTAMINATION
LARGE SCALE WEATHER FORECASTS
SMALL SCALE WEATHER FORECAST
WEATHER RESEARCH
TROPOSPHERIC CONTAMINATION
ICE FORECASTS
ICE RESEARCH
GLACEOLOGY

OCEAN

GLOBAL OCEAN CONDITION FORECASTING
COASTAL OCEAN CONDITION FORECASTING
PHYSICAL OCEAN RESEARCH
OCEAN ENGINEERING
MARINE GEOLOGY
OCEAN GEODESY AND BATHYMETRY
LIVING MARINE RESOURCES
BIOLOGICAL OCEAN RESEARCH
OCEAN CONTAMINATION
CHEMICAL OCEAN RESEARCH

BIOLOGICAL LAND USE

SURFACE WATER INVENTORY
SOIL MOISTURE BALANCE
WETLAND MANAGEMENT
FRESH WATER CONTAMINATION
CROP YIELD MANAGEMENT
GRAZING LAND MANAGEMENT
AGRONOMY RESEARCH
FOREST MANAGEMENT
GRASSLANDS MANAGEMENT
FORESTRY RESEARCH

PHYSICAL LAND USE

PHYSIOGRAPHIC MAPPING
SOCIAL/POLITICAL/ECONOMIC MAPPING
CARTOGRAPHY
EARTH GEODESY
LAND USE MANAGEMENT
SOIL MANAGEMENT
ROCK/MINERAL RESOURCE MANAGEMENT
TECTONICS RESEARCH
GEOTHERMAL ANOMOLIES
EARTH GEOPHYSICAL PROPERTIES

MILITARY AND SPECIAL OPERATIONS

TACTICAL AIR FORCE OPERATIONS
STRATEGIC AIR FORCE OPERATIONS
TACTICAL NAVAL OPERATIONS
STRATEGIC NAVAL OPERATIONS
TACTICAL ARMY OPERATIONS
STRATEGIC ARMY OPERATIONS
CIVILIAN NAVIGATION/LOCATION AIDS

MEASUREMENT PARAMETERS

TEMPERATURE/RADIANCE PROPERTIES

1. IONOSPHERE TEMPERATURE PROFILE
2. VERTICAL ATMOSPHERIC TEMPERATURE PROFILE
3. CLOUD TOP TEMPERATURE
4. SURFACE AIR TEMPERATURE
5. SURFACE WATER TEMPERATURE (FRESH-WATER/OCEAN)
6. VERTICAL OCEAN TEMPERATURE PROFILE
7. ICE/SNOW SURFACE TEMPERATURE
8. VERTICAL ICE/SNOW TEMPERATURE PROFILE
9. LAND SURFACE TEMPERATURE
10. VERTICAL LAND TEMPERATURE PROFILE
11. SPECIAL TEMPERATURE ANOMOLIES (FIRE/GEOTHERMAL/INDUSTRIAL/URBAN)
12. CLOUD/ATMOSPHERE ALBEDO
13. WATER ALBEDO (FRESH-WATER/OCEAN/ICE/SNOW)
14. LAND ALBEDO

MEASUREMENT PARAMETERS

ATMOSPHERIC PROPERTIES

1. SEA SURFACE PRESSURE
2. VERTICAL PRESSURE PROFILE
3. SEA SURFACE WIND - AMPLITUDE/DIRECTION (19 m REF)
4. VERTICAL WIND - AMPLITUDE DIRECTION
5. VERTICAL WIND CONVECTIVE DUCTS - LOCATION/SIZING
6. VERTICAL HUMIDITY PROFILE
7. CLOUD EXTENT
8. CLOUD LEVELS AND THICKNESS
9. CLOUD PARTICLE SIZE DISTRIBUTION
10. PRECIPITABLE WATER PROFILE
11. PRECIPITATION EXTENT/AMOUNTS
12. PRECIPITATION FORM
13. PRECIPITATION RATES
14. FOG/MIST VISIBILITY

MEASUREMENT PARAMETERS

ATMOSPHERIC COMPOSITION

1. O_3
2. O
3. OH
4. H_2O
5. CO
6. CO_2
7. H_2CO
8. CH_4
9. C_XH_Y
10. NO
12. N_2O
13. NH_3
14. HNO_3

1. $C\ell$
2. F
3. $C\ell O$
4. $HC\ell$
5. HF
6. $CF_XC\ell_Y$
7. SO_2
8. H_2S
9. AEROSOLS
10. Hg
11. Pb

MEASUREMENT PARAMETERS

OCEAN DYNAMICS

1. ASTRONOMICAL AND STORM TIDES
2. SEA SURFACE WIND SHEAR AMPLITUDE/DIRECTION
3. WAVE HEIGHT AMPLITUDE
4. WAVE LENGTH AMPLITUDE/DIRECTION
5. OCEAN SURFACE CURRENT AMPLITUDE/DIRECTION
6. OCEAN SURFACE CURRENT LOCATION
7. COASTAL/ESTUARY CIRCULATION AMPLITUDE/DIRECTION
8. COASTAL/ESTUARY CIRCULATION LOCATION
9. UPWELLING LOCATION/EXTENT
10. SEDIMENT TRANSPORT LOCATION/EXTENT
11. SEDIMENT TRANSPORT AMPLITUDE/DIRECTION
12. SHOAL/SHORELINE MOVEMENTS
13. COASTAL BATHYMETRY
14. MARINE GEOID

MEASUREMENT PARAMETERS

BIOORIENTED WATER COMPOSITION

1. SURFACE SALINITY CONCENTRATION
2. CHLOROPHYL CONCENTRATION/EXTENT
3. PHYLOPLANKTON TYPE/EXTENT
4. ZOOPLANKTON TYPE/EXTENT
5. ALGAE TYPE/EXTENT
6. OCEAN/LAKE VEGETATION TYPE/EXTENT
7. OCEAN DISEASE VECTOR TYPE EXTENT
8. FISH OIL/BIPRODUCT TYPE/EXTENT
9. FISH OIL/BIPRODUCT THICKNESS
10. FISH IDENTIFICATION/SIZING
11. TURBIDITY
12. SUSPENDED PARTICLE CONCENTRATION/SIZE DISTRIBUTION
13. SEDIMENTATION RATE

MEASUREMENT PARAMETERS

POLLUTANT-ORIENTED WATER COMPOSITION

1. DISSOLVED NUTRIENTS/SOLIDS - CONCENTRATIONS
2. DISSOLVED OXYGEN - CONCENTRATION
3. HEAVY METAL TYPE/CONCENTRATION/PROFILE
4. ACID/BASE BALANCE - PH
5. CHEMICAL POLLUTANT - TYPE/CONCENTRATION/EXTENT
6. PETROLEUM POLLUTANT - TYPE/EXTENT
7. PETROLEUM POLLUTANT - THICKNESS
8. PESTICIDE POLLUTANT - TYPE/EXTENT
9. COLIFORM - BACTERIA/SEWAGE-LOCATION/EXTENT
10. RADIOACTIVE WASTE - TYPE/STRENGTH/EXTENT

MEASUREMENT PARAMETERS

ICE

1. ICE/SNOW EXTENT
2. ICE/SNOW FRACTION
3. SEA ICE DRIFT RATE
4. ICE DEFORMATION RATE
5. ICE THICKNESS
6. SNOW DEPTH
7. ICE TOP SURFACE ROUGHNESS
8. ICE BOTTOM SURFACE ROUGHNESS
9. WATER EQUIVALENCY OF SNOW
10. ICE AGE
11. ICE LEAD LOCATION/SIZING
12. CREVASSE LOCATION/SIZING
13. ICEBERG LOCATION/SIZING
14. ICEBERG FORMATION RATE

MEASUREMENT PARAMETERS
LAND WATER

1. FRACTION OCEAN / FRESH-WATER / ICE / SNOW / LAND / VEGETATION
2. SOIL MOISTURE CONTENT / PROFILE
3. LAKE / RESERVOIR / RIVER / CANAL EXTENT
4. LAKE / RESERVOIR DEPTH
5. WETLANDS EXTENT
6. IRRIGATION EXTENT
7. DROUGHT INDEX
8. SOIL SLOPE AND DRAINAGE
9. TOPSOIL TRANSPORT
10. DEPTH OF WATER TABLE
11. PERCENT SATURATION OF VADOSE ZONE
12. WATER EVAPORATION RATE
13. ICE / SNOW SUBLIMATION RATE

MEASUREMENT PARAMETERS

LAND VEGETATION

1. VEGETATION EXTENT/TYPE (CROPS, WEEDS, TREES, GRASS, etc)
2. PLANT DENSITY/SIZING/MATURITY (CROPS, TREES)
3. PLANT VIGOR/GROWTH RATE
4. PLANT WATER STRESS/MOISTURE CONTENT
5. PLANT DISEASE STRESS EXTENT/TYPE
6. VEGETATION DAMAGE EXTENT/TYPE (GRAZING, INFESTATION, ICE, FROST, OVERFERTILIZATION, FIRE, etc)
7. CULTIVATION INTENSITY/EXTENT/METHOD
8. CHEMICAL/PESTICIDE CONCENTRATION/EXTENT/IDENTIFICATION
9. FUEL MOISTURE/COMBUSTIBLES AVAILABILITY
10. PLANT PHENOLOGY

MEASUREMENT PARAMETERS

LAND GEOLOGY/MINEROLOGY

1. GEOLOGICAL FORMATION MAPPING
2. SURFACE CHARACTER/ROUGHNESS
3. MINERAL IDENTIFICATION/LOCATION
4. MINING/DRILLING LAND USE
5. SOIL/ROCK COMPOSITION
6. SOIL POROSITY
7. SOIL PERMEABILITY
8. SOIL GRANULARITY
9. SOIL SALINITY CONCENTRATION
10. SOIL ACID BASE BALANCE/SOIL CHEMISTRY
11. SOIL ORGANIC CONTENT
12. TOPSOIL DEPTH
13. SOIL MECHANICAL PROPERTIES
14. RADIOACTIVE NUCLIDES - TYPE/STRENGTH/EXTENT

MEASUREMENT PARAMETERS

EARTH PHYSICS

1. SOLAR CONSTANT
2. RADIATION BUDGET
3. CRUSTAL SHIFTS (CONTINENTAL DRIFT)
4. CRUSTAL BULGES/SURFACE TOPOGRAPHY
5. MAGMA TRANSPORT RATE
6. EARTH SPAN RATE WOBBLE
7. EARTH SPIN AXIS WOBBLE
8. MAGNETIC FIELD STRENGTH
9. GRAVITY FIELD STRENGTH
10. TRAPPED PARTICLE ENERGY DISTRIBUTION/EXTENT
11. X RAY ENERGY DISTRIBUTION
12. γ RAY ENERGY DISTRIBUTION

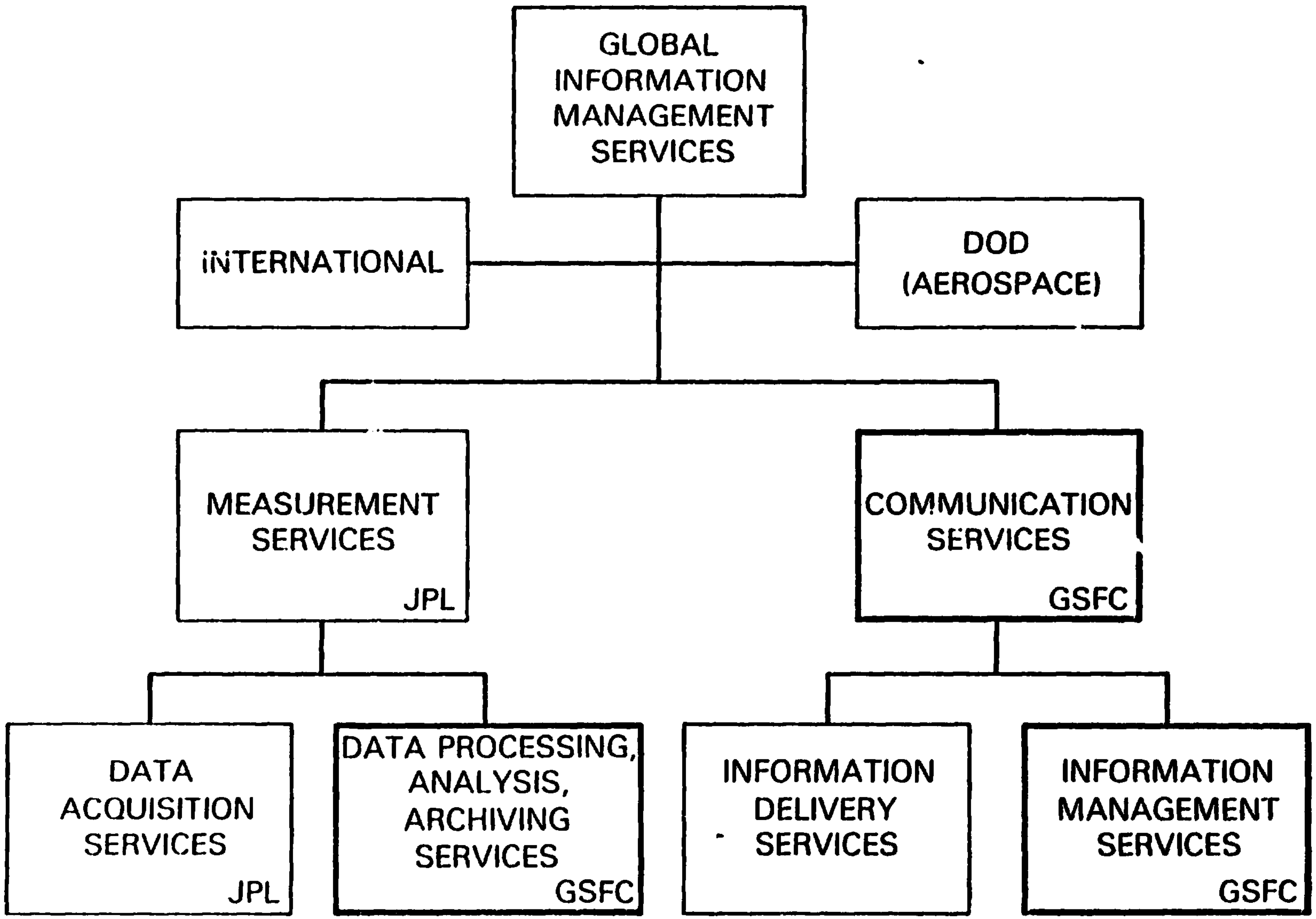
MEASUREMENT PARAMETERS
MISCELLANEOUS

1. URBAN LAND USE FRACTIONS - POWER/TRANSPORT/INDUSTRY/DISTRIBUTION/LIVING
2. SEARCH AND RESCUE
3. SHIP LOCATION/SIZING/IDENTIFICATION/ACTIVITY DETERMINATION
4. AIRPLANE LOCATION/SIZING/IDENTIFICATION/ACTIVITY DETERMINATION
5. AUTO/TRUCK/TANK LOCATION/SIZING/IDENTIFICATION/ACTIVITY DETERMINATION
6. SPACECRAFT LOCATION/SIZING/IDENTIFICATION/ACTIVITY DETERMINATION
7. WAR LOCATION/SIZING/IDENTIFICATION
8. NUCLEAR POWER STATION LOCATION/SIZING
9. SOLID WASTE IDENTIFICATION/EXTENT

GOAL/MIN USEFUL RESOLUTION - H, V TEMPORAL REPEAT [ ] ← REFERENCE SOURCE

DISCIPLINE \ PARAMETER	IONOSPHERE TEMPERATURE PROFILE	VERTICAL ATMOSPHERIC TEMPERATURE PROFILE	CLOUD TOP TEMPERATURE	SURFACE AIR TEMPERATURE (6M LEVEL)	SURFACE WATER TEMPERATURE (OCEAN & FRESH WATER)	VERTICAL OCEAN TEMPERATURE PROFILE	ICE/SNOW SURFACE TEMPERATURE	VERTICAL ICE/SNOW TEMPERATURE PROFILE	LAND SURFACE TEMPERATURE	VERTICAL LAND TEMPERATURE PROFILE	SPECIAL TEMPERATURE ANOMOLIES (FIRE, GEOTHERMAL, VOLCANO, URBAN, INDUSTRY)	CLOUD/ ATMOSPHERE ALBEDO	WATER ALBEDO (OCEAN, FRESH-WATER, ICE, SNOW)	LAND ALBEDO
RANGE				-40 TO 35° C	-2 TO 35° C	-2 TO 35° C								
CLIMATE		1/2° C 500 km, 200 mb 1-2 DAYS [1]	1/2° C 500 km [1]	0.2/1° C 200 km DAILY [2]	0.1/1° C 200 TO 500 km 1 TO 3 DAYS [1,2]	0.2/1° C VARIABLE MONTHLY [1]						2/4 % 500 km MONTHLY [1]	3/3 % 500 km MONTHLY [1]	3/3 % 500 km MONTHLY [1]
UPPER ATOMOSPHERE RESEARCH														
STRATOSPHERIC CONTAMINATION														
LARGE SCALE WEATHER FORECASTS		0.25/1° C 25 km, 1 km [2]		0.1/1° C 100 TO 200 km 2/DAY [2]	0.25/1° C 100 TO 200 km DAILY [2]									
SMALL SCALE WEATHER FORECASTS		0.1/0.5° C 1 km, 1 km [2]		0.1/0.5° C 1 TO 100 km 2 TO 10/DAY [2,8]	0.1/1°C 100 TO 200 km 2/DAY [2,8]							0.2% 10 km [2]		
WEATHER RESEARCH														
TROPOSPHERIC CONTAMINATION														
ICE FORECASTS				0.1/0.5 10 TO 100 km DAILY [2]	0.25/0.5° C 25 TO 200 km DAILY [2]									
ICE RESEARCH				0.1/0.5°C 10 TO 100 km DAILY [2]										
GLACIOLOGY														

GLOBAL SERVICES



GLOBAL SERVICES

GSFC TASKS

- COMMUNICATIONS SERVICES
  - USER COMMUNICATIONS NEEDS
  - DELIVERY SYSTEM
- INFORMATION MANAGEMENT SYSTEM
  - DATA PROCESSING/ANALYSIS
  - INFORMATION MANAGEMENT
  - ARCHIVING

GSFC SUB-TASKS (1)

COMMUNICATIONS

- REVIEW POTENTIAL COMMUNICATIONS NEEDS IN EXISTING USER DOCUMENTATION INCLUDING THAT DEVELOPED IN THE PSCTS PROGRAM.
- OBTAIN ADDITIONAL INPUT FROM OTHER AVAILABLE SOURCES.
- FILTER, APPLY JUDGEMENT TO INPUTS, DEVELOP REFINED SET OF REQUIREMENTS.
- COORDINATE COMMUNICATIONS REQUIREMENTS WITH LARC, LERC, MSFC.
- DOCUMENT REQUIREMENTS. SUPPLY AS INPUT TO INFORMATION MANAGEMENT SUB-TASK.
- DEVELOP & DEFINE COMMUNICATIONS SYSTEM CONCEPT TO MEET REQUIREMENTS.
- IDENTIFY TECHNOLOGY REQUIREMENT OPTIONS FOR COMMUNICATIONS SYSTEM.
- EVALUATE IDENTIFIED TECHNOLOGIES FOR READINESS IN ~1995 TIME-FRAME.

GSFC SUB-TASKS (2)

INFORMATION MANAGEMENT

- REVIEW CURRENT TECHNOLOGY IN BOTH GROUND & SPACE SYSTEM DATA PROCESSING, ANALYSIS AND DATA STORAGE.
- USE SENSOR & COMMUNICATION DOCUMENTATION TO DEVELOP & DEFINE INFORMATION MANAGEMENT SYSTEM. INCLUDE COMPUTER TECHNOLOGY FOR PROCESSING AND ANALYSIS, DATA STORAGE AND SWITCHING, ROUTING AND BILLING PROCEDURES.
- IDENTIFY TECHNOLOGY REQUIREMENT OPTIONS FOR THE INFORMATION MANAGEMENT SYSTEM.
- EVALUATE IDENTIFIED TECHNOLOGIES FOR READINESS IN ~1995 TIME-FRAME.

SCHEDULE, FUNDING, MANPOWER

SCHEDULE

o INTER-CENTER ORGANIZATION MEETING	15-16 DEC 77
o SOW/PR PACKAGES COMPLETE	27 JAN 78
o TASK ORDER AWARDS	24 FEB 78
o COMMUNICATIONS REQUIREMENTS DOCUMENTED	21 APR 78
o FINAL REPORTS BOTH SUB-TASKS COMPLETE	18 AUG 78

FUNDING

o COMMUNICATIONS SUB-TASKS	35K
o INFORMATION MANAGEMENT SUB-TASK	55K

MANPOWER

o COMMUNICATIONS	0.5MY
o INFORMATION MANAGEMENT	0.5MY

ADVANCED JPL APPLICATIONS MISSIONS
SUGGESTED TECHNOLOGY PLANNING TASKS FY79

1. FOLLOWON TO PUBLIC INFORMATION MANAGEMENT SERVICES SYSTEM
   - MULTIPLE SYSTEM IMPLEMENTATIONS TO SCOPE TECHNOLOGY
   - TECHNOLOGY DEVELOPMENT STRATEGIES
   - TECHNOLOGY ENABLEMENT
2. POLESITTER
   - GEOSTATIONARY SATELLITE OVER POLE
   - TECHNOLOGY READINESS
   - TECHNOLOGY ENABLEMENT
3. EARTH BASED APPLICATIONS MISSIONS TECHNOLOGY READINESS/ENABLEMENT
   - AIRCRAFT TECHNOLOGY ENABLEMENT TO MAKE COMPETITIVE FOR SOME MISSIONS
   - BALLOON TECHNOLOGY READINESS/ENABLEMENT FOR LOCAL MONITORING MISSIONS
   - DRIFTING BUOY TECHNOLOGY READINESS FOR LOW-COST, DISPOSABLE, SATELLITE RELAY IMPLEMENTATION
4. MULTISPECTRAL IMAGING RADAR TECHNOLOGY ENABLEMENT STUDY
   - VOIR/SEASAT TECHNOLOGY READINESS FOLLOWON
   - MULTIBEAM IMPLEMENTATION ENABLEMENT
   - MULTISPECTRAL, MULTIVIEW ANGLE IMPLEMENTATION ENABLEMENT

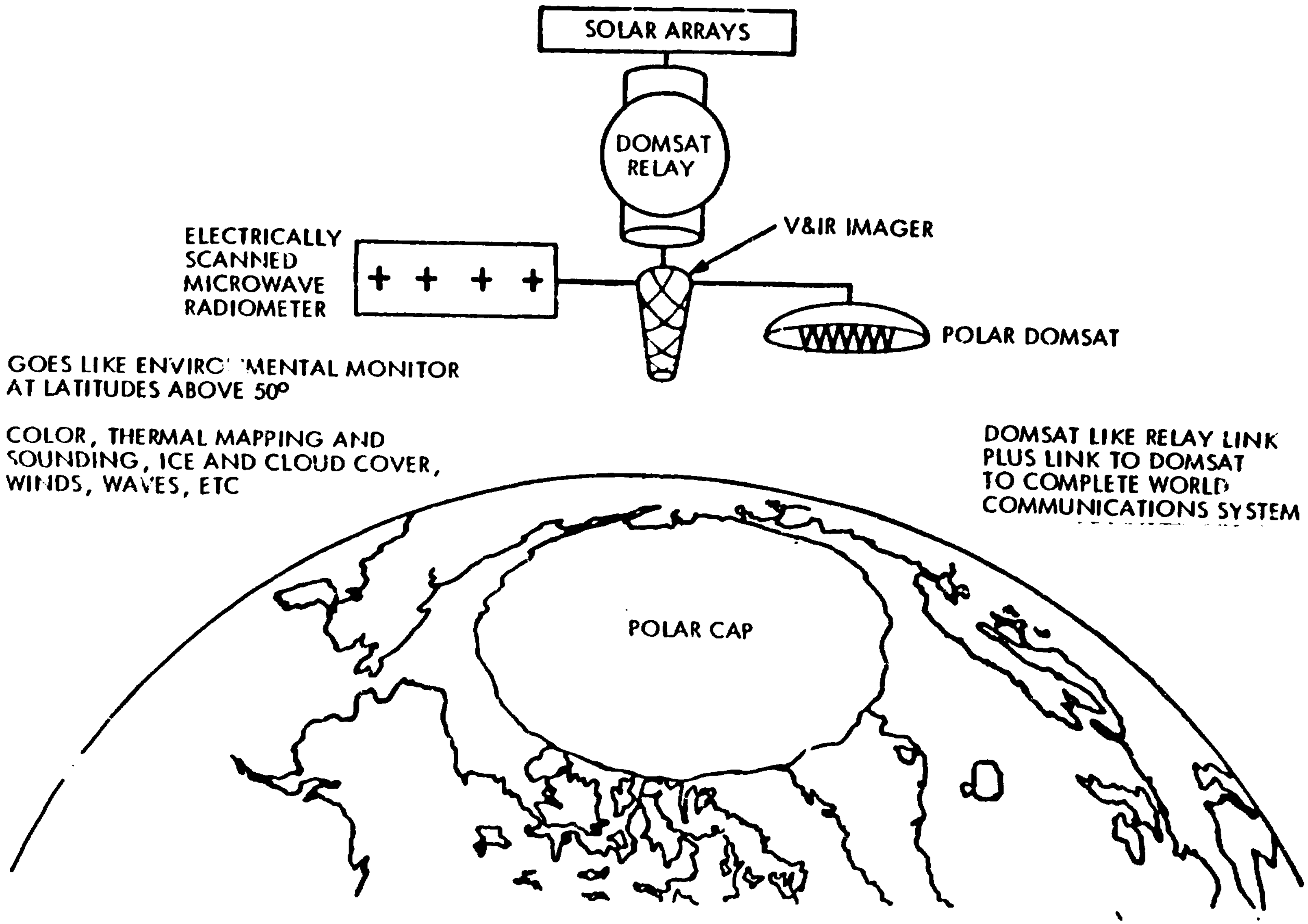
POLESITTER
(GEOSTATIONARY OVER EARTH SPIN AXIS)

TECHNOLOGY - READINESS/
TECHNOLOGY - ENABLEMENT
STUDY

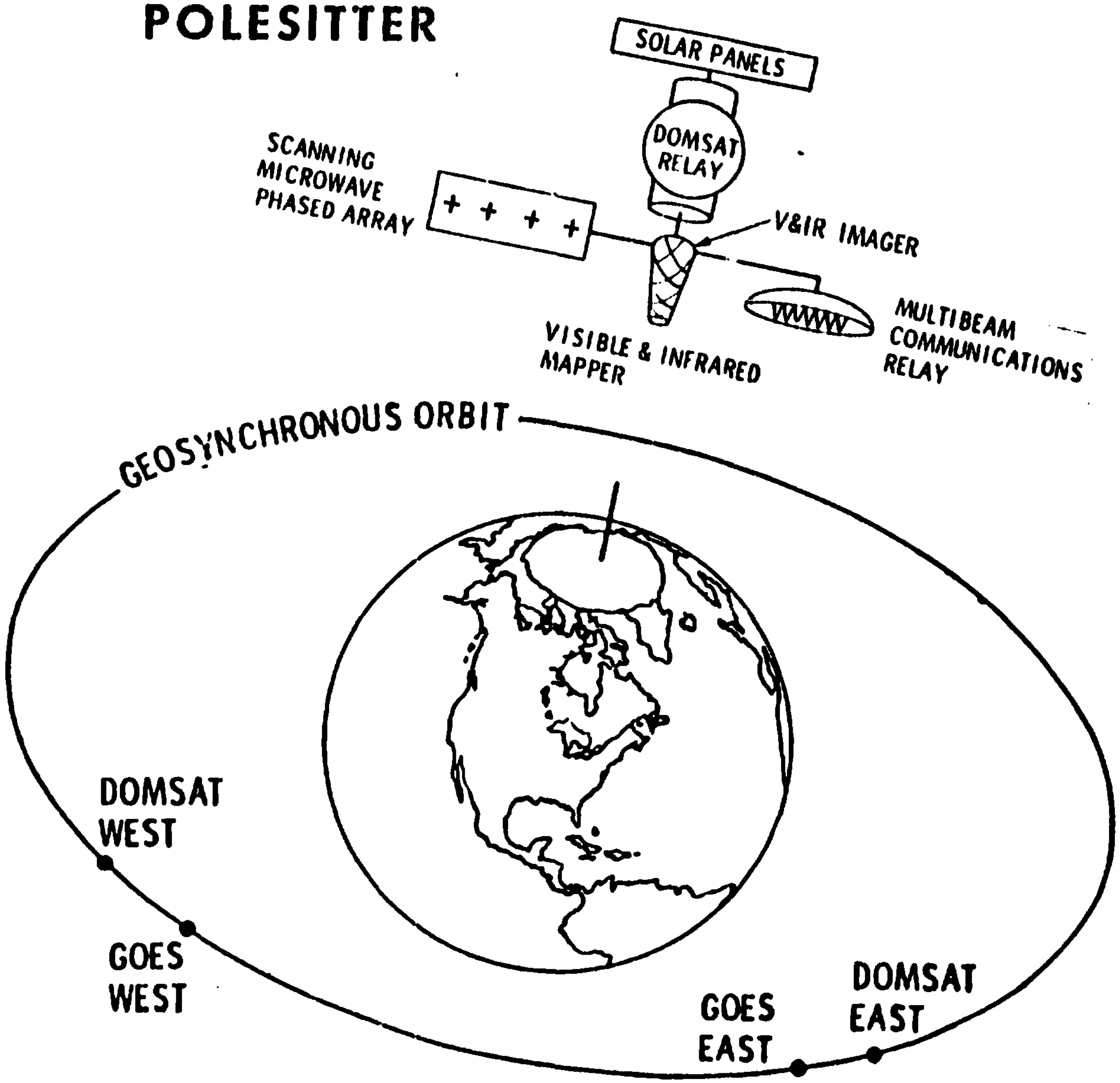
JET PROPULSION LABORATORY

JANUARY 1978

POLESITTER


SOLAR ARRAYS
DOMSAT RELAY
V&IR IMAGER
ELECTRICALLY SCANNED MICROWAVE RADIOMETER
POLAR DOMSAT
GOES LIKE ENVIRONMENTAL MONITOR AT LATITUDES ABOVE 50°
COLOR, THERMAL MAPPING AND SOUNDING, ICE AND CLOUD COVER, WINDS, WAVES, ETC
DOMSAT LIKE RELAY LINK PLUS LINK TO DOMSAT TO COMPLETE WORLD COMMUNICATIONS SYSTEM
POLAR CAP

POLESITTER



SOLAR PANELS
DOMSAT RELAY
SCANNING MICROWAVE PHASED ARRAY
V&IR IMAGER
VISIBLE & INFRARED MAPPER
MULTIBEAM COMMUNICATIONS RELAY
GEOSYNCHRONOUS ORBIT
DOMSAT WEST
GOES WEST
GOES EAST
DOMSAT EAST

WHY POLESITTER

- ACTS LIKE GOES FOR CONTINUOUS MONITORING OF POLAR WEATHER, OCEAN, AND ICE CONDITIONS
    - ORBIT FEASIBILITY STUDY IN PROGRESS - OSTA FUNDING
    - SENSOR PAYLOAD OPTIONS STUDY IN PROGRESS - OSTA FUNDING
- ACTS LIKE DOMSAT TO COMPLETE COMMUNICATIONS LINKS AT HIGH LATITUDES
    - LINK OPTIONS STUDY TO BE PROPOSED TO OSTA IN FY '79
- PROVIDES IMPORTANT 3RD DIMENSION FOR GLOBAL NAVIGATION
    - TO BE STUDIED

HOW POLESITTER

- ACTIVE PROPULSION SYSTEM USED TO HOLD SPACECRAFT IN POSITION - DYNAMIC SUN ORBIT PRECESSION, EARTH/MOON GRAVITY ATTRACTION
  - SOLAR MOST LIKELY INIT. L CANDIDATE
  - ALTERNATIVE PROPULSION SYSTEMS FOR LOW LEVEL STUDY
    - NUCLEAR ELECTRIC
    - SOLAR SAIL
    - SUPER CONDUCTING RING

POLESITTER

TECHNOLOGY READINESS

- EQUILIBRIUM POSITION USING EXISTING SOLAR ELECTRIC PROPULSION TECHNOLOGY
- GROUND RESOLUTION CAPABILITIES FROM AVAILABLE SENSOR OPTICS TECHNOLOGY

TECHNOLOGY ENABLEMENT

- INVESTMENT NEEDED TO BRING EQUILIBRIUM ALTITUDE CLOSER TO EARTH
- INVESTMENT NEEDED TO INCREASE OPTICS SIZES
- BEST INVESTMENT COMBINATIONS TO ACHIEVE NECESSARY MONITORING RESOLUTIONS

MAJOR CHARACTERISTICS OF POLESITTER
(SPECULATIVE FEASIBILITY - UNDER STUDY)

USER ORIENTATION

- INTERNATIONAL OPERATIONS/RESEARCH NEEDS EMPHASIZED
  - ARCTIC OIL OPERATIONS, FISHERIES MANAGEMENT, ARCTIC TRANSPORTATION
  - INTERNATIONAL ECONOMIC/SOCIAL BENEFIT ORIENTED
  - ICE/SNOW/GLACIER EXTEN, THICKNESS, AGE, DEFORMATION PATTERNS PLUS TEMPERATURES AND WINDS
  - ALL WEATHER
  - FUNCTIONS LIKE A GOES BUT AT POLE

ORBIT

- ORBIT KEYED TO ARCTIC COVERAGE
  - GEOSTATIONARY OVER POLE USING ACTIVE PROPULSION TO RETAIN POSITION
  - PRESENT TECHNOLOGY ALLOWS LUNAR DISTANCE TO 1/3 LUNAR DISTANCE LOCATION

SENSORS

- SENSOR CANDIDATES
  - V&IR SURFACE MAPPER - LINESCAN OR CCD CAMERA
  - IR SOUNDER
  - MICROWAVE SURFACE MAPPER
  - SPUN SYNTHETIC APERTURE RADAR
  - SWEPT FREQUENCY MICROWAVE MAPPER
  - SWEPT FREQUENCY SCATTEROMETER

INFORMATION EXTRACTION

- DATA-PREPROCESSING/INFORMATION-EXTRACTION CANDIDATES
  - REAL TIME DELIVERY TO CENTRAL SITE
- JOINT INTERNATIONAL FUNDING

EARTH BASED APPLICATIONS MISSIONS TECHNOLOGY READINESS/ENABLEMENT

JET PROPULSION LABORATORY

JANUARY 1978

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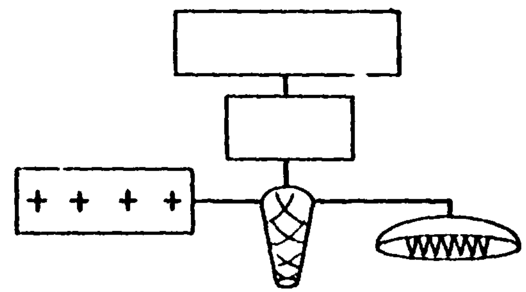
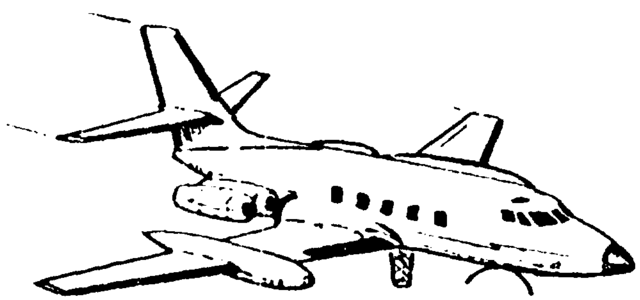
EARTH vs SPACE BASED APPLICATIONS MISSIONS

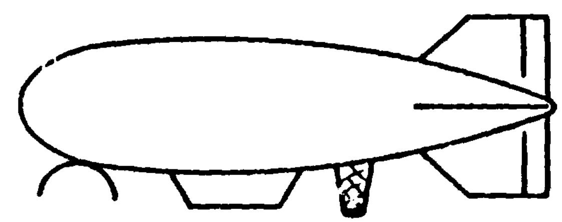
BENEFIT
- RESOLUTION
- SYNOPTICITY
- LOCAL CONTINUITY

COST
- CAPITAL INVESTMENT
- OPERATING EXPENSES

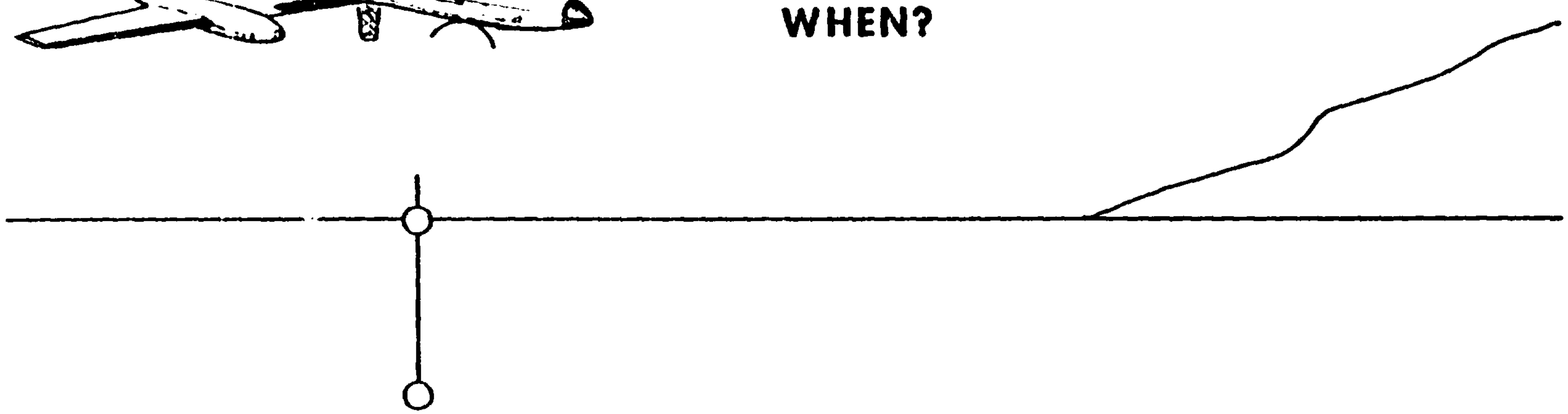




WHICH?



WHEN?



EARTH BASED APPLICATIONS MISSIONS
TECHNOLOGY READINESS/ENABLEMENT QUESTIONS

AIRCRAFT

- FOR WHICH MISSIONS ARE AIRCRAFT COMPETITIVE OR NEAR-COMPETITIVE WITH SPACECRAFT
- HOW DO TECHNOLOGY INVESTMENTS IN ALTITUDE, VELOCITY, MANEUVERABILITY EFFECT THE RELATIVE COMPETITIVENESS ?

BALLOONS/AEROSTATS

- FOR WHICH MISSIONS ARE BALLOONS/AEROSTATS COMPETITIVE OR NEAR-COMPETITIVE WITH SPACECRAFT ?
- HOW DO TECHNOLOGY INVESTMENTS IN TRANSIENT SURVIVAL, STATIONKEEPING, HIGHER ALTITUDES EFFECT THE RELATIVE COMPETITIVENESS ?

BUOYS

- HIGH TECHNOLOGY, SATELLITE RELAY, DISPOSABLE DRIFTING GUOYS ARE AN EXTREMELY IMPORTANT ADJUNCT TO SATELLITE ORIENTED OCEAN RESEARCH ?
- HOW WOULD TECHNOLOGY INVESTMENTS IN LOW COST IMPLEMENTATION EFFECT THE COST VIABILITY OF THESE IMPORTANT SYSTEM COMPONENTS ?

MULTISPECTRAL IMAGING RADAR TECHNOLOGY ENABLEMENT

JET PROPULSION LABPRATORY

JANUARY 1978

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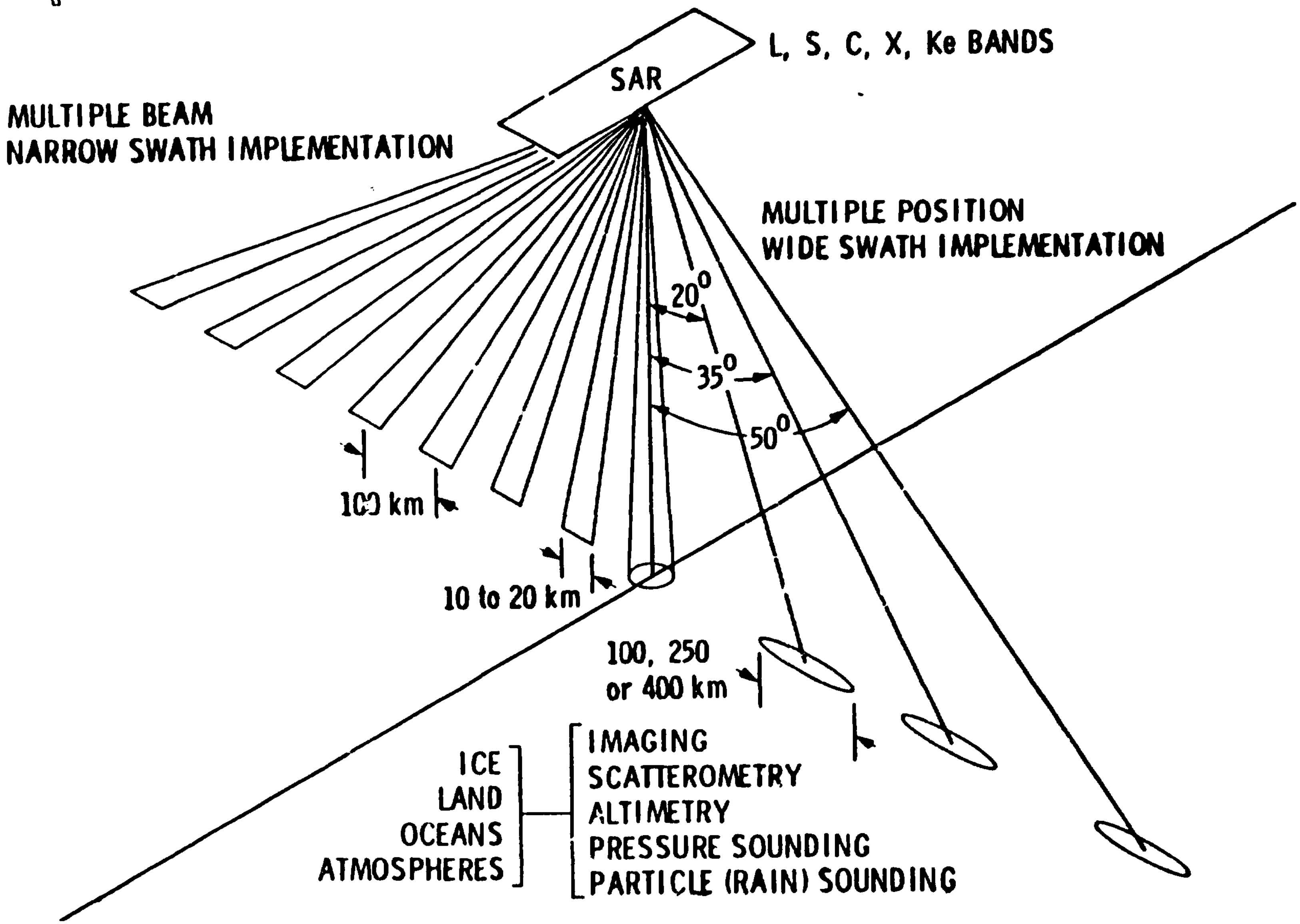
MULTISPECTRAL IMAGING RADAR



MULTISPECTRAL IMAGING RADAR
TECHNOLOGY ENABLEMENT STUDY

NEEDS

- CRITICAL FUTURE SENSOR(S)
- MULTIPLE APPLICATIONS
- MULTIPLE OPTIMIZATIONS

PROBLEMS

- MULTIPLE SPECTRAL CHANNELS NEEDED
- MULTIPLE INCIDENCE ANGLES NEEDED
- MULTIPLE BEAM WIDTHS NEEDED
- IMAGING, ALTIMETRY, SCATTEROMETRY, SOUNDING OPTIMIZES ON DIFFERENT PARAMETERS
- SUPPORT NEEDS DEMANDING/COSTLY
- HOW TO BEST DIRECT A LIMITED FUNDING BASE FOR SENSOR/PROCESSING DEVELOPMENT

SESSION 'A' - APPLICATIONS

SEASAT Follow-On Technology Readiness Study (J. West, JPL)

DISCUSSION: Contact should be made with LeRC on their dynamic power studies. The point was made that for orbit maintenance of LANDSAT-type sun synchronous orbits, electric propulsion could be used; but this study was based on SEASAT-B using available technology.

Technology Readiness for a Global Service Missions (W. Hook, LaRC)

DISCUSSION: None.

Public Service Platform (T. Durnam, GSFC)

DISCUSSION: Future communications requirements and the utilization of more power on these types of satellites was discussed.

Penetrator Concepts (J. Murphy, ARC)

DISCUSSION: Penetrator usage for prospecting was discussed, and the fact that they would be low-cost, nonrecoverable items. This concept is of interest to oil companies and could benefit them. The problem of examining trade-offs was raised, but that was not included in the purpose of this study. Mr. Murphy mentioned that there has been very enthusiastic response to the planned workshop. He also stated that some FY 78 funding, perhaps joint with OSTA, was necessary.

Post-LANDSAT-D Advanced Concept Evaluation (PLACE) (F. Flatow, GSFC)

DISCUSSION: Mr. Flatow suggested a follow-on to look at weather and climate related applications systems.

Enabling Technology for Global Service Missions (W. Hook, LaRC)

DISCUSSION: Mr. Hook stated that the forecasts presented were based on many sources of information. Mr. Aviv mentioned that intense relativistic electron devices (IREDs) should be considered for energy transmission. Art Henderson brought up the lack of OSTA involvement in the preliminary part of this effort.

Public Information Management Services System (R. Nagler, JPL)

DISCUSSION: None.

Global Services (T. Durham, GSFC)

DISCUSSION: None.

Global Services (D. Aviv, Aerospace)

DISCUSSION: Stan Sadin stated that this activity is primarily to serve as a DoD interface. He also mentioned that the purpose of the space studies is to stretch technology, not to push missions for NASA to fund.

According to Mr. Aviv, one of the major common NASA and DoD needs is a manned space service system. However, studies at LeRC claim to show that replacement is cheaper than fix-up for satellites in GEO.

A working group session of the investigators for the previous four studies was to be held on 13 January 1978.

Geostationary Platform (S. Sadin, HQ)

DISCUSSION: In the absence of an MSFC representative to present the status of this OSTA funded study, S. Sadin made some brief remarks. This study was concerned with a possible program for the 1980s which would handle information transfer only. However, there is considerable question whether even such a modest program will be possible at such an early date.

Discussion of FY 79 Plans in Applications

There must be OSTA participation in the multi-Center global services study (LaRC - Lead). This study includes consideration of TDRS follow-on, but the proposed global positioning satellite precludes some of the TDRS follow-on requirements.

R. Nagler presented three JPL ideas: (1) polar stationary satellite for such uses as triangulation, (2) multi-Center study of close-in technology requirements (aircraft, balloons, buoys) instead of satellites for applications purposes similar to the ARC penetrator study, (3) multifunctional uses of radar beyond VOIR, etc.

F. Flatow mentioned the possibility of a cooperative weather and climate program with OSTA. Stan Sadin raised the question as to how (or whether) the PLACE activity should be coupled into the multi-Center global services study; this will be discussed in a future working group meeting.

Marta Cheleski brought up the point that NASA must be aware of, and be concerned about, future economic, political, and socialogical factors (such as user needs) or such things as the global services missions discussed in this session may never occur. Ray Hook said that this problem has received some attention. The related problem of the NASA commitment to and interest in the operational aspects of providing the resulting satellite information was also explored. Stan Sadin commented that he feels that NASA will have to provide an applications operations service for the users.

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OF POOR QUALITY

SECTION 7

SESSION 'S'

REVIEW OF SCIENCE AND EXPLORATION STUDY PROGRAMS

PRESENTATION TO OAST - CODE RX
STUDY, ANALYSIS AND PLANNING OFFICE

SPACEBORNE ANTENNA AND MICROWAVE SYSTEMS TECHNOLOGY STUDY

RTOP No. 790-40-36

FUNDING: FY77 $75K

FY78 $50K

ROBERT E. EDELSON

JANUARY 12, 1978

285

STUDY OBJECTIVES AND STATUS

FOR A 200 TO 300 m SPACEBORNE ANTENNA OPERATING AT 20 TO 300 GHz IN GEOSYNCHRONOUS ORBIT,

- DETERMINE SYSTEM FUNCTIONAL REQUIREMENTS
- DEVELOP SYSTEM SPECIFICATION
- DEVISE CONCEPTUAL SYSTEM DESIGN
- → IDENTIFY CRITICAL REQUIRED TECHNOLOGIES
- o RECOMMEND NASA PROGRAMMATIC APPROACH INCLUDING SYSTEM DEMONSTRATIONS

REE-2
1-3-78

SPACEBORNE ANTENNA AND MICROWAVE
SYSTEMS TECHNOLOGY STUDY

SYSTEM FUNCTIONAL REQUIREMENTS HIGHLIGHTS

- 10 YEAR OPERATIONAL LIFETIME
- 20 TO 300 GHz
- 300 m EQUIVALENT APERTURE DIAMETER
- 100% SKY COVERAGE
- SHUTTLE COMPATIBLE CONCEPT

SENSITIVITY DEMONSTRABLY BETTER THAN THAT ATTAINABLE FROM GROUND

REE-3
1-3-78

SPACEBORNE ANTENNA AND MICROWAVE
SYSTEMS TECHNOLOGY STUDY

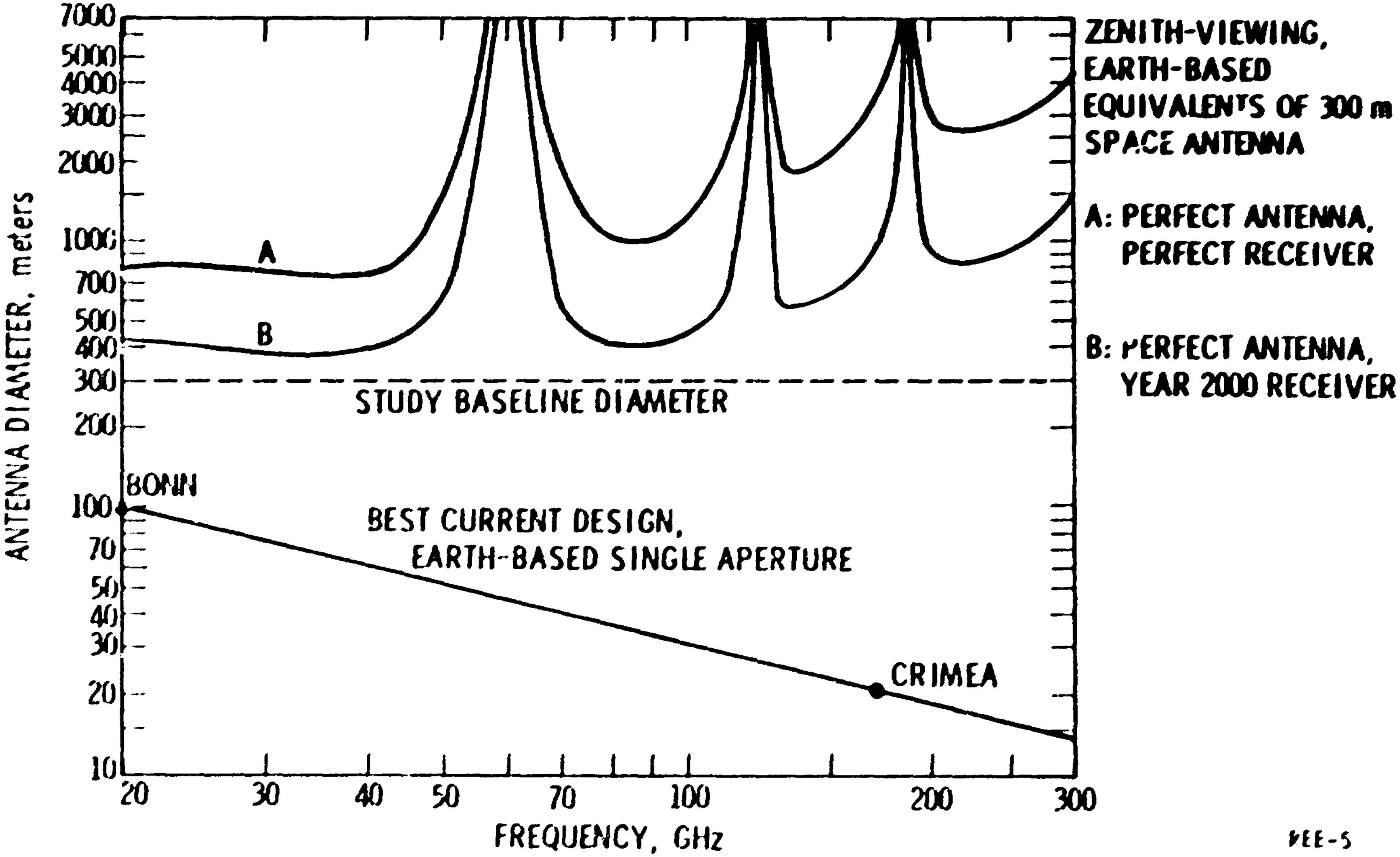
PRINCIPAL TECHNOLOGY CHALLENGES

- LOW NOISE AMPLIFIERS AND ASSOCIATED LONG-LIFE CRYOGENICS
- ARRAY OR ARRAY-REFLECTOR ANTENNA TECHNIQUES FOR BEAM-STEERING
- SHAPE CONTROL INVOLVING DISTRIBUTION OF SENSORS, ACTUATORS AND MICROPROCESSORS OVER ENTIRE STRUCTURE
- THRUSTERS FOR SELF-BOOST OF A FRAGILE STRUCTURE FROM LEO TO GEO
- MATERIAL WITH HIGH STRENGTH/WEIGHT WITH LOW THERMAL COEFFICIENT OF EXPANSION
- DESIGN AND ANALYSIS SOFTWARE
    - MULTI-NODE STRUCTURE OPTIMIZATION
    - LOGISTICS OPTIMIZATION
    - THERMAL ANALYSIS
- ROBOTIC ASSEMBLY OR MANUFACTURING TOOLS

REE-4
3-7

SPACEBORNE ANTENNA AND MICROWAVE SYSTEMS TECHNOLOGY STUDY

RATIONALE



1-3-78

SPACEBORNE ANTENNA AND MICROWAVE SYSTEMS TECHNOLOGY STUDY

CONCLUSIONS

SPACEBORNE ANTENNAS ARE THE ONLY MEANS OF EXTENDING SCIENTIFIC HORIZONS FOR THE MAJORITY OF THE MICROWAVE REGIME

LEADERSHIP BY OAST IS REQUIRED FOR PRODUCING THE ENABLING TECHNOLOGY

TO PERMIT A YEAR 2000 CAPABILITY, THE TECHNOLOGY DEVELOPMENT PLAN SHOULD BE PRODUCED NOW

EXTRASOLAR PLANETARY DETECTION

METHODS:

- IR INTERFEROMETRY (NO FY78 FUNDS)
  - --FY77 STUDY BY BRACEWELL (STANFORD GRANT)
- APODIZED VISUAL TELESCOPE

OBJECTIVES:

- CONCEPT DEVELOPMENT
- TECHNOLOGY REQUIREMENTS
- CRITIQUE OF 1976 NASA/ASEE DESIGN STUDY (PROJECT ORION) APODIZING CONCEPTS

RESOURCES: $50K

CENTER: ARC

CONTACT: DAVID C. BLACK

STATUS

- Sole Source Proposal from Hewlett-Packard received and funded for two years (FY77-78) study on apodization
- Preliminary IR Interferometry Study completed by Bracewell; no FY78 activity at present
- Detailed briefing by Black in January on both IR & Apodization
- Interim Report by H-P in June

PRESENTATION TO OAST-CODE RX

STUDY, ANALYSIS, AND PLANNING OFFICE

PROGRESS REPORT

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY

PART I: VOIR

RTOP No. 790-40-25 (-01)

FUNDING: 75 K FY '77, 20 K FY '78

JOHN L. WEST

JANUARY 12, 1978

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

PRESENTATION OVERVIEW

- STUDY OBJECTIVES
- GUIDELINES
- PRODUCTS
- STATUS

JLW
1/12/78-1

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

STUDY OBJECTIVES

GENERAL

- PROVIDE INFORMATION USEFUL TO NASA IN PLANNING THE ADVANCED DEVELOPMENT PROGRAM AND INSURING ITS RELEVANCE TO AGENCY NEEDS jpl

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

STUDY OBJECTIVES (contd)

SPECIFIC

- PERFORM READINESS ASSESSMENT OF THE VOIR AND SEASAT-B MISSIONS
  - PROVIDES AN EVALUATION OF THE MATURITY AT PROJECT START AND RISKS OF UTILIZATION OF THE TECHNOLOGIES UPON WHICH USER-PROGRAM-OFFICE-DEVELOPED DESIGNS FOR THESE MISSIONS DEPEND
  - PROVIDES A COMPARISON OF THE MATURITY OF THESE TECHNOLOGIES WITH THE MATURITY OF THE TECHNOLOGIES AT PROJECT START OF PREVIOUS JPL MISSIONS TO PLACE IDENTIFIED RISKS IN HISTORICAL PERSPECTIVE
- PERFORM BENEFITS ASSESSMENT FOR THE VOIR AND SEASAT FOLLOW-ON MISSIONS
  - IDENTIFIES, FOR MUTUAL OAST/USER PROGRAM OFFICE CONSIDERATION, POSSIBLE TECHNOLOGY ALTERNATIVES WHICH MAY REDUCE RISK FOR AND/OR ENHANCE THE USER-PROGRAM-OFFICE-DEVELOPED BASELINE DESIGNS
  - PROVIDES MEASURES OF THE INCREMENTAL BENEFITS, RISK, AND COST OF THESE ALTERNATIVES

JL //
1/12/78-3

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

GUIDELINES

AREA	GUIDELINE	
	VOIR	SEASAT-B
SOURCE OF BASELINE MISSION AND SPACECRAFT DESCRIPTIONS	• JPL FY '77 AND '78 PRE-PROJECT ACTIVITY SPONSORED BY NASA OSS/SL	• JPL FY '77 PRE-PROJECT ACTIVITY SPONSORED BY NASA OA
SOURCE OF TECHNOLOGY OPTIONS/ ALTERNATIVES	• JPL (WITH EMPHASIS) • INDUSTRY • GOVERNMENT (TO INCLUDE CONSIDERATION OF NASA-RELATED DOD TECHNOLOGIES IDENTIFIED BY THE AEROSPACE CORP IN AN FY '76 OAST/RX-SPONSORED STUDY*)	(SAME AS VOIR)
EMPHASIS OF TECHNOLOGY OPTIONS/ALTERNATIVES	• ALL SPACECRAFT ENGINEERING SUBSYSTEMS (EMPHASIS ON OPTIONS WHICH MIGHT PROVE BENEFICIAL FOR SUPPORT OF THE SYNTHETIC APERTURE RADAR (SAR)) • NO SCIENCE SUBSYSTEMS/ INSTRUMENTS • NO GROUND SUPPORT EQUIPMENT	(SAME AS VOIR)

*"TECHNOLOGY ASSESSMENT AND NEW OPPORTUNITIES - STUDY 2.3", THE AEROSPACE CORPORATION, D.G. AVIV

JLW
1/12/78-4

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

PRODUCTS+

PRODUCT	TITLE	DESCRIPTION
1	IDENTIFICATION OF BASELINE DESIGN TECHNOLOGY COMPONENTS	LIST OF SUBSYSTEM COMPONENTS UTILIZED IN USER-PROGRAM-OFFICE-GENERATED BASELINE DESIGN
2	IDENTIFICATION OF TECHNOLOGY OPTIONS	LIST OF SUBSYSTEM TECHNOLOGY OPTIONS WHICH MAY REDUCE RISK AND/OR ENHANCE THE BASELINE MISSION
3	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION STATE-OF-DEVELOPMENT ASSESSMENT	IDENTIFICATION OF COMPONENT STATE-OF-DEVELOPMENT AT PROJECT START ON A STANDARD 7-DEVELOPMENT LEVEL SCALE (FOR SCALE, SEE APPENDIX)
4	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION COMMITMENT CONDITION ASSESSMENT	EVALUATION OF COMPONENT SATISFACTION OF 7 CONDITIONS ESSENTIAL FOR COMPONENT COMMITMENT TO A PROJECT AT LOW RISK (FOR CONDITIONS, SEE APPENDIX)
5	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION RISK ASSESSMENT	EVALUATION OF COMPONENT RISK (HIGH, MEDIUM, LOW) IN THE AREAS OF TECHNOLOGY, ENGINEERING, PERSONNEL, AND FORESEEABLE PROBLEMS (FOR CRITERIA, SEE APPENDIX)
6	TECHNOLOGY MATURITY COMPARISON	COMPARISON OF THE MATURITY AT PROJECT START, BASED ON THE SCALE OF PRODUCT 3, OF THE TECHNOLOGIES OF WHICH THE BASELINE DESIGN IS COMPRISED WITH THE MATURITY AT PROJECT START OF THE TECHNOLOGIES OF PREVIOUS JPL MISSIONS
7	TECHNOLOGY OPTION BENEFIT RATING	PRIORITIZATION OF TECHNOLOGY OPTIONS BY THE DEGREE TO WHICH THEY PROVIDE MISSION BENEFITS (i.e., INCREASED SCIENCE INFORMATION QUANTITY AND/OR QUALITY AT REDUCED COST) FOR THE MISSION OF INTEREST
8	DEVELOPMENT PROGRAM RECOMMENDATIONS	RECOMMENDED NEW INITIATIVES, INITIATIVE AUGMENTATIONS, AND/OR INITIATIVE REVISIONS WHICH MAY REDUCE RISK TO AN ACCEPTABLE LEVEL FOR, AND/OR ENHANCE, THE BASELINE MISSION

+FOR APPROACH, SEE APPENDIX

JLW
1/12/78-5

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

STATUS

PRODUCT	STATUS / EXPECTED COMPLETION DATE	COMMENTS
1	ESSENTIALLY COMPLETE	COMPONENTS/DESIGN APPROACHES UNDEFINED IN OSS/SL - SPONSORED FY '77 PRE-PROJECT ACTIVITY AT JPL CURRENTLY BEING DEFINED IN FY '78 EFFORT
2	IN PROGRESS / MARCH 1978	• KEY OPTIONS: ON-BOARD SAR PROCESSOR, UNIFIED DATA SYSTEM, AEROBRAKE, DYNAMIC POWER, SPACE STORABLE PROPULSION • INVESTIGATION OF NASA-RELATED DOD TECHNOLOGIES JUST BEGINNING • HEADQUARTERS REVIEW/AUGMENTATION OF PRESENT OPTIONS LIST IS REQUESTED (FOR LIST, SEE APPENDIX)
3	IN PROGRESS / MARCH 1978	BASELINE TECHNOLOGY COMPONENT STATE-OF-DEVELOPMENT ASSESSMENT NEARLY COMPLETE. OPTIONS ASSESSMENT ONGOING
4	IN PROGRESS / MARCH 1978	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION COMMITMENT CONDITION ASSESSMENT ONGOING
5	IN PROGRESS / MARCH 1978	BASELINE TECHNOLOGY COMPONENT/COMPONENT OPTION RISK ASSESSMENT ONGOING
6	IN PROGRESS / MARCH 1978	TECHNOLOGY MATURITY COMPARISON ONGOING
7	IN PROGRESS / FEBRUARY 1978	IDENTIFICATION/WEIGHTING OF CRITERIA FOR ASSIGNMENT OF OPTION BENEFIT RATINGS JUST UNDERWAY
8	IN PROGRESS / APRIL 1978	DEVELOPMENT PROGRAM RECOMMENDATIONS CURRENTLY EMERGING

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1/12/78-6

APPENDIX

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

APPENDIX CONTENT

- STUDY APPROACH
- PRODUCT 2 - TECHNOLOGY OPTIONS LIST
- PRODUCT 3 CRITERIA - COMPONENT STATE-OF-DEVELOPMENT SCALE
- PRODUCT 4 CRITERIA - CRITERIA FOR COMPONENT COMMITMENT TO A PROJECT
- PRODUCT 5 CRITERIA - CRITERIA FOR COMPONENT RISK ASSESSMENT

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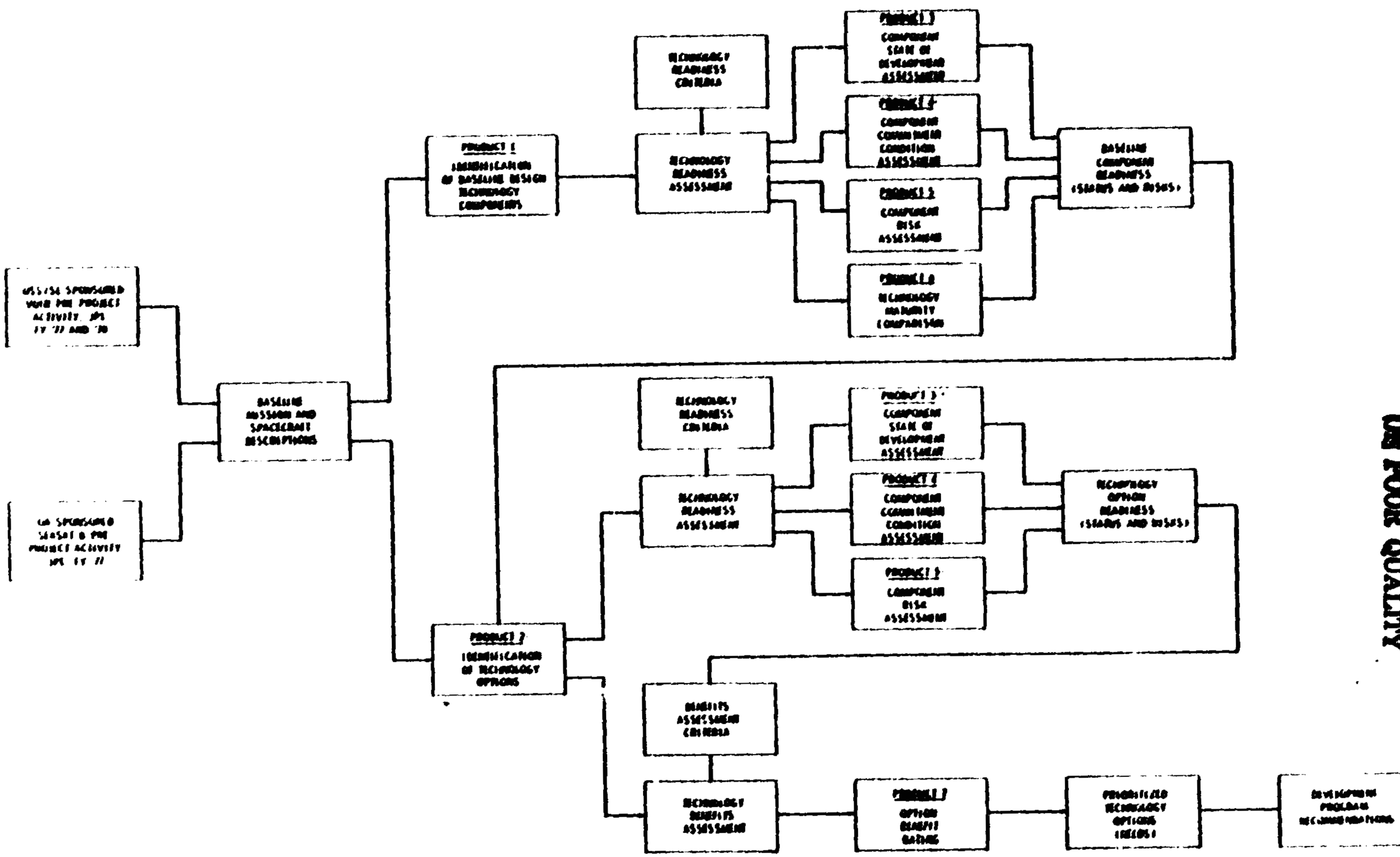
1/12/78-A1

VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

STUDY APPROACH



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VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

PRODUCT 2 - TECHNOLOGY OPTIONS LIST

TECHNOLOGY OPTIONS*	MISSION APPLICABILITY		ENGINEERING SUBSYSTEM APPLICABILITY											FUNDING STATUS	
			VOIR						SEASAT FOLLOW-ON						
	VOIR	SEASAT FOLLOW-ON	ENGINEERING MECHANICS	POWER	PROPULSION	ATTITUDE AND ARTICULATION CONTROL	TELECOMMUNICATIONS	DATA HANDLING AND CONTROL	ENGINEERING MECHANICS	THERMAL CONTROL	POWER	ATTITUDE CONTROL AND DETERMINATION	COMMUNICATIONS AND DATA HANDLING	FUNDED	UNFUNDED
MULTIDISCIPLINARY RESEARCH (NO OPTIONS IDENTIFIED)															
MATERIALS R&T (NO OPTIONS IDENTIFIED)															
STRUCTURE R&T															
• METAL-LINED COMPOSITE PROPELLANT TANKS	X				X									X	
SENSING & DETECTION R&T (NO OPTIONS IDENTIFIED)															
GUIDANCE & CONTROL R&T (TO BE INVESTIGATED)															
DATA REDUCTION & DISTRIBUTION R&T															
• ON-BOARD SAR IMAGE PROCESSOR	X	X						X					X	X	
• DIGITAL DATA SYSTEMS (UNIFIED DATA SYSTEM)	X	X						X							
• DIGITAL RADIO	X	?					X						?	X	
• Ku-BAND PLANAR ARRAY ANTENNA		X											X	X	
• OTHER															
CHEMICAL PROPULSION R&T															
• FLOURINE-HYDRAZINE RETRO-PROPULSION TECHNOLOGIES	X				X									X	
ELECTRIC PROPULSION R&T															
• ELECTRIC PROPULSION	X				X									X	

* CLASSIFIED BY OAST SPACE R&T PROGRAM/DISCIPLINE OBJECTIVE. SOURCES INCLUDE "SR&T TECHNOLOGY PROGRAM AND SPECIFIC OBJECTIVES," OAST, FY '78; "VOIR 1983 MISSION AND SYSTEM STUDY," OCT 1978; "SEASAT-B OPTIONS PHASE FINAL REPORT," JUNE 1977
X INDICATES MISSION/SUBSYSTEM APPLICABILITY AND FUNDING STATUS

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VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

PRODUCT 2 - TECHNOLOGY OPTIONS LIST (contd)

TECHNOLOGY OPTIONS*	MISSION APPLICABILITY		ENGINEERING SUBSYSTEM APPLICABILITY											FUNDING STATUS	
			VOIR						SEASAT FOLLOW-ON						
	VOIR	SEASAT FOLLOW-ON	ENGINEERING MECHANICS	POWER	PROPULSION	ATTITUDE AND ARTICULATION CONTROL	TELECOMMUNICATIONS	DATA HANDLING AND CONTROL	ENGINEERING MECHANICS	THERMAL CONTROL	POWER	ATTITUDE CONTROL AND DETERMINATION	COMMUNICATIONS AND DATA HANDLING	FUNDED	UNFUNDED
SPACE ENERGY SYSTEMS R&T															
• BRAYTON ISOTOPE POWER SYSTEM (BIPS)	X			X										X	
• KILOWATT ISOTOPE POWER SYSTEM (KIPS)	X			X										X	
• AUTOMATED POWER SYSTEM MANAGEMENT	X	X		X							X			X	
• OTHER															
NUCLEAR ENERGY R&T (NO OPTIONS IDENTIFIED)															
HIGH POWER LASERS & ENERGETICS R&T (TO BE INVESTIGATED)															
ENTRY R&T (TO BE INVESTIGATED)															
ELECTRONIC SYSTEMS TECHNOLOGY (TO BE INVESTIGATED)															
MATERIALS AND STRUCTURES SYSTEMS TECHNOLOGY (TO BE INVESTIGATED)															
PROPULSION AND POWER SYSTEMS TECHNOLOGY															
• FLOURINE - HYDRAZINE RETRO PROPULSION (SPACE STORABLE BIPROPELLANT PROPULSION)	X				X									X	
• AEROBRAKE	X				X										X

* CLASSIFIED BY OAST SPACE R&T PROGRAM/DISCIPLINE OBJECTIVE. SOURCES INCLUDE "SR&T TECHNOLOGY PROGRAM AND SPECIFIC OBJECTIVES," OAST, FY '78; "VOIR 1983 MISSION AND SYSTEM STUDY," OCT 1978; "SEASAT-B OPTIONS PHASE FINAL REPORT," JUNE 1977

X INDICATES MISSION/SUBSYSTEM APPLICABILITY AND FUNDING STATUS

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VOIR/SEASAT FOLLOW-ON TECHNOLOGY
READINESS STUDY - PART 1: VOIR

PRODUCT 3 CRITERIA - COMPONENT STATE-OF-DEVELOPMENT SCALE

STATE-OF-DEVELOPMENT LEVEL	DEFINITION	
	HARDWARE*	SOFTWARE
1	BASIC PRINCIPLES OBSERVED AND REPORTED	BASIC THEORY DEVELOPED AND PUBLISHED
2	CONCEPTUAL DESIGN FORMULATED	APPLICABILITY TO SPECIFIC PROBLEMS PROPOSED
3	CONCEPTUAL DESIGN SUBJECTED TO ANALYTICAL INVESTIGATION AND/OR EXPERIMENTAL TEST	USED TO IDENTIFY PARTS OF EXISTING MISSION DESIGN
4	CRITICAL FUNCTION OR CHARACTERISTIC DEMONSTRATED (i.e., GROSS DESIGN FEASIBILITY ESTABLISHED)	FAVORABLE COMPARISON WITH AVAILABLE MISSION RESULTS ATTAINED
5	PROTOTYPE/BREADBOARD SUCCESSFULLY TESTED (i.e., PERFORMANCE AND LIFETIME REQUIRED BY THE MISSION OF INTEREST DEMONSTRATED) IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	ANALYSES REQUIRED FOR REFERENCE FUTURE MISSION PERFORMED
6	ENGINEERING MODEL SUCCESSFULLY TESTED IN THE RELEVANT, GROUND-SIMULATED ENVIRONMENT	DEMONSTRATION THAT ALL FUNCTIONS REQUIRED FOR REFERENCE FUTURE MISSION CAN BE PERFORMED TO THE REQUIRED ACCURACY
7	ENGINEERING MODEL SUCCESSFULLY FLIGHT TESTED OR SUCCESSFULLY FLOWN IN THE SPACE ENVIRONMENT	SOFTWARE USED IN SUPPORT OF AT LEAST ONE PREVIOUS MISSION

*ABSTRACTED FROM GD CONVAIR RPT. No. CASD-NAS-75-016, "FUTURE PAYLOAD TECHNOLOGY REQUIREMENTS STUDY," JUNE 1975.

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1/12/78-A5

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PRODUCT 4 CRITERIA - CRITERIA FOR COMPONENT COMMITMENT TO A PROJECT

COMMITMENT CONDITION	DEFINITION
1.	THE COMPONENT STATE OF DEVELOPMENT MUST CORRESPOND TO A LEVEL OF 5 OR HIGHER ON THE APPROPRIATE HARDWARE OR SOFTWARE COMPONENT STATE-OF-DEVELOPMENT SCALE
2.	THE COMPONENT MUST NOT PLACE REQUIREMENTS ON OTHER SUBSYSTEMS WHICH REQUIRE THEIR ADVANCEMENT BEYOND THE STATE-OF-THE-ART
3.	COMPONENT PIECE PARTS (OR THEIR EQUIVALENTS) MUST BE AVAILABLE (AND REMAIN SO) AND MUST MEET PROJECT QUALITY REQUIREMENTS
4.	THERE MUST BE NO UNSOLVABLE PROBLEMS TO THE COMPONENT SURVIVING AND FUNCTIONING IN THE EXPECTED ENVIRONMENTS
5.	COMPONENT MASS, POWER, AND VOLUME ESTIMATES MUST BE COMPATIBLE WITH SYSTEM PERFORMANCE CAPABILITIES
6.	COMPONENT DEVELOPMENT COSTS AND SCHEDULE MUST BE CONSISTENT WITH THE PROJECT PLAN AND ANTICIPATED RESOURCES
7.	COMPONENT MANUFACTURING REQUIREMENTS MUST NOT EXCEED INDUSTRY CAPABILITY IN QUALITY OR QUANTITY

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VOIR/SEASAT FOLLOW-ON TECHNOLOGY READINESS STUDY - PART 1: VOIR

PRODUCT 5 CRITERIA - CRITERIA FOR COMPONENT RISK ASSESSMENT

AREA	LEVELS OF RISK		
	LOW	MEDIUM	HIGH
TECHNOLOGY	TECHNOLOGY EXISTS AND HAS DEMONSTRATED THE PERFORMANCE AND LIFETIME REQUIRED BY THE MISSION OF INTEREST, CORRESPONDING TO A STATE-OF-DEVELOPMENT LEVEL OF 5 OR HIGHER.	TECHNOLOGY EXISTS ONLY AS A CONCEPTUAL DESIGN UNDERGOING EVALUATION, CORRESPONDING TO LEVELS 2-4.	TECHNOLOGY DOES NOT EXIST AND MUST BE DEVELOPED FROM BASIC PRINCIPLES, CORRESPONDING TO LEVEL 1.
	TECHNOLOGY OPTIONS OR ALTERNATIVES EXIST.	TECHNOLOGY OPTIONS OR ALTERNATIVES EXIST ONLY AS CONCEPTUAL DESIGNS.	TECHNOLOGY OPTIONS OR ALTERNATIVES DO NOT EXIST.
	PARALLEL TECHNOLOGY DEVELOPMENTS ARE FEASIBLE WITHIN ANTICIPATED RESOURCES AND SCHEDULE.	ANTICIPATED RESOURCES AND SCHEDULE ARE MARGINAL FOR PARALLEL TECHNOLOGY DEVELOPMENTS.	PARALLEL TECHNOLOGY DEVELOPMENTS ARE NOT FEASIBLE.
ENGINEERING	PROBLEM IS COMMONPLACE AND MAY BE SOLVED BY THE APPLICATION OF ANY ONE OF A NUMBER OF ROUTINE DESIGN APPROACHES.	PROBLEM IS SOMEWHAT NOVEL AND REQUIRES A DESIGN APPROACH SHOWING SOME INGENUITY AND CREATIVITY.	PROBLEM IS NOVEL, ALTHOUGH SOLUTIONS BASED ON EXISTING TECHNOLOGY DO EXIST, AND REQUIRES A DESIGN APPROACH OF CONSIDERABLE INGENUITY AND CREATIVITY.
PERSONNEL	PERSONNEL WHO ARE CONSIDERED EXPERTS IN THEIR FIELDS AND WHO HAVE SUCCESSFULLY SUPPORTED SIMILAR PROJECTS ARE AVAILABLE.	PERSONNEL OF HIGH QUALITY, BUT LIMITED APPLICABLE EXPERIENCE, ARE AVAILABLE.	PERSONNEL OF UNKNOWN OR QUESTIONABLE CAPABILITIES ARE AVAILABLE.
	COMMITMENT OF ABOVE PERSONNEL TO PROJECT FOR ITS DURATION WOULD BE FIRM.	PERSONNEL COMMITMENT TO PROJECT IS CONDITIONAL.	PERSONNEL COMMITMENT TO PROJECT IS UNDETERMINED.
FORESEEABLE PROBLEMS	ENOUGH IS KNOWN TO FORESEE ALL MAJOR PROBLEMS AND ACCURATELY ASSESS RISKS.	ENOUGH IS KNOWN TO FORESEE MOST MAJOR PROBLEMS AND ASSESS RISKS WITH SOME ACCURACY.	NOT ENOUGH IS KNOWN TO FORESEE MAJOR PROBLEMS OR ASSESS RISKS
	ENOUGH IS KNOWN TO FORESEE MOST MINOR PROBLEMS.	ENOUGH IS KNOWN TO FORESEE SOME MINOR PROBLEMS.	NOT ENOUGH IS KNOWN TO FORESEE MINOR PROBLEMS.

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1/12/78-A7

PRESENTATION TO OAST-CODE RX

STUDY, ANALYSIS, AND PLANNING OFFICE

STUDY PLANS

MARS SAMPLE RETURN TECHNOLOGY READINESS STUDY

RTOP No. 790-40-25 (-02)

FUNDING: 40K FY '78

JOHN L. WEST

JANUARY 12, 1978

PRESENTATION OVERVIEW

- STUDY OBJECTIVES
- APPROACH
- PRODUCTS
- SCHEDULE

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1/12/78-1

STUDY OBJECTIVES

GENERAL

- PROVIDE INFORMATION USEFUL TO NASA IN PLANNING THE ADVANCED DEVELOPMENT PROGRAM AND INSURING ITS RELEVANCE TO AGENCY NEEDS

SPECIFIC

- PERFORM READINESS ASSESSMENT OF EACH OF THE MISSION OPTIONS FOR THE NEXT MARS MISSION CURRENTLY UNDERGOING EVALUATION BY JPL UNDER OSS/SL - SPONSORSHIP IN THE FY '78-'79 MARS PROGRAM
    - PROVIDES AN EVALUATION OF THE MATURITY AT PROJECT START AND RISKS OF UTILIZATION OF THE TECHNOLOGIES UPON WHICH EACH MISSION OPTION, INCLUDING MARS SAMPLE RETURN, IS BASED
    - IDENTIFIES, FOR MUTUAL OAST/USER PROGRAM OFFICE CONSIDERATION, DEVELOPMENT PROGRAMS WHICH WILL REDUCE IDENTIFIED RISKS TO AN ACCEPTABLE LEVEL, OR IF AN ACCEPTABLE LEVEL IS NOT ACHIEVABLE, TO THE LOWEST LEVEL POSSIBLE AT PROJECT START

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APPROACH

- UTILIZE METHODOLOGY CURRENTLY BEING APPLIED BY JPL UNDER OAST/RX SPONSORSHIP TO ASSESS TECHNOLOGY READINESS AND RISK FOR THE VOIR AND SEASAT FOLLOW-ON MISSIONS

- PERFORM ASSESSMENT INDEPENDENT FROM BUT IN PARALLEL WITH, AND UTILIZING RAW DATA GENERATED BY, THE OSS/SL - SPONSORED FY '78 MARS PROGRAM WHICH HAS AS AN ESSENTIAL OBJECTIVE THE DEFINITION OF THE NEXT MARS MISSION

- CONSIDER THIS STUDY AS TASK 1 OF A POTENTIAL TWO-TASK STUDY

  - TASK 1 (FY'78, 40 K) - READINESS ASSESSMENT TO EVALUATE TECHNOLOGY MATURITY AND RISK FOR EACH USER-PROGRAM-OFFICE GENERATED MISSION OPTION FOR THE NEXT MARS MISSION AND TO FORMULATE RECOMMENDATIONS FOR DEVELOPMENT PROGRAMS THAT MAY REDUCE IDENTIFIED RISKS

  - TASK 2 (FY'79, 30 K - PERFORMANCE TBD) - BENEFITS ASSESSMENT TO EVALUATE, GIVEN THAT CIRCUMSTANCES INDICATE A BENEFIT TO THE FY'78-79 MARS PROGRAM EFFORT TO DEFINE THE NEXT MARS MISSION, THE INCREMENTAL BENEFITS, RISKS, AND COSTS OF IDENTIFIED TECHNOLOGY OPTIONS

JLW
1/12/78-3

MARS SAMPLE RETURN TECHNOLOGY READINESS STUDY

PRODUCTS

PRODUCT	TITLE	DESCRIPTION
1	TECHNOLOGY COMPONENT AND TECHNIQUE LIST AND DESCRIPTIONS	LIST OF COMPONENTS AND TECHNIQUES UTILIZED IN EACH USER-PROGRAM-OFFICE-GENERATED MARS MISSION OPTION
2	TECHNOLOGY COMPONENT STATE-OF-DEVELOPMENT ASSESSMENT	IDENTIFICATION OF COMPONENT STATE-OF-DEVELOPMENT AT PROJECT START ON A STANDARD 7-DEVELOPMENT LEVEL SCALE (FOR SCALE, SEE VOIR/SEASAT PRESENTATION)
3	TECHNOLOGY COMPONENT COMMITMENT CONDITION ASSESSMENT	EVALUATION OF COMPONENT SATISFACTION OF 7 CONDITIONS ESSENTIAL FOR COMPONENT COMMITMENT TO A PROJECT AT LOW RISK (FOR CONDITIONS, SEE VOIR/SEASAT PRESENTATION)
4	TECHNOLOGY COMPONENT RISK ASSESSMENT	EVALUATION OF COMPONENT RISK (HIGH, MEDIUM, LOW) IN THE AREAS OF TECHNOLOGY, ENGINEERING, PERSONNEL, AND FORESEEABLE PROBLEMS (FOR CRITERIA, SEE VOIR/SEASAT PRESENTATION)
5+	TECHNOLOGY MATURITY COMPARISON	COMPARISON OF THE MATURITY AT PROJECT START, BASED ON THE SCALE OF PRODUCT 2, OF THE TECHNOLOGIES OF WHICH EACH MISSION OPTION IS COMPRISED WITH THE MATURITY AT PROJECT START OF THE TECHNOLOGIES OF PREVIOUS JPL MISSIONS
6	DEVELOPMENT PROGRAM RECOMMENDATIONS	IDENTIFIES DEVELOPMENT PROGRAMS WHICH WILL REDUCE IDENTIFIED RISKS TO AN ACCEPTABLE LEVEL, OR IF AN ACCEPTABLE LEVEL IS NOT ACHIEVABLE, TO THE LOWEST LEVEL POSSIBLE AT PROJECT START

+ VALUE UNCERTAIN, PERFORMANCE TO BE DETERMINED

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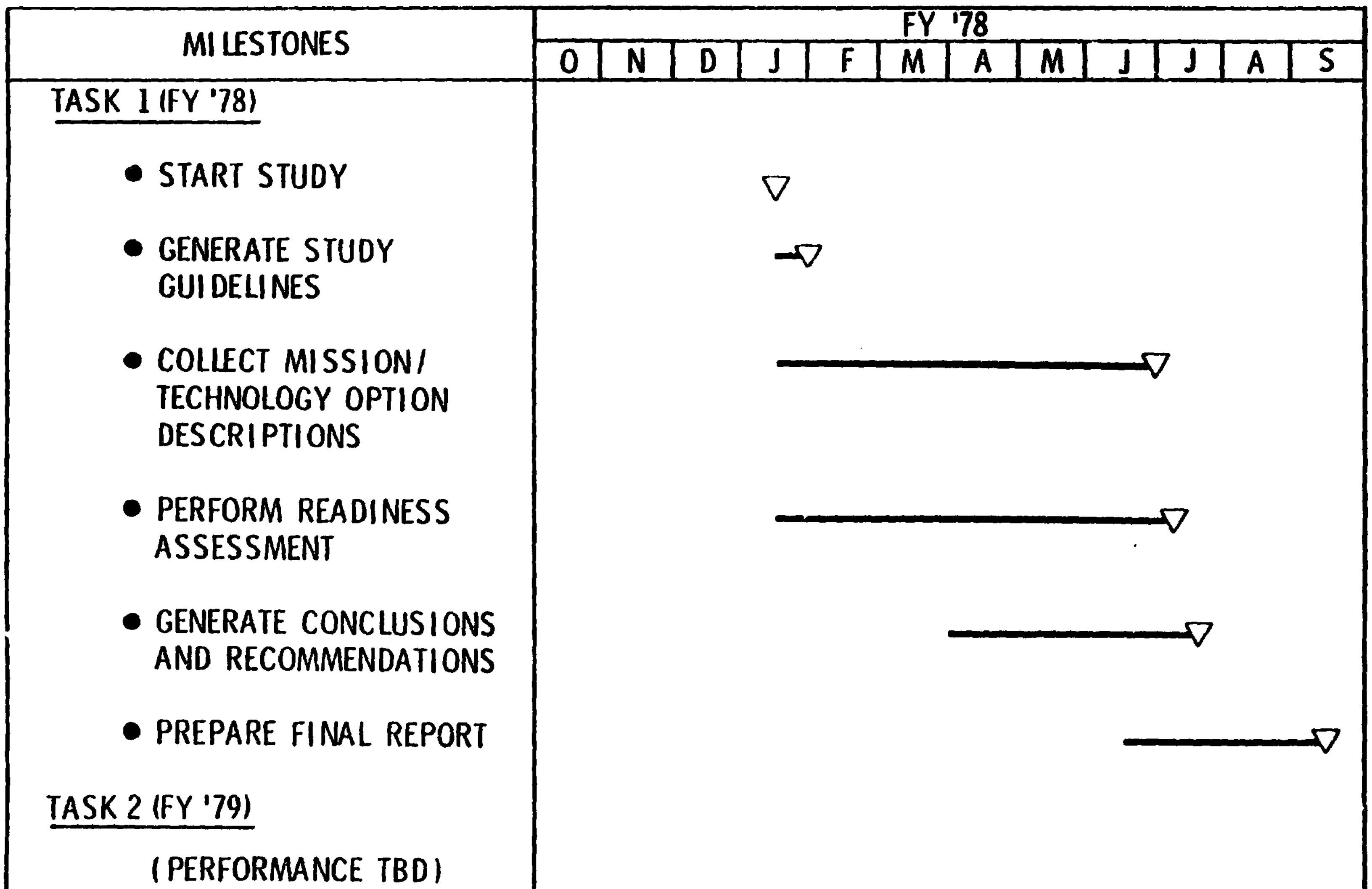
MARS SAMPLE RETURN TECHNOLOGY READINESS STUDY

SCHEDULE



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1/12/78-5

PRESENTATION TO OAST-CODE RX

STUDY, ANALYSIS, AND PLANNING OFFICE

STUDY PLANS

TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS

(ADVANCED SAMPLE RETURN CONCEPTS)

RTOP No. 790-40-15(-04)

FUNDING: 50 K FY '78, 40 K FY '79

JOHN L. WEST

JANUARY 12, 1978

TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS

PRESENTATION OVERVIEW

- STUDY OBJECTIVES
- GUIDELINES
- APPROACH
- SCHEDULE

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TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS

STUDY OBJECTIVES

GENERAL

- PROVIDE INFORMATION USEFUL TO NASA IN PLANNING THE ADVANCED DEVELOPMENT PROGRAM AND INSURING ITS RELEVANCE TO AGENCY NEEDS

SPECIFIC

- ASSESS ADEQUACY OF CURRENT OAST TECHNOLOGY DEVELOPMENT PROGRAM TO SUPPORT SAMPLE RETURN MISSIONS AS A CLASS AND GENERATE RECOMMENDATIONS FOR PROGRAM NEW INITIATIVES/AUGMENTATIONS/REVISIONS TO FILL VOIDS OR GAPS SHOULD THEY BE IDENTIFIED

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TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS

GUIDELINES

AREA	GUIDELINE
SELECTION OF DRIVER SET OF SAMPLE RETURN MISSIONS	• DRIVER SAMPLE RETURN MISSION SET TO INCLUDE ONLY THOSE MISSIONS FEASIBLE FROM A PERFORMANCE STANDPOINT UTILIZING PROPULSION SUB-SYSTEMS EITHER CURRENTLY EXISTING OR UNDER DEVELOPMENT (i.e., CONVENTIONAL LIQUIDS AND SOLIDS, SPACE STORABLES, ION DRIVE) • DRIVER MISSION SET TO INCLUDE MISSIONS HAVING IDENTIFIED MISSION OPPORTUNITIES IN THE MID-80's TO MID-90's TIME FRAME • TENTATIVE MISSION SET TO INCLUDE MARS, VENUS, LUNAR, COMET, AND ASTEROID MISSIONS (ASSUMING ABOVE CONDITIONS MET)
SOURCE OF MISSION PERFORMANCE INFORMATION/ MISSION DEFINITIONS	• COMPLETED/CONCURRENT STUDIES, PERFORMED UNDER PROGRAM OFFICE SPONSORSHIP • MARS - JPL FY '78-'79 MARS PROGRAM ACTIVITY (OSS/SL) • VENUS - SAI* FY '78 VENUS DESCENT AND ASCENT STRATEGIES STUDIES (OSS/SL) • LUNAR - JPL FY '77 LUNAR SAMPLE RETURN STUDIES (OSS/SL-PROGRAM 684) • COMET - JPL FY '78 ENCKE COMET SAMPLE RETURN STUDIES (OSS/SL) • ASTEROID - JPL FY '77 STUDIES (UNSPONSORED). POSITIVE INCLUSION IN DRIVER SAMPLE RETURN MISSION SET WOULD REQUIRE OSS MISSION PERFORMANCE STUDIES IN FY '78 - '79
EMPHASIS OF TECHNOLOGIES INVESTIGATED	• SPACECRAFT (VEHICLE) ENGINEERING SUBSYSTEMS (INCLUDING TECHNOLOGIES REQUIRED FOR SAMPLE ACQUISITION/PROCUREMENT AND HANDLING) • NO SCIENCE SUBSYSTEMS/INSTRUMENTS • NO GROUND SUPPORT EQUIPMENT

*SCIENCE APPLICATIONS, INC.

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TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS
APPROACH

TASK	FUNCTION	DESCRIPTION
1	IDENTIFY CRITICAL SAMPLE RETURN TECHNOLOGY AREAS	IDENTIFICATION OF THOSE AREAS WHICH MAY BE CONSIDERED PRIME CANDIDATES FOR SAMPLE RETURN TECHNOLOGY DEVELOPMENT, BASED ON THE REQUIREMENTS OF THE IDENTIFIED SET OF DRIVER MISSIONS
2	ASSESS TECHNOLOGY NEEDS IN CRITICAL TECHNOLOGY AREAS	INVESTIGATION OF THE NEED FOR NEW TECHNOLOGIES IN EACH OF THE CRITICAL AREAS IDENTIFIED IN TASK 1 AND IDENTIFICATION OF NEW TECHNOLOGIES OR TECHNOLOGY IMPROVEMENTS REQUIRED TO MEET THESE NEEDS WHERE THEY EXCEED CAPABILITIES
3	COMPARE TECHNO-LOGY NEEDS WITH CAPABILITIES CURRENTLY UNDER OAST DEVELOPMENT	COMPARISON OF TECHNOLOCY NEEDS IDENTIFIED IN TASK 2 WITH CAPABILITIES CURRENTLY UNDER OAST DEVELOPMENT TO IDENTIFY PROGRAM DEFICIENCIES, SHOULD THEY EXIST, IN PROVIDING NEEDED CAPABILITIES TO SUPPORT THE DRIVER SET OF SAMPLE RETURN MISSIONS
4	GENERATE RECOMMENDATIONS FOR PROGRAM AUG-MENTATION/INITIA-TIVE REVISION TO FILL IDENTIFIED SAMPLE RETURN TECHNOLOGY NEEDS	RECOMMENDATION OF TECHNOLOGY DEVELOPMENT NEW INITIATIVES/ INITIATIVE REVISIONS, RANKED BY POTENTIAL BENEFIT TO THE DRIVER MISSION SET, WHICH ARE ESSENTIAL TO THE SUCCESSFUL COMPLETION OF FUTURE SAMPLE RETURN MISSIONS

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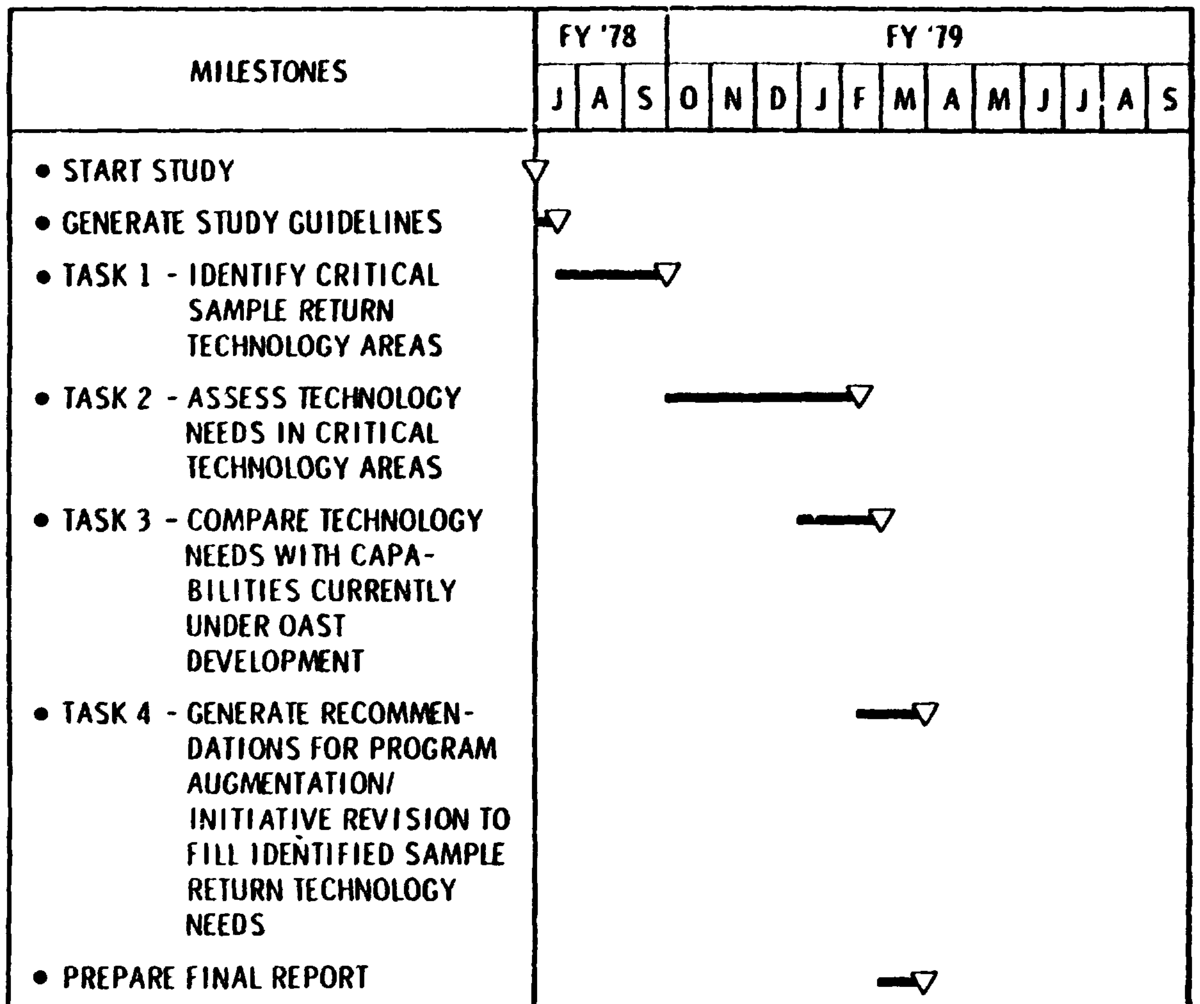
1/12/78-4

TECHNOLOGY NEEDS FOR SAMPLE RETURN MISSIONS

SCHEDULE



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PRESENTATION TO OAST - CODE RX

STUDY, ANALYSIS AND PLANNING OFFICE

FINAL REPORT

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

(SURFACE EPA)

RTOP NO. 790-40-33

FUNDING: $35K

ROY G. BRERETON

JAN 12, 1978

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SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

OBJECTIVES

- TO DEFINE THE SCIENTIFIC INSTRUMENTS AND SUPPORT MECHANISMS THAT WILL BE REQUIRED FOR AUTOMATED REMOTE-SURFACE EPA

IN ORDER TO:

- FORECAST POTENTIAL FUTURE SYSTEMS FOR THIS TASK
- FORECAST THE TECHNOLOGY NEEDED IN THEIR SUPPORT

RGB; 1-12-78
SECT 910; p. 2

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

APPROACH

- EXAMINE HOW EPA IS ACCOMPLISHED ON EARTH
  - MAN ESSENTIAL "COG" IN LOOP
  - ANALYSES FACILITY
  - FIELD INSTRUMENTS AND EQUIPMENT
- EXAMINE HOW THIS CAN BE AUTOMATED FOR REMOTE-SURFACE EPA
- MODEL FOR ACCOMPLISHING REMOTE-SURFACE EPA
  - FUNCTIONS
  - SCIENTIFIC INSTRUMENTS
  - SUPPORT MECHANISMS
- COMPARE THE MODEL AND ITS REQUIREMENTS WITH AVAILABLE INSTRUMENTS AND MECHANISMS TO GET NEW TECHNOLOGY REQUIREMENTS

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SECT 910; p.3

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING
REPORT

- INSTRUMENT TECHNOLOGY FOR REMOTE-SURFACE EXPLORATION, PROSPECTING, AND ASSAYING - PART A - JPL 710-7, 28 OCT 77

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SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

REMOTE SURFACE EPA MODEL, FUNCTIONS AND INSTRUMENTS

MAJOR FUNCTION	DESCRIPTION OF FUNCTION	TYPICAL INSTRUMENTS OR MECHANISMS
IMAGING	VIEWING OF THE REMOTE SURFACE, SAMPLES AND SKY FOR THE FIELD GEOLOGY FUNCTIONS AND PHOTO GEOLOGY, TO ASSIST IN THE SELECTION, ACQUISITION, AND ANALYSIS OF THE SAMPLES, TO AID IN INSTRUMENT HANDLING AND PLACEMENT, AND FOR NAVIGATION, GUIDANCE AND POSITIONING	1. VIDICON CAMERA 2. FACSIMILE CAMERA 3. CCD CAMERA
GEOCHEMISTRY	DETERMINATION OF THE MINERALOGY/PETROLOGY, THE ELEMENTAL/ISOTOPIC COMPOSITION, THE MINERAL PHASES, THE STRUCTURE AND TEXTURE, AGE-DATING AND THE ASSAYING OF REMOTE SURFACE MATERIAL	1. X-RAY DIFFRACTOMETER 2. X-RAY SPECTROMETER 3. PETROGRAPHIC MICROSCOPE 4. ELECTRON MICROPROBE 5. ION MICROPROBE 6. PULSED NEUTRON/GAMMA RAY SPECTROMETER 7. MASS SPECTROMETER

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SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

REMOTE SURFACE EPA MODEL, FUNCTIONS AND INSTRUMENTS

MAJOR FUNCTION	DESCRIPTION OF FUNCTION	TYPICAL INSTRUMENTS OR MECHANISMS
GEOPHYSICS	DETERMINATION OF THE GEOPHYSICAL PARAMETERS BODY PHYSICS THAT ARE IMPORTANT IN ORE SEARCH AND REMOTE SURFACE EPA	1. SEISMOMETER 2. GRAVIMETER 3. MAGNETOMETER 4. ELECTRIC METHODS 5. ELECTROMAGNETIC METHODS 6. RADIOACTIVE METHODS 7. WELL LOGGING METHODS
FIELD GEOLOGY	PROVIDES THE GEOLOGIC CONTEXT FOR ALL MEASUREMENTS, INCLUDING THE INSTRUMENTS AND TECHNIQUES FOR RECONNAISSANCE AND SURFACE MAPPING, PRELIMINARY MINERAL AND ROCK IDENTIFICATION, AND THE SITE SELECTION FOR SAMPLING AND EXPERIMENTING	1. HAND LENS 2. BRUNTON COMPASS 3. SAMPLE AND COMPASS MANIPULATOR 4. RECORD/MAP 5. ODOMETER 6. SPIRIT LEVEL (WYE LEVEL) 7. TRANSIT

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

REMOTE SURFACE EPA MODEL, FUNCTIONS AND INSTRUMENTS

MAJOR FUNCTION	DESCRIPTION OF FUNCTION	TYPICAL INSTRUMENTS OR METHOD
SAMPLE ACQUISITION	TO ACQUIRE SURFACE AND SUBSURFACE SAMPLES OF MATERIAL FROM REMOTE SURFACES. SAMPLES MAY INCLUDE ORIENTED CORES, CHIPPED SECTIONS FROM OUTCROPS, SELECTED MATERIAL FROM THE SURFACE, OR HOMOGENIZED REGOLITH MATERIAL	1. CORE DRILL (DIAMOND-DRILL) 2. ROTARY DRILL 3. CABLE DRILL 4. AUGER 5. DRIVE TUBE 6. SURFACE SAMPLER 7. ROCK CHIPPER
SAMPLE PREPARATION	TO PREPARE SAMPLES BY CRUSHING, SIEVING, SLICING, LAPING ENCASING, ETC FOR ANALYSIS	1. ROCK CRUSHER 2. SIEVER 3. SAMPLE SAW 4. ROCK THIN SECTIONING 5. SLIDE MOUNTING 6. BRUSH 7. LAPIDARY WHEEL
SAMPLE HANDLING AND STORAGE	PROVIDES PRECISION MANIPULATION OF SAMPLES TO ANALYSIS INSTRUMENTS, CONTAINERS FOR SAMPLES THAT WON'T CONTAMINATE RESULTS, ROUTING FROM THE ACQUISITION AND PREPARATION INSTRUMENTS TO THE ANALYSIS INSTRUMENTS AND STORAGE WITH STORAGE RECALL	1. VIEWING STAGE 2. SAMPLE CONTAINERS (VARIOUS) 3. STORAGE BOX

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SECT 910; p.7

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

REMOTE SURFACE EPA MODEL FUNCTIONS AND INSTRUMENTS

MAJOR FUNCTION	DESCRIPTION OF FUNCTION	TYPICAL INSTRUMENTS OR METHODS
EXPERIMENT HANDLING	TO OFF-LOAD AND RETRIEVE INSTRUMENTS AND VARIOUS EQUIPMENT AS REQUIRED - i.e., PLACING CHARGES AND SENSORS FOR ACTIVE SEISMIC PROSPECTING	1. VARIOUS FOR a) GEOCHEM SENSORS b) GEOPHYSICS SENSORS c) FIELD GEOLOGY d) SURVEYING
NAVIGATION AND POSITIONING	DETERMINATION OF RANGE, LATITUDE/LONGITUDE, POSITION ON A GRID, ETC., FOR MAPPING AND ALL SURFACE EPA ACTIVITIES	1. LASER RANGING 2. RADAR RANGING 3. RADIO RANGING 4. SURVEYING 5. LAND MARK (WITH IMAGING) 6. CELESTIAL 7. DEAD RECKONING
OTHERS	SPECIAL EXPERIMENTS OR HANDLING AND PROCESSING EQUIPMENT THAT DOESN'T FIT INTO THE ABOVE CATEGORIES	

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SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

SUMMARY

SCIENTIFIC INSTRUMENTS, NEW TECHNOLOGY AND PROBLEMS

SCIENTIFIC INSTRUMENTS	1. INSTRUMENT GENERAL: NEW SENSORS	ACTIVE COOLING	RADIATION AND ENVIRONMENTAL CONTROL	SENSOR SENSITIVITY	MATERIAL AND COMPONENTS	2. INSTRUMENT DESIGN	3. SAMPLE ACQUISITION	4. SAMPLE PREPARATION	5. SAMPLE HANDLING	6. EXPERIMENT HANDLING AND MOBILITY	7. OTHER
IMAGING											
1. VIDICON										M	1
2. FACSIMILE										M	1
3. CCD	X	X			X	X				M	1
GEOCHEMISTRY											
4. X-RAY DIFFRACTOMETER	X	X	X	X	X	M	X	X			
5. X-RAY SPECTROMETER	X	X	X	X	X	X	X	X			
6. RADIOACTIVE SURVEY			X	X						X	
7. PETROGRAPHIC MICROSCOPE					X	M	X	M	M		
8. MASS SPECTROMETER			X		X	M	X	M			
9. SCANNING ELECTRON MICROSCOPE/MICROPROBE/MASS					M	M	X	M	X		

X = SOME
M = MAJOR
1 = DATA RATE AND GROUND CONTROL
2 = DEEP DRILLING

RGB; 1-12-78
SECT 910; p.9

SURFACE EXPLORATION, PROSPECTING, AND ASSAYING

SUMMARY

SCIENTIFIC INSTRUMENTS, NEW TECHNOLOGY AND PROBLEMS

SCIENTIFIC INSTRUMENTS	TECHNOLOGY CATEGORY										
	1. INSTRUMENT GENERAL	NEW SENSORS	ACTIVE COOLING	RADIATION AND ENVIRONMENTAL CONTROL	SENSOR SENSITIVITY MATERIAL AND COMPONENTS	2. INSTRUMENT DESIGN	3. SAMPLE ACQUISITION	4. SAMPLE PREAPRATION	5. SAMPLE HANDLING	6. EXPERIMENT HANDLING AND MOBILITY	7. OTHER
GEOCHEMISTRY											
10. ION MICROPROBE/MASS ANALYZER (IMMA)					M	M	X	X	X		
11. PULSED NEUTRON GAMMA RAY SPECTROMETER		X	X			X				X	
12. ALPHA-PARTICLE BACK-SCATTER SPECTROMETER			X			X		X		X	
13. AGE-DATING					M	M	M	M	M		
GEOPHYSICS											
14. SEISMIC						X				M	
15. GRAVIMETERY	X			X	X	X					
16. MAGNETOMETERY			X								
17. ELECTRIC AND ELECTROMAGNETIC	X				X	X				M	
18. WELL LOGGING					X	X				X	2

X = SOME
M = MAJOR
1 = DATA RATE AND GROUND CONTROL
2 = DEEP DRILLING

RGB; 1-12-78
SECT 910; p.10

SESSION 'S' - SCIENCE AND EXPLORATION

Spaceboren Antenna and Microwave Systems Technology Study
(R. Edelson, JPL)

DISCUSSION: D. Williams stated that composite manufacturing may be possible in space before the year 2000. Mr. Edelson proposed a technology development plan for FY 79, i.e., steps leading up to a 300-m antenna. It was mentioned that OSS has funded studies in other regions of the microwave spectrum, as has OSTDS for DSN uses. Stan Sadin stated that OAST cannot afford to fund development plans; instead, it is interested in feeding programs such as ESS and LSST. Mr. Aviv mentioned that a related study concerns a 180-m space-based radar system using adaptive antenna design.

Extrasolar Planetary Detection (J. Murphy, ARC)

DISCUSSION: Stan Sadin commented that this study could lead to an OSS mission.

VOIR Technology Readiness Study (J. West, JPL)

DISCUSSION: Stan Sadin mentioned that the readiness methodology developed by JPL was excellent, and recommended it for all such studies. This raised the question of when it was published; J. West said the present version would be published in May 1978, which some people felt was not soon enough.

Mars Sample Return Technology Readiness Study (J. West, JPL)

DISCUSSION: Readiness studies must use program office baseline designs, unless specific agreement to do otherwise is obtained from OAST and the program office.

Technology Needs for Sample Return Missions (J. West, JPL)

DISCUSSION: As part of this study, the JSC expertise on sample acquisiton and handling will be utilized.

Surface Exploration, Prospecting, and Assaying (P. Meeks, JPL)

DISCUSSION: None.

Discussion of FY 79 Plans in Science and Exploration

A. Hibbs presented six JPL ideas:

1. Planetary exploration system study, similar to the present global services study; the advanced propulsion comparative study (report, March 1973) was given as a reference. Stan Sadin commented that this appeared to be more of an OSS effort because it appeared to be more of a programmatic study than a technology study. He said a more specific issue involved in the future extensive exploration phase of the solar system, such as sample management which would involve ARC and JSC, would be more to his liking.
2. Other uses of the IUS.
3. Better uses of the STS.
4. Technology readiness studies of Saturn orbiter dual probe, solar probe, and ion drive for Comet Enke mission. However, the latter was felt to have been adequately covered in the recent SEP/solar sail studies.
5. Wind powered balloon.
6. Autonomous operations technology enablement study.

J. Murphy presented an ARC idea: advanced IR astronomy mission concepts and technology requirements. Stan Sadin stated that such a study should cover more of the spectrum.

Mr. DiBattista from LaRC gave a presentation of the extended LDEF mission study, which will require $400K for a facility study. Stan Sadin said that RX has not funded this type study in the past, but would have to discuss the subject with various OAST people to see if perhaps such funding should be provided in the future.

SECTION 8

SESSION 'X'

REVIEW OF ANALYSIS STUDY PROGRAM

OAST Space Systems Technology Model

and

OAST Technology Forecast Handbook

Thomas Zakrzewski

Dave Riffelmacher

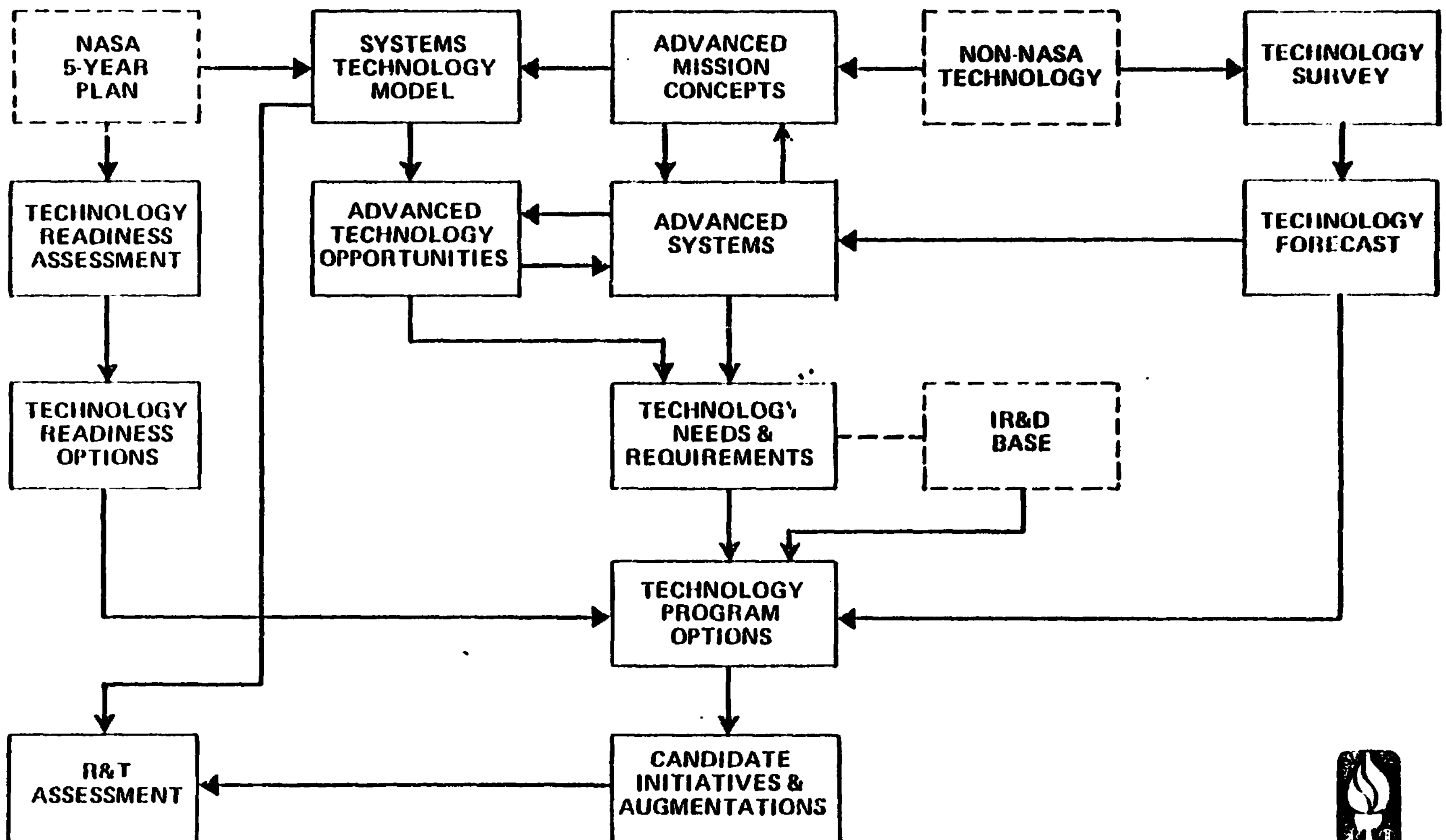
Ray Chase

General Research Corporation

12 January 1978

333

OAST Space Systems Studies



OAST Space Systems Technology Model

- PART OF THE OAST TECHNOLOGY PROGRAM PLANNING PROCESS
- DIVIDED INTO NEAR & FAR TERM MISSION OPPORTUNITIES
- PURPOSES
  - ASSIST IN DEVELOPING TECHNOLOGY PROGRAM OPTIONS
  - IDENTIFY MAJOR TECHNOLOGY AREAS REQUIRING CONCENTRATED EFFORTS
  - SERVE AS AN EVALUATION CRITERIA FOR CURRENT TECHNOLOGY PROGRAMS
- MODEL IS A SET OF GENERIC SYSTEMS
  - SELECTED TO DRIVE CRITICAL TECHNOLOGIES
  - DESIGNED TO PROVIDE REALISTIC CHALLENGES FOR TECHNOLOGY AREAS
- MODEL IS NOT
  - PREDICTING THE FUTURE
  - STATING NASA/OAST POLICY OR PLANS

OAST Space Systems Technology Model

- KEY DATA SOURCES
  - NASA OUTLOOK FOR SPACE
  - OAST SPACE THEME WORKSHOP
  - NASA FIVE YEAR PLAN
  - NASA ADVANCED STUDIES REPORTS
  - NASA PROGRAM OFFICES
  - OAST SPACE DIRECTORS
  - NASA CENTER TECHNOLOGISTS
  - GRC TECHNICAL STAFF

OAST Space Systems Technology Model

VOLUME I: FAR TERM 1990-2000

EXPLORATION OF THE UNIVERSE

1. Automated Planetary Station
2. Large Earth Orbital Solar Observatory
3. Astrophysics Space Laboratory
4. Atmospheric Physics Laboratory
5. Space-Based Radio Telescope

GLOBAL SERVICES

6. Large-Scale All Weather Survey System
7. High-Resolution Sea Survey System
8. Geological Mapping System
9. Earth Energy Budget Monitoring System
10. Global Communications System
11. Global Navigation System
12. Global Crop Inventory and Production Forecasting System
13. Disaster Warning System
14. Satellite Power System

UTILIZATION OF THE SPACE ENVIRONMENT

15. Space Station
16. Nuclear Waste Disposal System
17. Teleoperator Vehicle System
18. Lunar Base

SPACE TRANSPORTATION SYSTEMS

19. Single-Stage-to-Orbit Launch Vehicle
20. Space-Based Orbital Transfer Vehicle
21. Heavy-Lift Launch Vehicle
22. Advanced Escape Vehicle
23. Advanced Low-Thrust Escape Vehicle

OAST Space Systems Technology Model

VOLUME II: NEAR TERM 1980-1990

EXPLORATION OF THE UNIVERSE

1. Space Telescope
2. Out-of-Ecliptic Mission
3. Solar Maximum Mission Reflight
4. Spacelab Multiuser Instrument Program
5. Solar Probe
6. Origin of Plasmas in the Earth's Neighborhood (OPEN)
7. Synoptic Troposphere and Terraspace Environment Satellite
8. Pinhole Satellite
9. Solar Mesosphere Explorer
10. Active Magnetospheric Particle Tracer Experiment
11. Cosmic/X-Ray Observatory
12. HEAO-B
13. HEAO-C
14. Advanced X-Ray Astrophysical Facility
15. Cosmic Background Explorer
16. Gamma Ray Observatory
17. Large Area Moderate Angular Resolution X-Ray Array
18. Lunar Polar Orbiter
19. Jupiter Orbiter/Probe
20. Viking Mobile Lander
21. Halley Rendezvous
22. Venus Orbital Imaging Radar
23. Mars Surface Sample Return
24. Saturn Orbiter/Probe
25. Extreme Ultraviolet Explorer

OAST Space Systems Technology Model

VOLUME II: NEAR TERM 1980-1990 (Cont.)

GLOBAL SERVICES

26. Multimission Modular Spacecraft
27. SEASAT-B
28. Environmental Monitoring Satellite
29. Global Communications Land Mobile Services
30. Stormsat-A
31. Geodetic Survey Satellite
32. Public Service Communications Satellite
33. TIROS-O
34. Geostationary Platform
35. Molecular Wake Shield

UTILIZATION OF THE SPACE ENVIRONMENT

36. Teleoperator Orbiter Bay Experiment
37. Advanced Spacelab Space Processing Payloads
38. Space Manufacturing Module
39. 250-kW Power Module
40. 25-kW Power Module

SPACE TRANSPORATION SYSTEMS

41. Spin-Stabilized Upper Stage
42. Solar Electric Propulsion Stage
43. Orbital Transfer Vehicle

OAST Space Systems Technology Model

- **STATUS OF MODEL**

  - SECOND DRAFT DISTRIBUTED TO HEADQUARTERS PROGRAM OFFICES AND CENTERS IN DECEMBER

    - COMMENTS FROM CENTER TECHNOLOGISTS AND HQ PROGRAM OFFICES ON FIRST DRAFT INCORPORATED

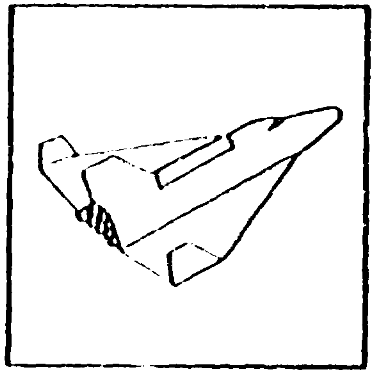
  - CONTENTS OF SECOND DRAFT AND COMMENTS COMING IN ON SECOND DRAFT BEING INCORPORATED INTO REVISED FORMAT

OAST Space Systems Technology Model

- **PRINCIPAL GOALS OF REVISED FORMAT**
  - PROVIDE AN OVERVIEW OF EACH OF THE SPACE THRUSTS
  - PROVIDE AS DETAILED INFORMATION AS POSSIBLE ON EACH SYSTEM DESCRIPTION AND THE TECHNICAL PROBLEMS WHICH MUST BE SOLVED
  - FOR EACH SYSTEM, IDENTIFY POTENTIAL SOLUTIONS, GIVING ALL KNOWN ALTERNATIVES
  - PROVIDE INFORMATION SOURCES AND NAMES OF COGNIZANT PERSONS TO CONTACT FOR MORE INFORMATION FOR EACH SYSTEM
  - GROUP TECHNOLOGY NEEDS BY FUNCTION WITHIN EACH SYSTEM
  - DISCUSS THE COMMONALITY/UNIQUENESS OF THE TECHNOLOGY NEEDS OF THE VARIOUS SYSTEMS BY SPACE THRUST

Far-Term Technology Model System No. 19

PRIORITY LAUNCH VEHICLE



PRIMARY DESIGN REQUIREMENT: **Provide economical (i.e., low cost per flight) transportation to and from low earth orbit for a wide variety of missions which include small-to-moderately size cargo and personnel. Design payload is in the range of 15 to 100 metric tons.**

VEHICLE CONCEPTS

A. A fully reusable, vertical-takeoff-horizontal landing (VTOHL), single-stage-to-orbit vehicle (SSTO) utilizing dual-mode rocket propulsion.

B. A horizontal-takeoff-horizontal landing (HTOHL) SSTO with sled-assisted takeoff.

C. A VTOHL 2-stage vehicle.

D. A HTOHL staged system using turbojet power boosters.

COMPARATIVE CONCEPT

The characteristics of concepts A and B are well defined at this time. The absolute and comparative features of concepts C and D are not well defined. Concept C would be expected to have most technology requirements in common with concept A. Concept D (turbojet booster) is in an early conceptual stage needing much more study. The turbojet technology has SST commonality; however, many other technology implications are expected to be unique for this concept.

INFORMATION SOURCES

References:

1. NASA CR-2866, 2867, and 2868
2. NASA CR-2878, 2879

Contacts

1. B. Z. Henry/LaRC

Far-Term Technology Model System No. 19 (Cont.)

PRIMARY TECHNOLOGY NEEDS	CAPABILITY MEASURE/ DESIRED VALUE	CONCEPT COMMONALITY	SYSTEM TECHNOLOGY COMMONALITY
ADVANCED STRUCTURES	WEIGHT REDUCTIONS/20-40%	ALL	20
COMPOSITE MATERIALS AND ADVANCED DESIGN FOR:			
WING/TAIL			
PROPELLANT TANKS	MASS FRACTION/3-5%		
THRUST STRUCTURE			
SECONDARY (e.g., DOORS, ADAPTERS)			
METALLIC HONEYCOMB FOR HOT STRUCTURES	NO. OF FLIGHTS REUSABLE/ 1000-2000		
PROPULSION			
DUAL-MODE ROCKETS, HIGH P_c HYDROCARBONS	PROPELLANT VOLUME REDUCTION/	A, C	20
	THRUST/10^6 — 10^7N		
	ENGINE WEIGHT REDUCTION/		
DUAL-MODE ROCKETS, SERIES, DUAL EXP.		A	
DUAL POSITION NOZZLES	I_{sp} INCREASE/		20
	EXPANSION RATIO/200:1-40:1	A, B	20

Far-Term Technology Model System No. 19 (Cont.)

SECONDARY TECHNOLOGY NEEDS	CAPABILITY MEASURE/ DESIRED VALUE	CONCEPT COMMONALITY	SYSTEM TECHNOLOGY COMMONALITY
ADVANCED STRUCTURES			
SUBSYSTEMS	WEIGHT REDUCTIONS/15-20%	ALL	20
ADVANCED DESIGN AND MATERIALS			
THERMAL PROTECTION SYSTEM	WEIGHT REDUCTION/5-10%	ALL	20
REUSABLE SURFACE INSULATION	NO. OF FLIGHTS REUSABLE/ 100-200		
METALLIC STANDOFF	TEMPERATURE CAPABILITY/		
AUTOMATED DESIGN INTEGRATION	RDT&E MANPOWER REDUCTIONS/70-80%	ALL	20
AUTOMATED CONTROL LANDING GEAR	WING FORCE REDUCTION/ 25%	ALL	
PROPULSION			
PROPELLANTS			
SUB-COOLED CRYOGENS	VOLUME REDUCTIONS/		20
LOW-COST HYDROCARBONS			

OAST Technology Forecast Handbook

- PART OF THE OAST TECHNOLOGY PROGRAM PLANNING PROCESS
- DISPLAYS TECHNOLOGY READINESS OF VARIOUS CAPABILITY MEASURES/DESIRED VALUES FOUND IN OAST SPACE SYSTEMS TECHNOLOGY MODEL
  - —STATE-OF-THE-ART
  - —FUTURE TREND OF CAPABILITY MEASURE

OAST Technology Forecast Handbook

- **KEY DATA SOURCES**
  - A FORECAST OF SPACE TECHNOLOGY, 1980 – 2000
  - OUTLOOK FOR SPACE
  - NASA CONTRACTOR REPORTS
  - TECHNICAL JOURNALS
  - POPULAR MAGAZINES
  - "FUTURES" STUDIES
  - TECHNOLOGY FORECASTS BY GOVERNMENT & INDUSTRY

OAST Technology Forecast Handbook

- **STATUS OF HANDBOOK**

  – FORECASTS FOR VARIOUS INFORMATION SYSTEMS AND TRANSPORTATION SYSTEMS "CAPABILITY MEASURES" HAVE BEEN ASSEMBLED

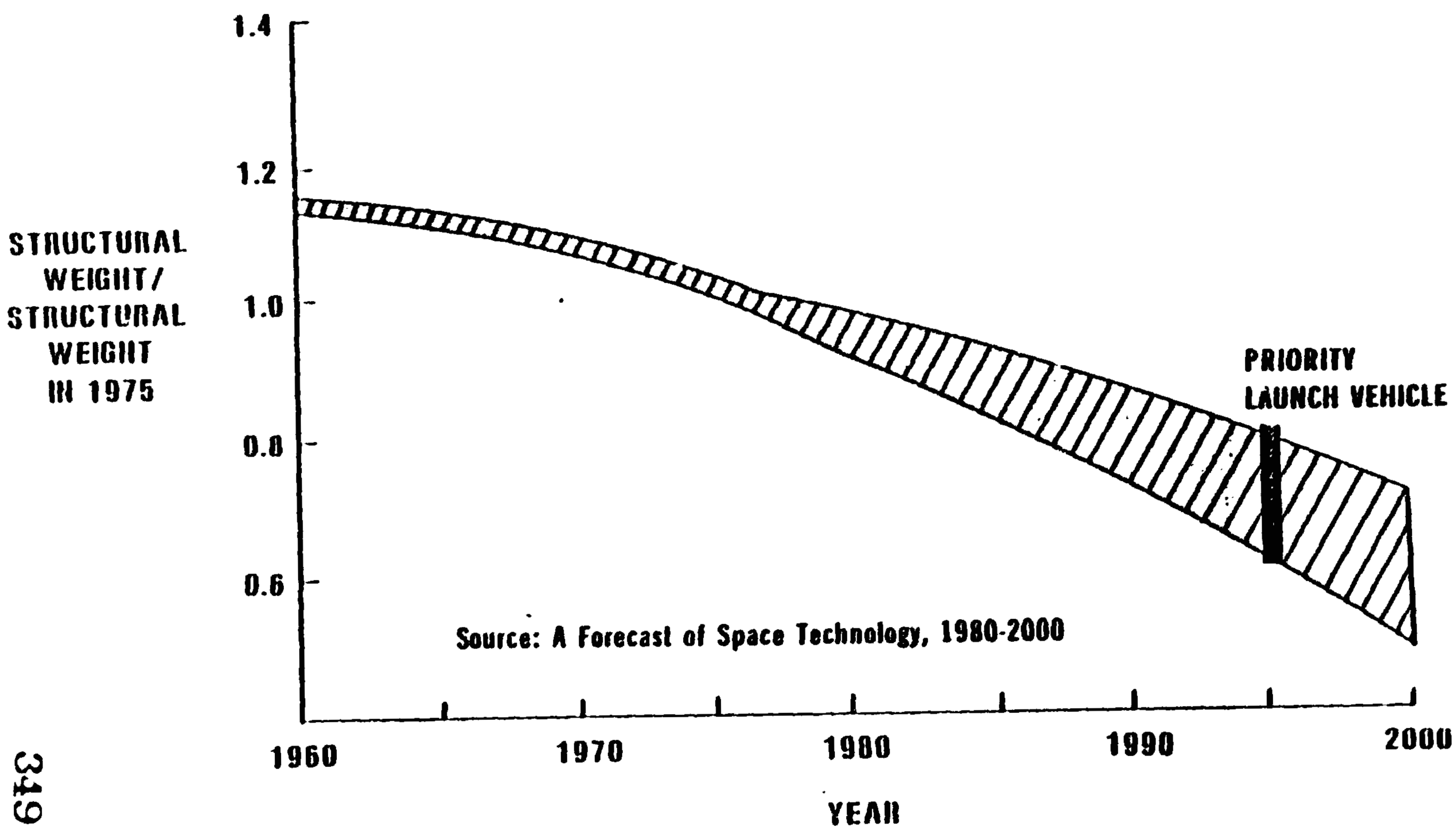
  – FOR AVAILABLE FORECASTS, "DESIRED VALUES" ARE BEING COMPARED WITH PROJECTED VALUES

Far-Term Technology Model System No. 19 (Cont.)

PRIMARY TECHNOLOGY NEEDS	CAPABILITY MEASURE/ DESIRED VALUE	CONCEPT COMMONALITY	SYSTEM TECHNOLOGY COMMONALITY
ADVANCED STRUCTURES	WEIGHT REDUCTIONS/20-40%	ALL	20
COMPOSITE MATERIALS AND ADVANCED DESIGN FOR:			
WING/TAIL			
PROPELLANT TANKS	MASS FRACTION/3-5%		
THRUST STRUCTURE			
SECONDARY (e.g., DOORS, ADAPTERS)			
METALLIC HONEYCOMB FOR HOT STRUCTURES	NO. OF FLIGHTS REUSABLE/ 1000-2000		
PROPULSION			
DUAL-MODE ROCKETS, HIGH P_c HYDROCARBONS	PROPELLANT VOLUME REDUCTION/	A, C	20
	THRUST/10^6 — 10^7 N		
	ENGINE WEIGHT REDUCTION/		
DUAL-MODE ROCKETS, SERIES, DUAL EXP.		A	
DUAL POSITION NOZZLES	I_{sp} INCREASE/		20
	EXPANSION RATIO/200:1-40:1	A, B	20

Space System Technology Forecast

● STRUCTURAL WEIGHT REDUCTION FOR SPACE SYSTEMS



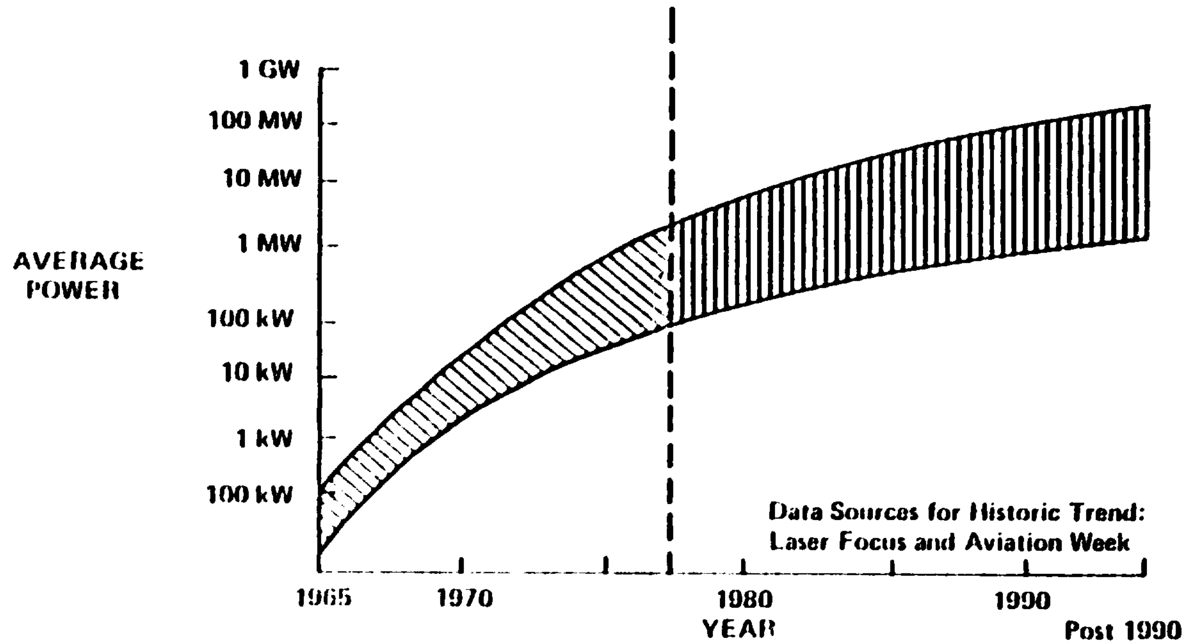
- **PLANS FOR HANDBOOK**
  - SELECT THOSE "TECHNOLOGY NEEDS" AND "CAPABILITY MEASURES" FROM THE OAST SPACE SYSTEMS TECHNOLOGY MODEL FOR WHICH FORECASTS ARE NEEDED
  - PERFORM A LITERATURE SEARCH FOR HISTORIC DATA POINTS FOR EACH SELECTED "CAPABILITY MEASURE" TO DETERMINE THE PAST TREND
  - PROJECT THESE HISTORIC TRENDS INTO THE FUTURE (TO 2000) BY TREND EXTRAPOLATION AND CHECK THE TREND EXTRAPOLATIONS TO ENSURE NO FUNDAMENTAL LIMITS ARE VIOLATED
  - DISTRIBUTE THE RESULTING FORECASTS TO EXPERTS IN RELEVANT TECHNOLOGY AREAS FOR COMMENTS/ALTERATIONS
  - GENERATE TECHNOLOGY FORECASTS WHICH INCORPORATE THE COMMENTS

OAST Technology Forecast Handbook

- **FORMAT FOR OBTAINING EXPERT OPINION ON TREND PROJECTIONS**
  - PRESENT EXPERT WITH HISTORIC TREND AND PROJECTION
  - ASK FOR REFERENCES TO SIGNIFICANT RECENT WORK
  - ASK THE EXPERT TO RATE FACTORS WHICH MAY INFLUENCE THE TREND
  - ASK FOR THE EXPERT'S PROJECTION FOR THE YEARS 1990 and 2000
  - INQUIRE ABOUT THE MEANS BY WHICH THE EXPERT'S PROJECTION MAY BE FULFILLED

Sample Trend Projection Format

FIGURE 1 SHOWS THE TREND OF THE AVERAGE POWER OF HIGH ENERGY LASERS AND AN ENVELOPE OF PROJECTED FUTURE RANGE.



1a. HAVE YOU ENCOUNTERED SIGNIFICANT WORK WITHIN THE PAST YEAR WHICH MAY AFFECT THE FUTURE TREND? IF SO, PLEASE PROVIDE A REFERENCE:

Sample Trend Projection Format (cont.)

1b. MANY FACTORS MAY INFLUENCE THE PROJECTION, SOME OF WHICH WILL ENHANCE THE GROWTH OF LASER AVERAGE POWER, SOME OF WHICH WILL HINDER ITS GROWTH. CONSIDER THE INFLUENCING FACTORS LISTED IN TABLE 1. THE LEFT COLUMN CONTAINS ENHANCING FACTORS; THE RIGHT COLUMN CONTAINS HINDERING FACTORS. PLEASE ADD ANY ADDITIONAL INFLUENCING FACTORS WHICH YOU FEEL ARE IMPORTANT, IN THE BLANK SPACES PROVIDED. ASSIGN WEIGHTS TO ALL OF THE INFLUENCING FACTORS ON A SCALE OF 0 to 4 (0 = NOT IMPORTANT, 4 = VERY IMPORTANT)

ENHANCING	Weight (0-4)	HINDERING	Weight (0-4)
ANTAGONISMS AMONG VARIOUS NATIONS LEAD TO INTENSIFIED U.S. DEPARTMENT OF DEFENSE HIGH POWER LASER WORK.		FUTURE STRATEGIC ARMS LIMITATION TALKS RESTRICT HIGH ENERGY LASER MILITARY APPLICATIONS	
SEVERE ENERGY SHORTAGES LEAD TO GREAT EMPHASIS ON COLLECTING AND/OR GENERATING ENERGY IN SPACE AND TRANSFERRING IT TO EARTH BY LASER.		ALTERNATIVE FORMS OF ENERGY, e.g., COAL AND/OR SOLAR, PROVE MORE ECONOMICALLY AND/OR TECHNOLOGICALLY VIABLE THAN LASER FUSION.	
MUCH HIGHER POWER VERSIONS OF CURRENT STATE-OF-THE-ART LASERS PROVE ECONOMICALLY AND TECHNICALLY FEASIBLE.		HIGH ENERGY LASER DEVELOPMENT COSTS PROVE TO BE TOO GREAT TO MERIT CONTINUATION OF SUCH WORK.	
SEVERE ENERGY SHORTAGES LEAD TO INCREASED FUNDING OF U.S. DEPARTMENT OF ENERGY LASER FUSION WORK.		MUCH HIGHER POWER VERSIONS OF CURRENT STATE-OF-THE-LASERS PROVE ECONOMICALLY AND/OR TECHNICALLY IMPRACTICAL.	
A TECHNOLOGICAL BREAKTHROUGH, ANALOGOUS TO THE ADVENT OF THE GAS-DYNAMIC LASER SEVERAL YEARS AGO, LEADS TO A NEW TYPE OF LASER.		PUBLIC DISTRUST OF THE U.S. FEDERAL GOVERNMENT PRECLUDES A HIGH LEVEL OF U.S. EMPHASIS ON HIGH ENERGY LASER WORK.	

Sample Trend Projection Format (Cont.)

1c. What will be the maximum average power a laser achieves by the given year?

YEAR	AVERAGE POWER
1990	________
2000	________

1d. In the following table, please check one entry in each of the three columns to indicate the combination(s) of pumping method, lasing medium, and radiative phenomena which you believe will be exploited to achieve the average power predicted for the year 2000 in question 1c. If you choose "other", please specify. To indicate serveral combinations, use "✓", "X", etc.

PUMPING	✓	MEDIUM		✓	RADIATIVE PHENOMENA		✓
NUCLEAR		GAS	CO_2		ATOMIC	ELECTRON TRANSITION	
SOLAR			CO				
FLASHLAMP			HF			OTHER:	
ACOUSTIC			DF			OTHER:	
ELECTRON BEAM			OTHER:		MOLECULAR	DISASSOCIATION	
ELECTRIC DISCHARGE			OTHER:			VIBRATIONAL	
ELECTRON INJECTION		SOLID	Nd: GLASS			ELECTRONIC	
SHOCK HEATING			Nd: YAG			ROTATIONAL	
GASDYNAMIC			OTHER:			OTHER:	
TEA						OTHER:	
OTHER:		LIQUID	DYES			OTHER:	
			OTHER:				

OAST Technology Forecast Handbook

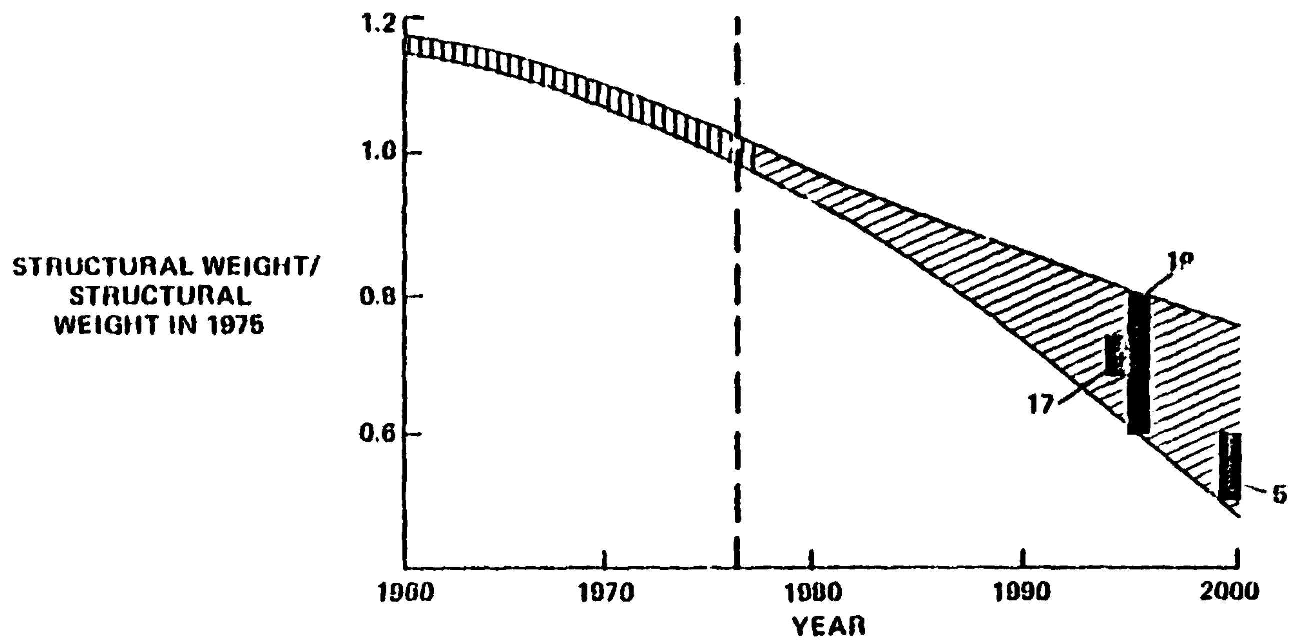
- **PUBLICATION OF RESULTANT FORECASTS**

  - REFERENCE DOCUMENT CONTAINING THE FORECASTS AND COMMENTS RECEIVED FROM THE EXPERTS AND A PROJECTION OF EACH "CAPABILITY MEASURE" BASED UPON AN ANALYSIS OF ALL AVAILABLE INFORMATION

  - SUMMARY DOCUMENT WHICH RELATES THE "CAPABILITY MEASURE" TREND PROJECTIONS TO THE "DESIRED VALUES" FOR THE SYSTEMS IN THE OAST SPACE SYSTEMS TECHNOLOGY MODEL

Sample Summary Format

- LIGHTWEIGHT ADVANCED STRUCTURES



SYSTEM	PRIMARY	DESIRED VALUE	DESIRED TECHNOLOGY READINESS DATE	PROJECTED TECHNOLOGY READINESS DATE
PRIORITY LAUNCH VEHICLE 19	✓	20-40% REDUCTION	1995	1985-1995 (20%) 1995-2000+ (40%)
SPACE-BASED RADIO TELESCOPE 5		40-50% REDUCTION	2000	1995-2000+ (40%) 2000+ (50%)
TELEOPERATOR VEHICLE SYSTEM 17		25-30% REDUCTION	1995	1990-2000 (25%) 1992-2000+ (30%)
HEAVY LIFT LAUNCH VEHICLE 20	✓	30-40% REDUCTION		1992-2000+ (30%) 1995-2000+ (40%)
ORBITAL ESCAPE VEHICLE 23		30-50% REDUCTION		1992-2000+ (30%) 2000+ (50%)

SESSION 'X' - ANALYSIS

OAST Space Systems Technology Model and OAST Technology Forecast Handbook (T. Zakrzewski, GRC)

DISCUSSION: The question was raised whether the critical technology needs identified in the model are really needs or ways of achieving the needs. Also, there was a request for a type of correlation matrix between the identified needs. It was suggested that the forecasts contain both the perturbed and unperturbed growth trend curves.

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OF POOR QUALITY

APPENDIX A

STUDY DESCRIPTION PACKAGE

EXTRACTED FROM REVIEW MEETING ANNOUNCEMENT

TABLE 1

SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

NASA Headquarters (FOB 10B), Room 625

FIRST DAY

8:15	Overview of OAST Space Studies Program
8:30	Session 'U' - Space Utilization
10:30	Session 'T' - Space Transportation
12:30	Lunch
1:30	Session 'M' - Multiprogram Technology

SECOND DAY

8:15	Session 'A' - Applications
12:10	Lunch
1:10	Session 'X' - Analysis
2:10	Session 'S' - Science and Exploration

TABLE 2

SPACE SYSTEMS STUDIES REVIEW MEETING

11 and 12 January 1978

NASA Headquarters (FOB 10B), Room 625

Session 'U' - Space Utilization	2 hr	
Space Utilization Studies	Gilbreath (ARC)	30 min
Large Space Systems Using Nonterrestrial Materials and Nonterrestrial Materials Processing	Crum (JSC)	30 min
Nonterrestrial Materials Fabrication Technology	von Tiesenhausen (MSFC)	30 min
FY 79 Programs	All	30 min
Session 'T' - Space Transportation	2 hr	
Advanced Transportation Systems	Henry (LaRC)	50 min
Advanced Transportation - Propulsion Systems	Pelouch (LeRC)	40 min
FY 79 Programs	All	30 min
Session 'M' - Multiprogram Technology	3 hr	
Advanced Automation Technology	Heer (JPL)	30 min
Pointing and Control Systems	Fechman (JPL)	15 min
Software Technology Enablement	Capps (MSFC)	30 min
New Data System Technology Requirements	Krchnak (JSC)	30 min
Cryogenics Technology	Manning (ARC)	15 min
Space Power	Stearns (JPL)	30 min
FY 79 Programs	All	30 min

TABLE 2 (Cont.)

Session 'A' - Applications	3 hr, 55 min	
SEASAT B Readiness	West (JPL)	20 min
Pollution Monitoring Mission	Hook (LaRC)	15 min
Public Services Platform	Durham (GSFC)	15 min
Advanced Penetration Concepts	Manning (ARC)	30 min
Post-LANDSAT Concept Evaluation	Flatow (GSFC)	30 min
Advanced Global Services Concepts	Hook (LaRC)	30 min
	Nagler (JPL)	25 min
	Durham (GSFC)	15 min
	Aviv (Aerospace)	15 min
Geostationary Platform	Hamilton (MSFC)	10 min
FY 79 Programs	All	30 min
Session 'X' - Analysis	1 hr	
Technology Model, Technology Forecasting Handbook	Zakrzewski (GRC)	30 min
FY 79 Programs	All	30 min
Session 'S' - Science and Exploration	2 hr, 50 min	
Space-Based Radio Telescope	Edelson (JPL)	30 min
Space-Based Planetary Detection	Black (ARC)	30 min
Mars Sample Return Readiness	West (JPL)	15 min
VOIR Readiness	West (JPL)	20 min
Prospecting Instrumentation	Brereton (JPL)	30 min
Advanced Sample Return Concepts	West (JPL)	15 min
FY 79 Programs	All	30 min

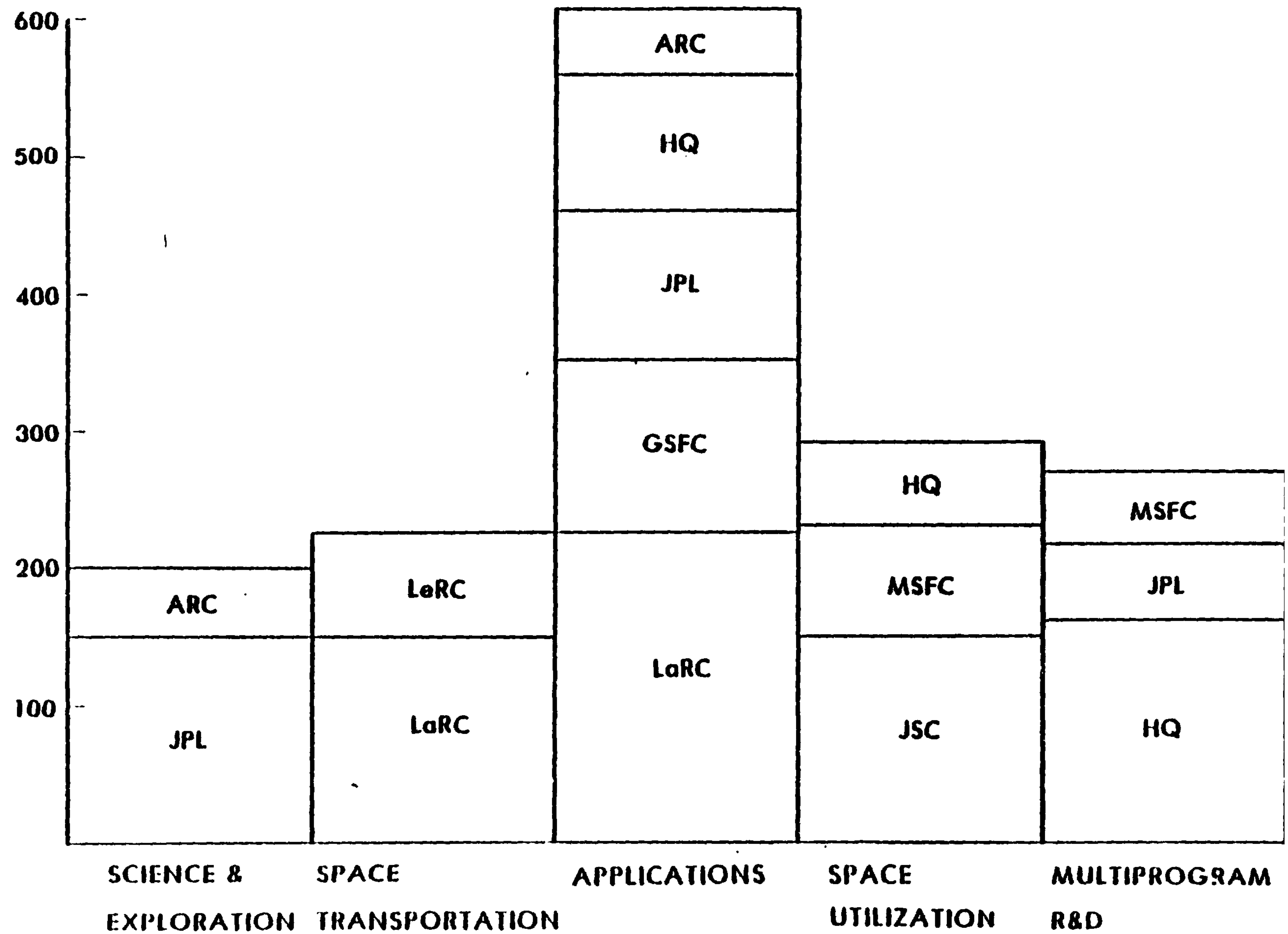
SPACE SYSTEM STUDIES

- STUDY FUTURE PROGRAMS AND TECHNOLOGY, BOTH PLANNED AND FORECAST, TO GENERATE OAST TECHNOLOGY PLANNING ALTERNATIVES

- EVALUATE ALTERNATIVES TO PROVIDE DEVELOPMENT COST, RISK, AND BENEFIT INSIGHTS OR MEASURES

- STUDY R&T BASE ACTIVITIES TO IDENTIFY AUGMENTATIONS/INITIATIVES IN
  - MAJOR TECHNOLOGY "DRIVERS"
  - SYSTEMS TECHNOLOGY PROJECTS
  - SPACELAB EXPERIMENTS

OAST SPACE SYSTEM STUDIES - FY78 NET R&D FUNDING

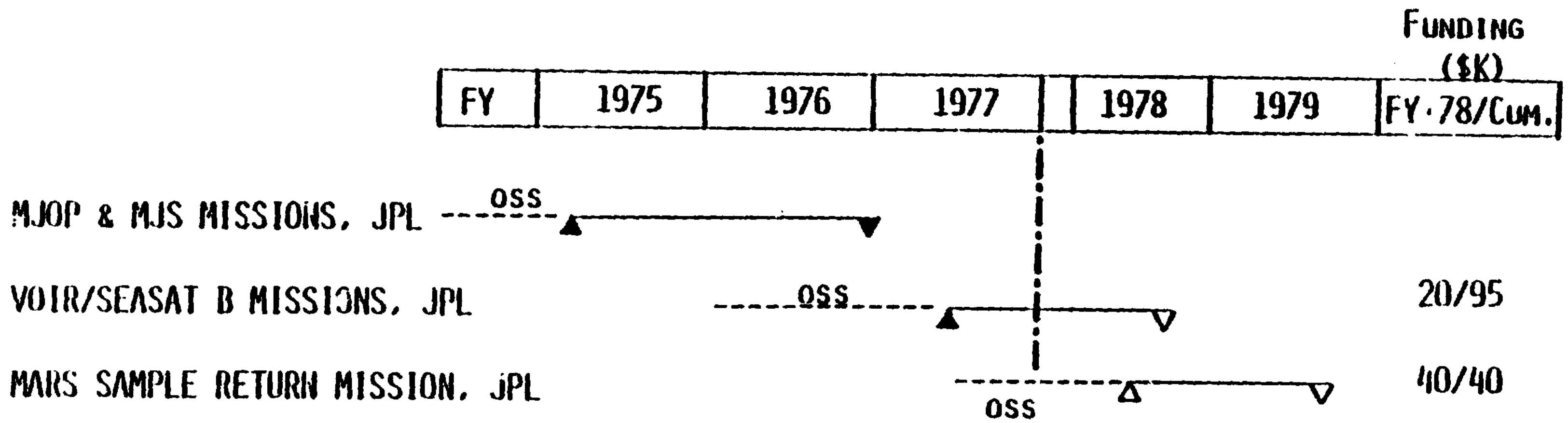


FY78 OAST SPACE SYSTEM STUDIES

AGENCY THEMES	TECHNOLOGY READINESS	ENABLING TECHNOLOGY	
SCIENCE & EXPLORATION	Astrophysics • Mars Sample Return Planetary • VOIR/SEASAT B	• Space Radio-Telescope • Planetary Detection • Sample Return • Penetrators	200K
APPLICATIONS	• Pollution Monitoring • Public Service Platform	• Post-LANDSAT • Global Services Mission	610K
SPACE UTILIZATION		• Space Industrialization • Lunar Materials:	280K
SPACE TRANSPORTATION		• Earth-To-GEO • Low Thrust Propulsion	225K
MULTIPROGRAM R&D		• Automation • Pointing & Control • Software Forecasting	Analysis & Planning • 265K
	165K	1235K	

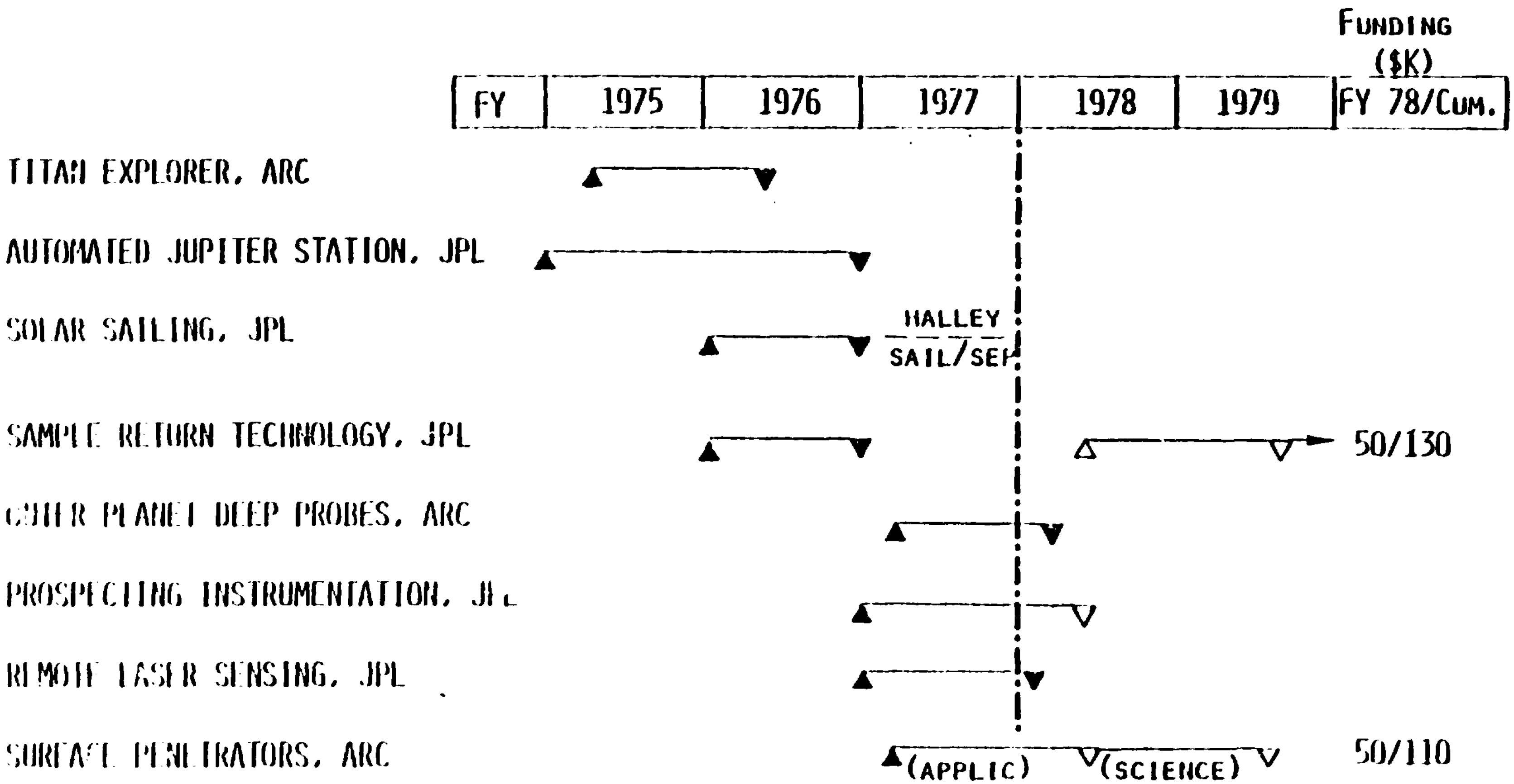
TECHNOLOGY READINESS - PLANETARY

IDENTIFY & EVALUATE TECHNOLOGY ALTERNATIVES FOR PLANNED AGENCY PLANETARY PROGRAMS.



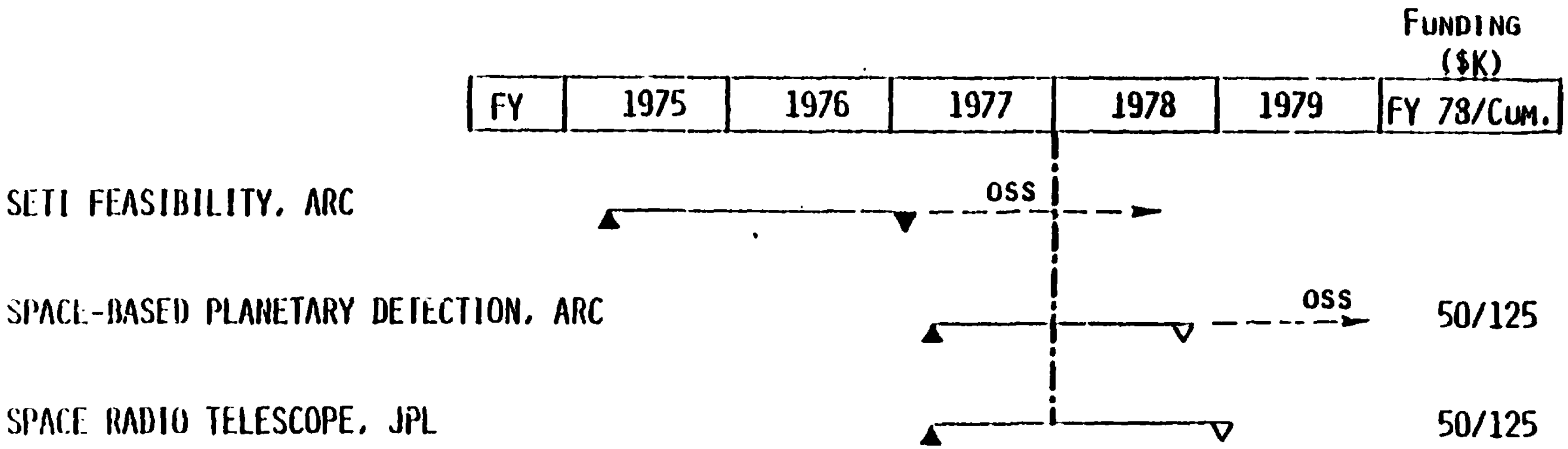
ENABLING TECHNOLOGY - PLANETARY

FORECAST FUTURE PLANETARY EXPLORATION SYSTEMS AND IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, & RANK CANDIDATES.



ENABLING TECHNOLOGY - ASTROPHYSICS

FORECAST SPACE ASTROPHYSICS SYSTEMS AND IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, AND RANK CANDIDATES



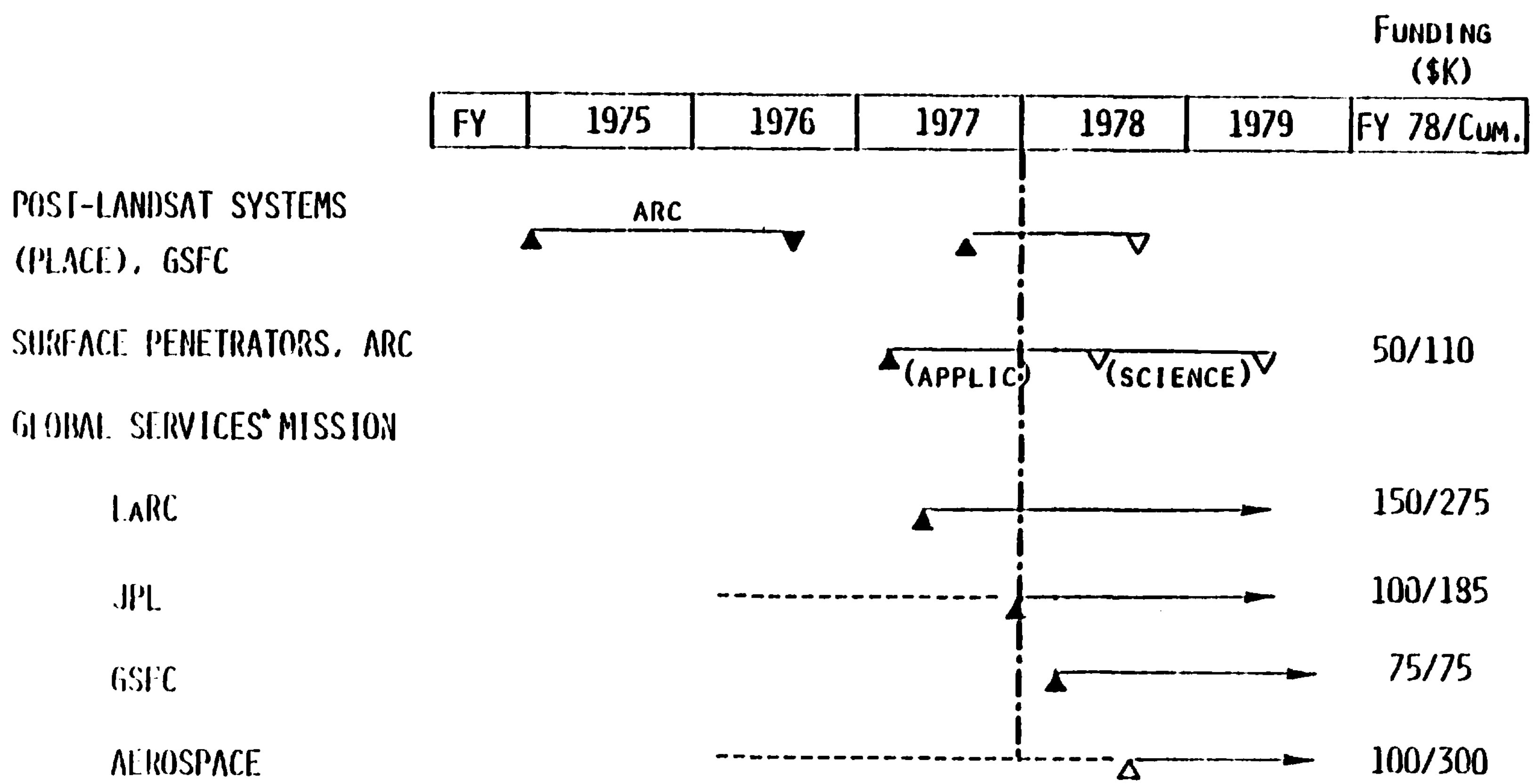
TECHNOLOGY READINESS - APPLICATIONS

IDENTIFY & EVALUATE TECHNOLOGY ALTERNATIVES FOR PLANNED AGENCY APPLICATIONS PROGRAMS.

FY	1975	1976	1977	1978	1979	FUNDING ($K) FY 78/CUM.
SEASAT B/VOIR MISSIONS, JPL		OA				20/95
POLLUTION MONITORING, LARC						75/75
PUBLIC SERVICE PLATFORM, GSFC						50/50

ENABLING TECHNOLOGY - APPLICATIONS

FORECAST FUTURE SPACE APPLICATIONS SYSTEMS & IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, & RANK CANDIDATES.



ADVANCED APPLICATION SYSTEMS CONCEPTS AND ENABLING TECHNOLOGY

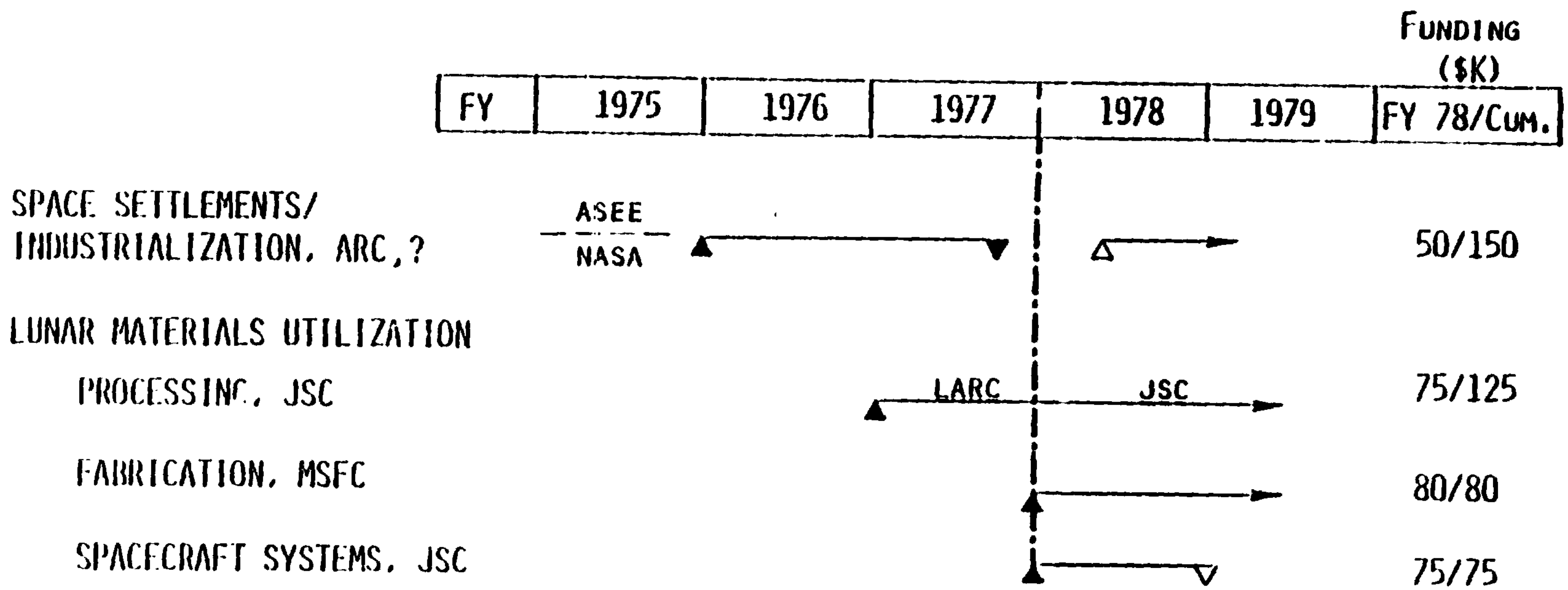
- ESTABLISH MODEL OF 1990s GLOBAL SERVICES PLATFORMS WITH CENTRALIZED SERVICES
  - SENSING
  - INFORMATION PROCESSING
  - INFORMATION TRANSFER
  - POWER
- GENERATE ENABLING TECHNOLOGY FORECASTS FOR PROPULSION, POWER, MATERIALS, STRUCTURES, AND ELECTRONICS

PARTICIPANT	ROLE	FY 78 RESOURCES		
		NET R&D	IMS	CS MY
LaRC	• LEAD CENTER RESPONSIBILITY • SYSTEM CONCEPT INTEGRATION AND MANAGEMENT	150	73	9.0
JPL	• TOP DOWN LOGIC • PARAMETRIC TRADES • OCEAN OBSERVATIONS	100	0	N.A.
GSFC	• COMMUNICATIONS/INFORMATION TRANSFER • LAND AND ATMOSPHERIC OBSERVATIONS • INTEGRATE WITH NEEDS	75		3-4
AEROSPACE	• CHANGE FROM CATALOGUING • DOD INTERFACE • RELEVANT DOD TECHNOLOGY	100	0	N.A.

0270

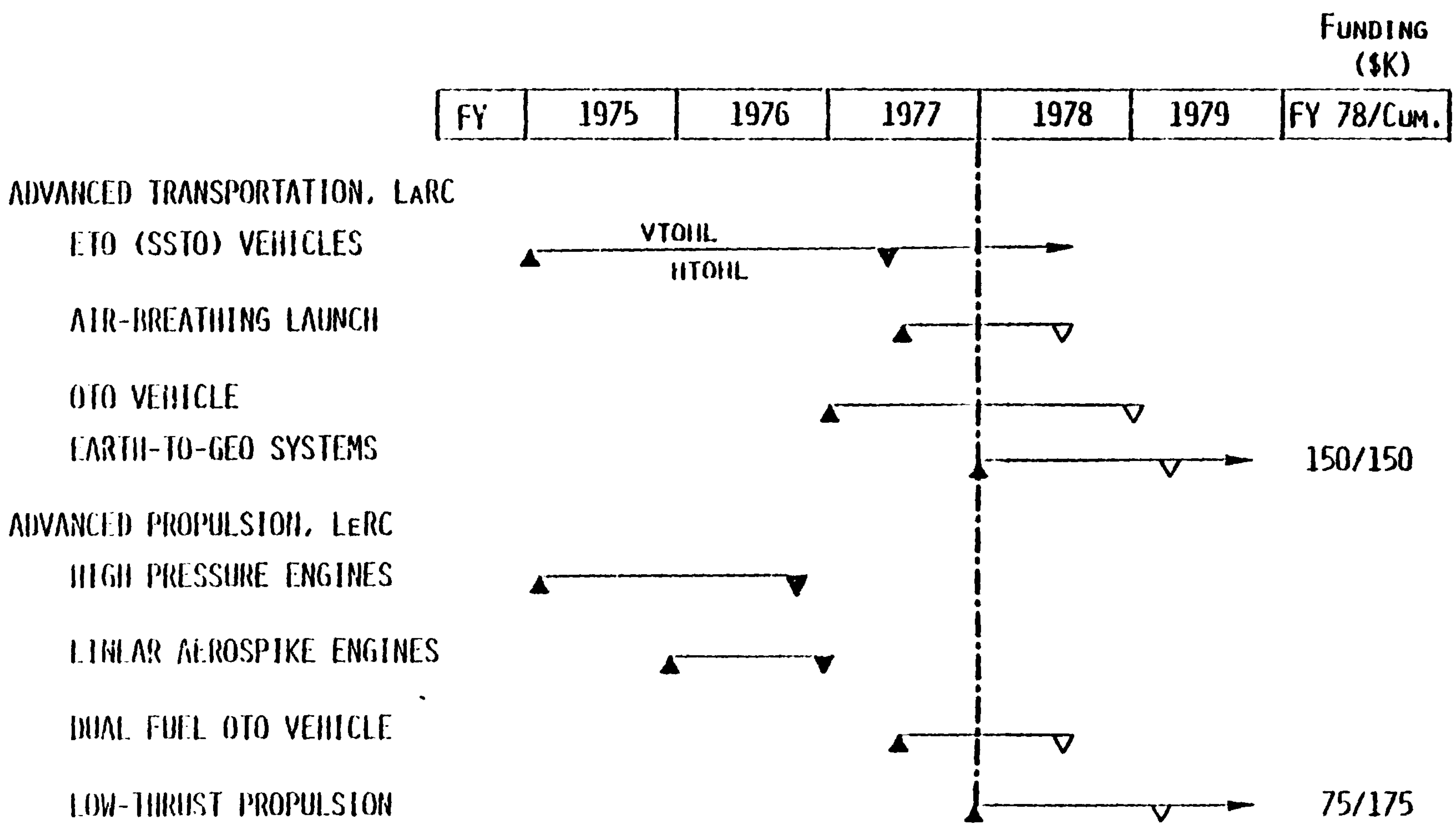
ENABLING TECHNOLOGY - UTILIZATION

FORECAST FUTURE SPACE UTILIZATION SYSTEMS & IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, & RANK CANDIDATES.



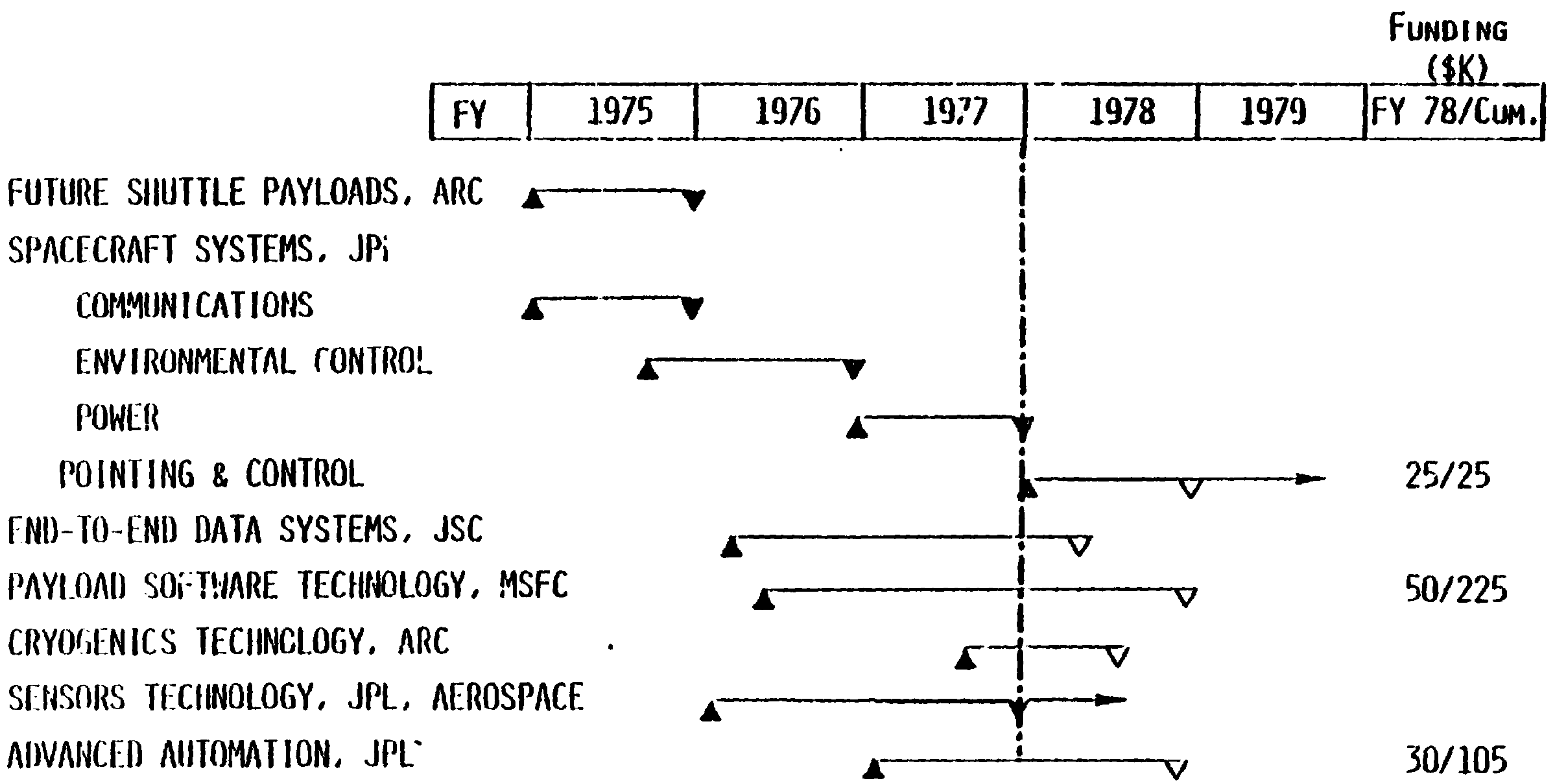
ENABLING TECHNOLOGY - TRANSPORTATION

FORECAST FUTURE SPACE TRANSPORTATION SYSTEMS & IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, & RANK CANDIDATES.



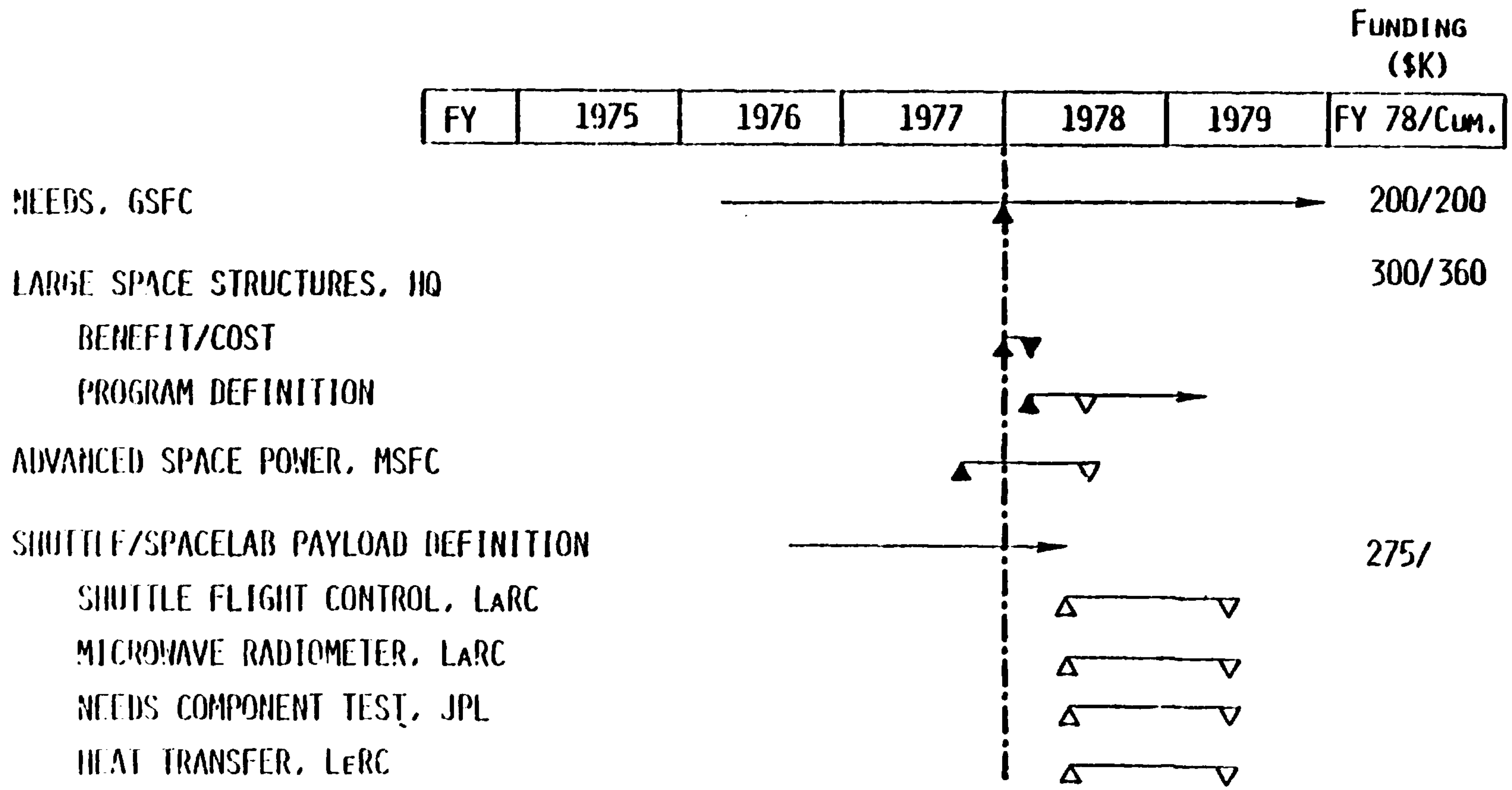
ENABLING TECHNOLOGY - MULTIPROGRAM

FORECAST MULTIPROGRAM SYSTEMS, IDENTIFY TECHNOLOGY NEEDS, DEVELOPMENT OPTIONS, & RANK CANDIDATES.



NEW INITIATIVES/AUGMENTATIONS - PROGRAM DEVELOPMENT

CONDUCT STUDIES TO DEVELOP TECHNICAL PLANS, SCHEDULES, & COSTS FOR TECHNOLOGY INITIATIVES & AUGMENTATIONS.



FY 78 OAST TECHNOLOGY INITIATIVES AND AUGMENTATIONS

	Information Systems		Spacecraft Systems					Transportation Systems			Power Systems	
	NEEDS	ESS	LSST	Nonlinear Large Deflection	Automated Operations	Nonterrestrial Resources	Long-Life Composites	Reusable Propulsion	CASTS	Low-Thrust Propulsion	MOPP	High-Performance Power
1. Science & Exploration	X	X	X		X		X					X
2. Applications	X	X	X		X						X	
3. Space Utilization			X	X	X	X		X			X	X
4. Space Transportation								X	X	X		
5. Multiprogram R&D	X	X	X	X	X			X		X	X	
6. Discipline	X	X	X								X	X

ATTACHMENT 2

FY 1978 PLANNING STUDY

1.	PROGRAM CATEGORY:	OAST Space Systems, Enabling Technology
2.	STUDY TITLE:	Space Utilization Grants
3.	STUDY PURPOSE:	Concepts studies and workshops for technology identification for space settlements.
4.	PRINCIPAL TASKS:	Consider lunar materials constructed systems, mass drivers, asteroid retrieval, etc.
5.	RESULTS EXPECTED:	Development of novel concepts.
6.	USE OF RESULTS:	Technology planning for 1990s. Provide insights for LSST, nonlinear large deflection, automated operations, nonterrestrial resources, reusable propulsion, MOPP, and high-performance power activities.
7.	LENGTH OF STUDY:	3 years
8.	MANAGEMENT:	OAST Study, Analysis, and Planning Office (RX)/
9.	RESOURCES ($K):	100; RX - 50, OSF - 50 Cumulative: 200
	MAN-YEARS (CS/SC):	0/2
10.	UNIQUE PROJECT NO.:	790-40-31(03)

[redacted]

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Mining and Processing Nonterrestrial Materials

3. STUDY PURPOSE: Provide guidelines for developing the technology necessary to utilize nonterrestrial materials as resources, particularly as metals, glasses, ceramics and composites, and useful gases.

4. PRINCIPAL TASKS:
   (1) Catalogue lunar resources.
   (2) Determine viable processes for converting nonterrestrial materials into useful products.

5. RESULTS EXPECTED: Design of bench scale processes that will yield metals, ceramics, glasses, composites, or useful gases, and determine technology requirements.

6. USE OF RESULTS: Help determine value and direction of nonterrestrial materials utilization program. Provide insights for Agency activities in ESS, automated operations, nonterrestrial resources, and MOPP.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Materials and Structures Division (RW), OAST Study, Analysis, and Planning Office (RX)/JSC, Lunar Science Institute

9. RESOURCES ($K): RW - 30. Cumulative: 90; RX - 60, RW - 30

   MAN-YEARS (CS/SC): 0.3/0.1

10. UNIQUE PROJECT NO.:

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Systems, Enhancing Technology

2. STUDY TITLE: Nonterrestrial Materials Fabrication Technology

3. STUDY PURPOSE: Examine secondary refining and manufacturing processes using nonterrestrial materials.

4. PRINCIPAL TASKS: Assess economic, resources, environmental, and other consequences of utilizing nonterrestrial materials.

5. RESULTS EXPECTED: Comparative assessment of space construction from terrestrial and nonterrestrial materials.

6. USE OF RESULTS: OAST technology planning. Provide insights for automated operations, nonterrestrial resources, and MOPP activities.

7. LENGTH OF STUDY: 1 year

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/MSFC

9. RESOURCES ($K): 80

MAN-YEARS (CS/SC): 1.6/

10. UNIQUE PROJECT NO.: 790-40-39

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space Studies

2. STUDY TITLE: Nonterrestrial Materials for Future Large Spacecraft Systems

3. STUDY PURPOSE: Estimate technical and economic factors for operating a lunar materials program consisting of mining, transport, processing, and fabrication.

4. PRINCIPAL TASKS: Determine technical and economic feasibility of using lunar resources including processing and transportation techniques.

5. RESULTS EXPECTED: Generate approach and initial evaluation of alternatives for using nonterrestrial materials in large spacecraft systems. Derive initial estimates of the threshold at which investment in a space based lunar material utilization program is economically feasible.

6. USE OF RESULTS: Help determine value and direction of a nonterrestrial materials utilization program. Provide insights for agency activities in LSST, automated operations, nonterrestrial resources, and MOPP.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JSC

9. RESOURCES ($K): 150

MAN-YEARS (CS/SC):

10. UNIQUE PROJECT NO.: 790-40-17(01)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Advanced Transportation Technology

3. STUDY PURPOSE: Identify and evaluate technology required for the design and operation of economical transportation in the post-shuttle time frame; initiate Earth-to-geosynchronous technology study program similar to previous OTO and SSTO programs.

4. PRINCIPAL TASKS: Perform integrated study of all space transportation requirements, including SSTO, cargo, priority, orbital transfer, etc.
   Identify system requirements, vehicle options, and advanced concepts for Earth-to-GEO vehicles

5. RESULTS EXPECTED: Identify crucial and cost-effective technologies and technology devices for integrated transportation system.

6. USE OF RESULTS: Technology identification and evaluation to support advanced transportation systems. Provide insights for agency activities in reusable propulsion and CASTS.

7. LENGTH OF STUDY: 1 year

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/LaRC

9. RESOURCES ($K): 150, 89 TMS

   MAN-YEARS (CS/SC): 3.6/1.1

10. UNIQUE PROJECT NO.: 790-40-33

P-5

FY 1978 PLANNING STUDY

1.	PROGRAM CATEGORY	OAST Space System Studies, Enabling Technology
2.	STUDY TITLE:	Low-Thrust Propulsion Systems
3.	STUDY PURPOSE:	Evaluate low-impulse thrusters and determine comparative value and preferred system applications. This study has two parts: (1) electric propulsion--a contract effort, (2) low-thrust propulsion--an in-house effort.
4.	PRINCIPAL TASKS:	(1) Parametric analysis of candidate systems: weight, size, performance, and operational characteristics. (2) Identify key technology experiments to verify feasibility and performance characteristics.
5.	RESULTS EXPECTED:	Conceptual designs and identification of key technology development needs and experiments.
6.	USE OF RESULTS:	Support new OAST technology initiative/augmentation in low-thrust propulsion.
7.	LENGTH OF STUDY:	1 year
8.	MANAGEMENT:	OAST Study, Analysis, and Planning Office (RX), OAST Space Propulsion and Power Division (RP)/LeRC
9.	RESOURCES ($K):	175; RX - 75, RP - 100 (FY 77)
	MAN-YEARS (CS/SC):	
10.	UNIQUE PROJECT NO.:	790-40-12

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enhancing Technology

2. STUDY TITLE: Advanced Automation Technology

3. STUDY PURPOSE: Assist NASA in enhancement of planned missions and enablement of future missions through projected advances in automation, machine intelligence, robotics, etc.

4. PRINCIPAL TASKS:
   (1) Conduct workshop series involving artificial intelligence spacialists and NASA personnel.
   (2) Explore for enhancing planned missions.
   (3) Explore for enabling novel missions.

5. RESULTS EXPECTED: Recommend programs of research, advanced development, and implementation of machine intelligence technology.

6. USE OF RESULTS: Provide insights for NEEDS and automated operations activities.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL

9. RESOURCES ($K): 30 Cumulative: 105

   MAN-YEARS (CS/SC): 0/0.3

10. UNIQUE PROJECT NO.: 790-40-15(01)

FY 1978 PLANNING STUDY

1.	PROGRAM CATEGORY:	OAST Space System Studies, Enabling Technology
2.	STUDY TITLE:	Multiple Requirements for Pointing and Control Systems
3.	STUDY PURPOSE:	Identify and assess the enabling pointing and control system technologies required by NASA missions in the 1985-2000 time period.
4.	PRINCIPAL TASKS:	Identify requirements of proposed NASA missions and advances in technology that could be effectively employed by these missions.
5.	RESULTS EXPECTED:	Ranking of technology planning options.
6.	USE OF RESULTS:	Pointing and control systems technology planning. Provide insights for NEEDS, LSST, nonlinear large deflection, automated operations, reusable propulsion, and low-thrust propulsion activities.
7.	LENGTH OF STUDY:	1 year
8.	MANAGEMENT:	OAST Study, Analysis, and Planning Office (RX)/JPL
9.	RESOURCES ($K):	50; RX - 25, RE - 25
	MAN-YEARS (CS/SC):	0/0.8
10.	UNIQUE PROJECT NO.:	790-40-15(03)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Software Technology Enablment

3. STUDY PURPOSE: Forecast software technology needs and capabilities that have the potential to reduce software costs and improve payload performance.

4. PRINCIPAL TASKS:
   (1) Generate future software forecast model and propose software for model.
   (2) Estimate future software magnitudes, complexity, and limitations.
   (3) Identify opportunities for advancement of software technology that offer substantial payload benefits.

5. RESULTS EXPECTED: Program plan for advancement of software technology.

6. USE OF RESULTS: Technology planning; reduce costs and improve performance for payloads beyond 1980. Provide insights for NEEDS actitity.

7. LENGTH OF STUDY: 3 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/MSFC

9. RESOURCES ($K): 50 - Cumulative: 225

   MAN-YEARS (CS/SC):

10. UNIQUE PROJECT NO.: 790-40-19

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Technology Readiness

2. STUDY TITLE: Venus Orbiting Imaging Radar and SEASAT B Technology Options

3. STUDY PURPOSE: Develop technology options by studying excursion from base-line configurations provided by OSS and OA.

4. PRINCIPAL TASKS: (1) Identify candidate options.
(2) Determine performance gains, cost, and risk to accomplish.
(3) Evaluate against base-line and recommended program changes.

5. RESULTS EXPECTED: Provide a ranking of the technologies by relative merit and establish the readiness of each technology for mission support.

6. USE OF RESULTS: Evaluation and potential enhancement of VOIR and SEASAT B. Provide insights for NEEDS, ESS, and high-performance power activities.

7. LENGTH OF STUDY: 1.5 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL

9. RESOURCES ($K): 20 Cumulative: 95

MAN-YEARS (CS/SC): 0/0.4

10. UNIQUE PROJECT NO.: 790-40-25(01)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Technology Readiness

2. STUDY TITLE: Technology Readiness for a Pollution Monitoring Mission

3. STUDY PURPOSE: Develop technology options by studying excursions from base-line configurations provided by OA.

4. PRINCIPAL TASKS:
   (1) Identify candidate options.
   (2) Determine performance gains, cost, and risk to accomplish.
   (3) Evaluate against base-line and recommended program changes.

5. RESULTS EXPECTED: Provide a ranking of the technologies by relative merit and establish the readiness of each technology for mission support.

6. USE OF RESULTS: Evaluation and potential enhancement of pollution monitoring missions. Provide insights for agency activity in ESS and MOPP.

7. LENGTH OF STUDY: 1 year

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/LaRC

9. RESOURCES ($K): 75, 24 IMS

   MAN-YEARS (CS/SC): 3/1

10. UNIQUE PROJECT NO.: 790-40-23

[redacted]

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Technology Readiness

2. STUDY TITLE: Public Service Platform Technology Readiness

3. STUDY PURPOSE: Develop technology options by studying excursions from base-line configurations provided by OA.

4. PRINCIPAL TASKS:
   (1) Identify candidate options.
   (2) Determine performance gains, cost, and risk to accomplish.
   (3) Evaluate against base-line and recommended program changes.

5. RESULTS EXPECTED: Provide a ranking of the technologies by relative merit and establish the readiness of each technology for mission support.

6. USE OF RESULTS: Evaluation and potential enhancement of public service platforms. Provide insights for agency activity in NEEDS, ESS, automated operations, and MOPP.

7. LENGTH OF STUDY: 1 year

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/GSFC

9. RESOURCES ($K): 50

   MAN-YEARS (CS/SC):

10. UNIQUE PROJECT NO.: 790-40-26

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Advanced Penetrator Missions

3. STUDY PURPOSE: Study the use of penetrators for mining assay missions in remote areas of the Earth and on the Moon and planets.

4. PRINCIPAL TASKS:
   (1) Conceptual configurations.
   (2) Type of sensors required.
   (3) Method of delivery.
   (4) Data retrieval techniques.
   (5) Cost comparison between penetrator and field exploration on Earth.

5. RESULTS EXPECTED: Conceptualization of penetrators and sensors to: determine elemental composition of subsurface material; predict ore deposites based on composition.

6. USE OF RESULTS: OAST planning in sensors, Earth applications, lunar resources, and planetary exploration. Provide insights for ESS activity.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/ARC

9. RESOURCES ($K): 50

   MAN-YEARS (CS/SC): 1/1 (estimate)

10. UNIQUE PROJECT NO.: 790-40-31(02)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Study of Advanced Global Services Concepts

3. STUDY PURPOSE: Establish model of 1990s global services as a set of LEO and GEO platforms with centralized power, sensing, and information processing/transfer services. Develop new concepts for global services to the public; make enabling technology forecasts for propulsion, power, materials, structures, and electronics; and identify associated flight experiments.

4. PRINCIPAL TASKS: (1) Function as lead center for global services activity.
(2) Perform system concept integration and management.

5. RESULTS EXPECTED: Technology forecasts defining focused R&T paths which meet NASA Earth orbit mission needs of the 1990s.

6. USE OF RESULTS: Enhance future NASA applications missions. Provide insights for Agency activities in NEEDS, ESS, LSST, automated operations, and MOPP.

7. LENGTH OF STUDY: Second year, continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/LaRC, joint effort with GSFC, JPL, Aerospace

9. RESOURCES ($K): 150, 73-IMS Cumulative: 275

MAN-YEARS (CS/SC): 9/1

10. UNIQUE PROJECT NO.: 790-40-13

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Study of Advanced Global Services Concepts

3. STUDY PURPOSE: Establish model of 1990s global services as a set of LEO and GEO platforms with centralized power, sensing, and information processing/transfer services. Develop new concepts for global services to the public; make enabling technology forecasts for propulsion, power, materials, structures, and electronics; and identify associated flight experiments.

4. PRINCIPAL TASKS: (1) Generate top down systems requirements logic.

   (2) Structure parametric trade-off analysis.

5. RESULTS EXPECTED: Technology forecasts defining focused R&T paths which meet NASA Earth orbit mission needs of the 1990s.

6. USE OF RESULTS: Enhance future NASA applications missions. Provide insights for Agency activities in NEEDS, ESS, LSST, automated operations, and MOPP.

7. LENGTH OF STUDY: First Year, continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL, joint effort with LaRC (Lead), GSFC, and Aerospace

9. RESOURCES ($K): 100

   MAN-YEARS (CS/SC):

10. UNIQUE PROJECT NO.: 790-40-15(02)

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Study of Advanced Global Services Concepts

3. STUDY PURPOSE: Establish model of 1990s global services as a set of LEO and GEO platforms with centralized power, sensing, and information processing/transfer services. Develop new concepts for global services to the public; make enabling technology forecasts for propulsion, power, materials, structures, and electronics; and identify associated flight experiments.

4. PRINCIPAL TASKS: (1) Emphasis on communications/information transfer platform.
(2) Provide requirements for land and atmospheric observations.

5. RESULTS EXPECTED: Technology forecasts defining focused R&T paths which meet NASA Earth orbit mission needs of the 1990s.

6. USE OF RESULTS: Enhance future NASA applications missions. Provide insights for Agency activities in NEEDS, ESS, LSST, automated operations, and MOPP.

7. LENGTH OF STUDY: First year, continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/GSFC, joint effort with LaRC (Lead), JPL, Aerospace

9. RESOURCES ($K): 75

MAN-YEARS (CS/SC): 3/0 (estimated)

10. UNIQUE PROJECT NO.: 790-40-36

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Study of Advanced Global Services Concepts

3. STUDY PURPOSE: Establish model of 1990s global services as a set of LEO and GEO platforms with centralized power, sensing, and information processing/transfer services. Develop new concepts for global services to the public; make enabling technology forecasts for propulsion, power, materials, structures, and electronics; and identify associated flight experiments.

4. PRINCIPAL TASKS:
   (1) Provide DoD interface to global services integrated activity.
   (2) Work with the advanced program personnel at NASA Headquarters and the various Centers to review planned missions and identify technologies from DoD.

5. RESULTS EXPECTED: Technology forecasts defining focused R&T paths which meet NASA Earth orbit mission needs of the 1990s.

6. USE OF RESULTS: Enhance future NASA applications missions. Provide insights for Agency activities in NEEDS, ESS, LSST, automated operations, and MOPP.

7. LENGTH OF STUDY: First year, continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/Aerospace, joint effort with LaRC (Lead), GSFC, JPL

9. RESOURCES ($K): 100

   MAN-YEARS (CS/SC): 0/1

10. UNIQUE PROJECT NO.: 790-40-40(01)

FY 1978 PLANNING STUDY

1. **PROGRAM CATEGORY:** OAST Space System Studies, Systems Planning and Analysis

2. **STUDY TITLE:** Space Studies, Analysis, and Planning

3. **STUDY PURPOSE:** Develop and maintain planning goals and objectives.

4. **PRINCIPAL TASKS:**
   (1) Generate technology advanced systems model.
   (2) Analyze study programs to derive future needs and requirements for OAST technology planning.
   (3) Conduct technology assessments.

5. **RESULTS EXPECTED:** Cost, benefit, and risk rankings. Technology forecasts. Assessments of R&T programs, identifying technology voids and gaps in OAST discipline structure.

6. **USE OF RESULTS:** OAST technology planning for NEEDS, ESS, LSST, automated operations, reusable propulsion, low-thrust propulsion, and MOPP activities.

7. **LENGTH OF STUDY:** Second year, continue into 1979

8. **MANAGEMENT:** OAST Study, Analysis, and Planning Office (RX)

9. **RESOURCES ($K):** 160 Cumulative: 530

   MAN YEARS (CS/SC): 0/2.0

10. **UNIQUE PROJECT NO.:** 790-40-40(02)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Space-Based Radio Telescope

3. STUDY PURPOSE: Generate conceptual design of 100 to 300 m antenna to serve SETI signal search and astrophysics experiments.

4. PRINCIPAL TASKS:
   (1) Identify technology drivers, e.g., cooling, data processing, figure control, etc.
   (2) Generate conceptual designs.
   (3) Estimate program schedules and costs for several deployment options.

5. RESULTS EXPECTED: Identify critical technology needs and develop new concepts.

6. USE OF RESULTS: Development of enabling technologies; future SETI and astrophysics planning. Provide insights for ESS, LSST, automated operations, and long-life composites activities.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL

9. RESOURCES ($K): 50 Cumulative: 125

   MAN-YEARS (CS/SC): 0/0.7

10. UNIQUE PROJECT NO.: 790-40-35(01)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Space-Based Planetary Detection Systems

3. STUDY PURPOSE: Evaluate known approaches and develop new concepts to search for extra-solar planetary systems.

4. PRINCIPAL TASKS: (1) Evaluate planetary detection workshop recommendations from SETI programs. (2) Conceive and explore new concepts. (3) Recommend further study of programs and technology.

5. RESULTS EXPECTED: Planetary detection concepts feasibility evaluations and recommended actions.

6. USE OF RESULTS: Planning by OAST and other offices. Provide insights for ESS activity.

7. LENGTH OF STUDY: 2 years

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/ARC

9. RESOURCES ($K): 50 Cumulative: 125

MAN-YEARS (CS/SC): 1/1 (estimate)

10. UNIQUE PROJECT NO.: 790-40-31(01)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Technology Readiness

2. STUDY TITLE: Mars Sample Return Technology Readiness

3. STUDY PURPOSE: Identify a group of spacecraft advanced technology alternatives for the Mars sample return mission.

4. PRINCIPAL TASKS: Evaluate the incremental benefits, risks, and costs of the utilization of identified alternatives in a complete spacecraft system.

5. RESULTS EXPECTED: Provide a ranking of the technologies by relative merit and establish the readiness of each technology for mission support.

6. USE OF RESULTS: Recommend advanced development program changes which will ensure that the technologies selected for the mission are at an acceptable state of development for project commitment. Provide insights for ESS, automated operations, and high-performance power activities.

7. LENGTH OF STUDY: First year, continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL

9. RESOURCES ($K): 40

   MAN-YEARS (CS/SC): 0/0.7

10. UNIQUE PROJECT NO.: 790-40-25(02)

FY 1978 PLANNING STUDY

1. PROGRAM CATEGORY: OAST Space System Studies, Enabling Technology

2. STUDY TITLE: Advanced Sample Return Concepts

3. STUDY PURPOSE: Evaluate technology implications of shift in emphasis to sample return from surface and/or atmosphere of planets, moons, asteroids, and comets instead of information return.

4. PRINCIPAL TASKS: (1) Define science and technology for automatic sample collection, and/or packaging and return.
(2) Identify technologies to support sample return missions.

5. RESULTS EXPECTED: Assessment of necessary technologies and their state of development; identify voids and gaps in technology development; and analyze the sensitivity to technological development investment.

6. USE OF RESULTS: Planning technology development for roving vehcile and sample return missions. Provide insights for ESS, automated operations, and high-performance power activities.

7. LENGTH OF STUDY: First year of renewed effort; continue into 1979

8. MANAGEMENT: OAST Study, Analysis, and Planning Office (RX)/JPL

9. RESOURCES ($K): 50 Cumulative: 130

MAN-YEARS (CS/SC): 0/1

10. UNIQUE PROJECT NO.: 790-40-35(02)