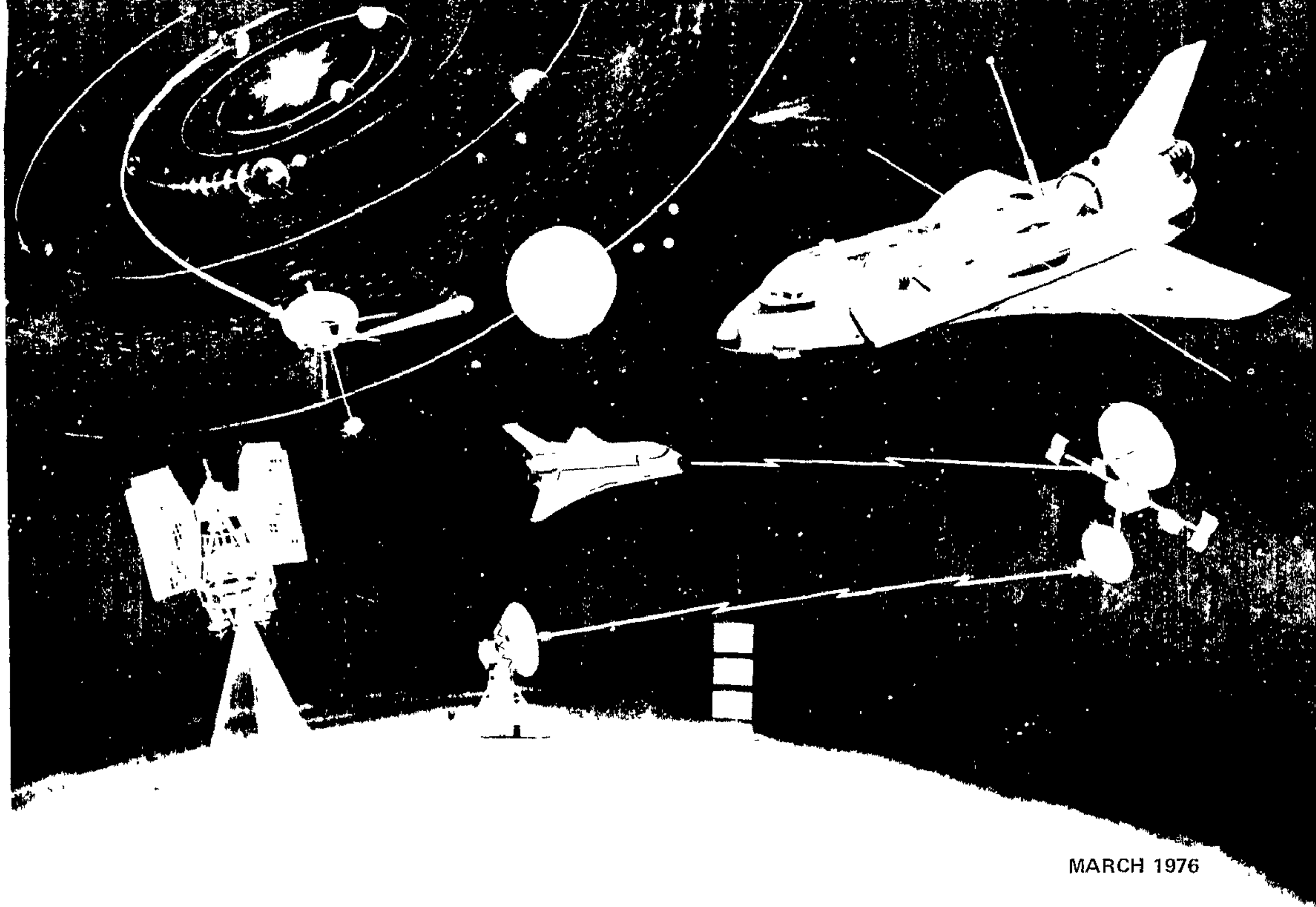
SPACE ELECTRONICS TECHNOLOGY SUMMARY



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SPACE ELECTRONICS TECHNOLOGY

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PURPOSE

THE SPACE ELECTRONICS TECHNOLOGY SUMMARY REPORT PROVIDES AN OVERVIEW OF CURRENT ELECTRONICS R&D ACTIVITIES, FUTURE THRUSTS AND RELATED NASA PAYOFFS.

IT DEMONSTRATES THAT MAJOR ADVANCES IN NASA CAPABILITY -

- 1000X INCREASE IN MISSION RETURN
- 10X REDUCTION IN MISSION COST

CAN BE ACHIEVED THROUGH A FOCUSED, LONG-RANGE TECHNOLOGY PROGRAM.

IT SERVES AS AN INTEGRATED BASE FOR PLANNING AND IMPLEMENTING NEW ACTIVITIES IN SPACE ELECTRONICS TECHNOLOGY.

THIS REPORT PROVIDES AN OVERVIEW OF NASA'S SPACE ELECTRONICS TECHNOLOGY ACTIVITIES, POTENTIAL FUTURE THRUSTS AND ASSOCIATED NASA PAYOFFS. MAJOR INCREASES IN NASA MISSION RETURN WITH SIGNIFICANT CONCURRENT REDUCTIONS IN MISSION COST APPEAR POSSIBLE THROUGH A FOCUSED, LONG-RANGE ELECTRONICS TECHNOLOGY PROGRAM.

THE OVERVIEW COVERS THE APPROACH USED FOR REVIEW OF ELECTRONICS-RELATED TECHNOLOGY EFFORTS AND FOR THE DELINEATION OF HIGH-PAYOFF FUTURE THRUSTS AND TECHNOLOGY GOALS; AN OUTLINE OF THE RESULTANT PROGRAM ELEMENTS AND PROJECTIONS; ASSESSMENTS OF THE CONSTITUENT DISCIPLINES GUIDANCE, NAVIGATION AND CONTROL, SENSING AND DATA ACQUISITION, AND DATA PROCESSING, STORAGE AND TRANSFER; AND A SUMMARY OF THE TOTAL PROGRAM GOALS AND BENEFITS.

SPACE ELECTRONICS TECHNOLOGY

INTRODUCTION	PETER R. KURZHALS
APPROACH	ARTHUR HENDERSON
PROGRAM OUTLINE	CHARLES E. PONTIOUS
GUIDANCE, NAVIGATION & CONTROL	WILLIAM B. GEVARTER
SENSING & DATA ACQUISITION	BERNARD RUBIN
DATA PROCESSING, STORAGE & TRANSFER	HAROLD ALSBERG
PROGRAM GOALS	CHARLES E. PONTIOUS
CONCLUSION	PETER R. KURZHALS

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ELECTRONICS-RELATED EXPENDITURES FOR NASA SPACE MISSIONS, ESTIMATED AS CLOSE TO $1 BILLION ANNUALLY, COMPRISE ABOUT 40% OF SPACE VEHICLE COSTS, 70% OF SPACECRAFT COSTS, AND 90% OF TRACKING AND DATA ACQUISITION COSTS. ASSOCIATED TECHNOLOGY PROGRAMS ARE FUNDED BY OA, OAST, OSF, OSS, OTDA AND LCSO AT APPROXIMATELY $60 MILLION NOA IN 1975.

NASA-WIDE COORDINATION AND PLANNING OF THESE PROGRAMS WAS INITIATED IN EARLY 1975 AT THE REQUEST OF THE ASSOCIATE ADMINISTRATOR TO ASSURE MAXIMUM PAYOFF FROM THIS KEY TECHNOLOGY. THE MAJOR MECHANISM FOR THIS EFFORT WAS A SERIES OF JOINT PROGRAM REVIEWS, HELD BOTH AT HEADQUARTERS AND THE CENTERS TO IDENTIFY AND COORDINATE CURRENT PROGRAM ELEMENTS. THE REVIEWS WERE FOLLOWED BY A TWO-WEEK SPACE TECHNOLOGY WORKSHOP WHICH DERIVED FUTURE TECHNOLOGY REQUIREMENTS, MAJOR THRUSTS, AND OVERALL GOALS FROM PROJECTED NASA MISSIONS, THE OUTLOOK FOR SPACE THEMES, AND REPRESENTATIVE USER NEEDS. THIS OVERVIEW INTEGRATES AND SUMMARIZES THE RESULTS OF THESE TWO ACTIVITIES AS A BASIS FOR FUTURE LONG-RANGE PLANNING.

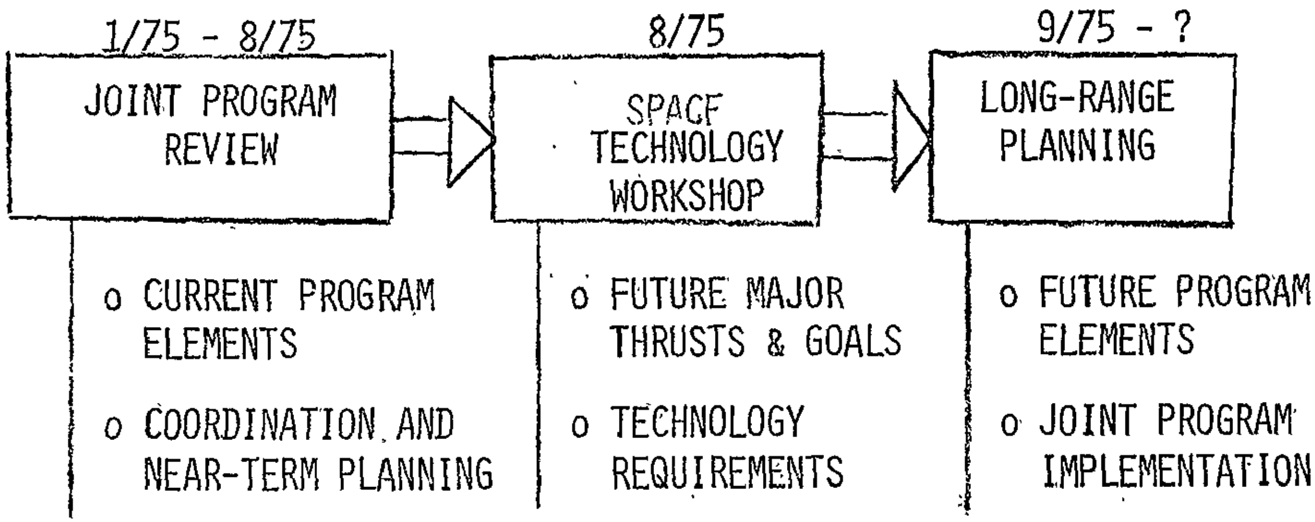
SPACE ELECTRONICS TECHNOLOGY

BACKGROUND

- o ELECTRONICS-RELATED APPLICATIONS REPRESENT MAJOR NASA INVESTMENT AND IMPACT ALL ASPECTS OF NASA OPERATIONS

- o ELECTRONICS-RELATED TECHNOLOGY PROGRAMS ARE SPONSORED BY EACH HEADQUARTERS PROGRAM OFFICE AND INVOLVE ALL NASA CENTERS

- o INDEPTH COORDINATION AND ASSESSMENT INITIATED IN 1975 TO MAXIMIZE CURRENT AND FUTURE PROGRAM BENEFITS



- o BRIEFING IS STATUS REPORT ON RESULTS TO DATE

APPROACH

ALL NASA CENTERS AND REPRESENTATITVES FROM THE HEADQUARTERS PROGRAM OFFICES WERE INVOLVED IN THE DEFINITION OF CURRENT AND FUTURE PROGRAM ELEMENTS COVERED BY THE SPACE ELECTRONICS TECHNOLOGY OVERVIEW. THE APPROACH SECTION SUMMARIZES THE MECHANICS OF THIS DEFINITION PROCESS.

SPACE ELECTRONICS TECHNOLOGY

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THE PRIME ELEMENTS OF THE APPROACH TAKEN TO ESTABLISH THE AGENCY'S SHORT- AND LONG-RANGE SPACE ELECTRONICS TECHNOLOGY NEEDS ARE INDICATED. AN ATTEMPT WAS MADE TO ASSESS THE VALUE OF TELECONFERENCING THE REVIEWS BY ESTABLISHING ITS COST AND SOLICITING CENTER COMMENTS.

SPACE ELECTRONICS REVIEW

APPROACH

JOINT PROGRAM REVIEW	OAST SPACE TECHNOLOGY WORKSHOP
SCOPE	WORKSHOP LOGIC
MECHANICS	ELECTRONICS THRUSTS
ACTION ITEMS	
COST	
CENTER COMMENTS	

ALL REVIEWS WERE TELECONFERENCED FROM THE HOST CENTER (FIRST NAMED) TO ALL OTHER CENTERS AND HEADQUARTERS. ALTHOUGH FRC HAD NO SPACE ELECTRONICS PROGRAMS, AND THEREFORE MADE NO PRESENTATIONS, IT PARTICIPATED IN THE TELECONFERENCE NETWORK. THE DISCIPLINES COVERED ALL ELECTRONICS RELATED TECHNOLOGY IN THE AGENCY.

ALL ACTIVITIES, RANGING FROM BASIC RESEARCH TO END-ITEM TESTING, WERE COVERED EXCEPT THOSE ASSOCIATED WITH APPROVED FLIGHT PROGRAMS.

JOINT PROGRAM REVIEW

SCOPE

- DISCIPLINES

  ELECTRONICS
  ELECTRO-OPTICS
  ELECTRO-MECHANICS
  APPLIED MATH

- ACTIVITIES

  RESEARCH
  STUDY
  DESIGN
  DEVELOPMENT
  TEST

SCHEDULE

JANUARY 22, 1975 - HQ OVERVIEW

APRIL 14-18, 1975 - JPL & ARC

JUNE 2-3, 1975 - LARC, LERC & WFC

JUNE 25-26, 1975 - GSFC

JULY 29-30, 1975 - MSFC & KSC

JULY 31, 1975 - JSC

OVERALL COORDINATION OF THE REVIEW WAS HANDLED BY THE INDIVIDUALS SHOWN. CENTER POINTS OF CONTACT COORDINATED THEIR CENTER'S PARTICIPATION IN THE REVIEWS. SOME OF THE RESPONSIBILITIES OF THE HOST CENTER POINT OF CONTACT ARE INDICATED ON THE FOLLOWING FIGURE.

JOINT PROGRAM REVIEW

POINTS OF CONTACT

CENTERS

ARC	HARMOUNT
FRC	DEETS
GSFC	FRIEDMAN
JPL	POWELL
JSC	FITZGERALD
KSC	CERRATO
LaRC	McIVER
LeRC	DAVISON
MSFC	CHASE
WFC	McGOOGAN

HEADQUARTERS

HQ	HENDERSON
OA	McCONNELL
OAST	PONTIOUS
OSF	SCHROCK
OSS	HAUGHEY
OTDA	FOSQUE
LCSO	RICHARDS

THE KEY FUNCTION OF THE HEADQUARTERS OVERVIEW WAS TO IDENTIFY THE RTOP'S ABOUT WHICH THE CENTERS BUILT THEIR PRESENTATIONS. THE PRIME RESPONSIBILITIES OF THE HOST CENTER ARE INDICATED; STRICT ADHERENCE TO SCHEDULE ASSURED THOSE AT REMOTE SITES THAT THEY COULD PLAN THEIR DAILY SCHEDULES ABOUT THE PRESENTATIONS THEY INTENDED TO PARTICIPATE IN.

JOINT PROGRAM REVIEW

MECHANICS

- HEADQUARTERS OVERVIEW
  - IDENTIFY RTOP's
- CENTER REVIEWS
  - HQ OVERVIEW RTOP's
  - OTHER APPROPRIATE RTOP's
- HOST CENTER RESPONSIBILITY
  - DISTRIBUTE VIEWRAPHS BEFORE TELECONFERENCE
  - ADHERE TO SCHEDULE
  - FIELD QUESTIONS
    - REAL TIME
    - TELEPHONE
  - GEAR AGENDA TO TIME ZONE DIFFERENTIAL

FIFTY COORDINATION AND PLANNING ACTION ITEMS WERE GENERATED DURING THE COURSE OF THE REVIEWS (1/2 IS SHOWN WHEN LEAD RESPONSIBILITY WAS SHARED BY TWO CENTERS). OVER 40 PERCENT OF THESE ACTION ITEMS HAVE BEEN CLOSED OUT TO DATE; THE OTHERS ARE BEING ACTIVELY PURSUED.

JOINT PROGRAM REVIEW

ACTION ITEM SUMMARY

	NAVIG., GUID. AND CONTROL	SENSING AND DATA ACQUIS.	DATA. PROCESS. STOR., & TRANS	GENERAL	TOTAL
OA	(1)	1 (5)	1 1/2 (9)	(2)	2 1/2 (17)
OAST	3 1/2 (11)	2 (12)	2 1/2 (16)	2 (1)	10 (40)
OEP		(1)			(1)
OPA		(1)			(1)
OSF	1 (7)	(2)	(4)	(2)	1 (15)
OSS	1/2 (5)	(5)	1 (6)	(2)	1 1/2 (18)
OTDA			1 (5)	(2)	1 (7)
LCSO	(3)	(2)	(6)	1 (1)	1 (12)
ARC	(2)	(1)	(2)		(5)
GSFC	2 (1)	2 (5)	1 (3)		5 (9)
JPL	1 (7)	1 (6)	6 (2)		8 (15)
JSC		1 (2)	(2)		1 (4)
KSC		(1)			(1)
LARC	3 (5)	5 (5)	1 (3)		9 (13)
LERC		(1)	1		1 (1)
MSFC	4 (5)	2 (2)	3 (1)		9 (8)
	15 (47)	14 (51)	18 (59)	3 (10)	50 (167)

KEY: LEAD RESPONSIBILITY (PARTICIPATION RESPONSIBILITY)

VIEWGRAPHS CONSTITUTED THE PRIMARY COST OF TELECONFERENCING THE REVIEWS. A COMPLETE SET WAS SENT TO EACH PARTICIPATING CENTER AND HEADQUARTERS; ALONG WITH THE HOST CENTER, 11 SETS WERE INVOLVED; THE NUMBERS SHOWN ARE TOTALS FOR EACH REVIEW. THE COST OF THE NEXT JOINT PROGRAM REVIEWS WILL BE MUCH LESS THAN SHOWN HERE FOR TWO PRIMARY REASONS:

- JPL HAS CHANGED THEIR VIEWGRAPH PRODUCTION PROCEDURE TO ONE WHICH NOW COSTS $0.50 EACH.
- HARD COPIES (AT ABOUT $0.10 A PIECE) WILL BE DISTRIBUTED TO CENTERS FROM WHICH THEY CAN MAKE VIEWGRAPHS OF ONLY THOSE PRESENTATIONS FOR WHICH THEIR PEOPLE EXPRESS INTEREST.

THE TELECONFERENCE NETWORK OF 10 CENTERS PLUS HEADQUARTERS ALLOWED FAR MORE PEOPLE TO PARTICIPATE IN THE REVIEWS THAN COULD HAVE IF EVERYONE HAD TO ATTEND THE HOST CENTER.

JOINT PROGRAM REVIEW

PARTICIPATION/COST SUMMARY

CENTERS	NUMBER VIEWGRAPHS	AVG. COST PER VG.	VIEWGRAPH COST	TELECON. NET COST	TOTAL COST	TELECON. AUDIENCE
JPL/ARC	7,000	$3	$21,000	$4,000	$25,000	163
LARC/LERC/ WFC	850	1	850	1,100	1,950	112
GSFC	1,240	1	1,240	1,100	2,340	118
MSFC/KSC	3,000	.75	2,250	1,400	3,650	123
JSC	1,200	.50	600	700	1,300	57
	13,290		25,940	8,300	34,240	573

ESTIMATED TRAVEL COST FOR TELECONFERENCE AUDIENCE = $160,000

1/4 AUDIENCE = $ 40,000

ASSUMPTIONS:

- $200 AIR FARE
- $30 PER DIEM
- NO RENTAL CAR

COMMENTS WERE SOLICITED FROM THE CENTERS TO HELP ASSESS THE VALUE OF TELECONFERENCING THE REVIEWS. THE CONCLUSIONS ARE THAT TELECONFERENCING IS VALUABLE, AND THAT THE PROCEDURES FOLLOWED CAN (AND WILL) BE IMPROVED UPON.

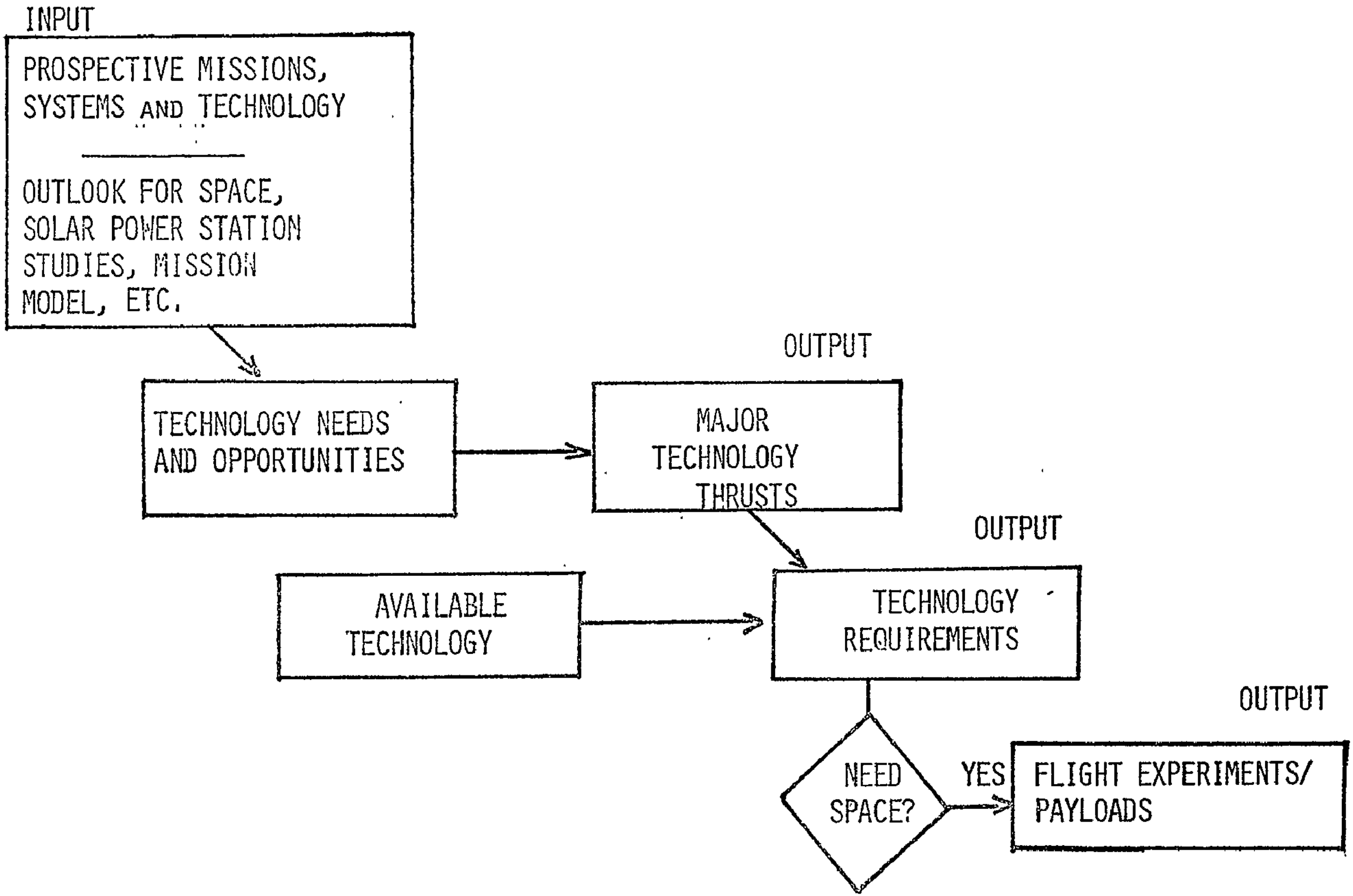
JOINT PROGRAM REVIEW

CENTER COMMENTS

- O THE REVIEW WAS OF EXCELLENT QUALITY, AND AN OUTSTANDING ACCOMPLISHMENT, BEING THE FIRST TECHNICAL TELECONFERENCE INVOLVING THE TEN NASA CENTERS AND HEADQUARTERS.
- O OUR TELECONFERENCE ATTENDEES GOT AS MUCH FROM THE PRESENTATIONS AS THEY WOULD IF THEY HAD BEEN ON SITE.
- O ADHERENCE TO SCHEDULE WAS EXCELLENT--OUR PEOPLE CITED THE GREAT CONVENIENCE OF BEING ABLE TO DROP IN TO HEAR ONLY THOSE BRIEFINGS OF INTEREST TO THEM.
- O FIRST OPPORTUNITY WE'VE HAD TO SEE WHAT ALL THE OTHER CENTERS ARE DOING IN ELECTRONICS.
- O DISTRIBUTE GOOD QUALITY REPRODUCIBLE COPIES OF PRESENTATION MATERIAL TO REMOTE SITES--GIVE THEM OPTION OF MAKING VIEWGRAPHS OR HARD COPIES FOR THEIR PEOPLE.
- O WOULD HAVE ATTRACTED WIDER AUDIENCE IF ORGANIZED BY DISCIPLINE RATHER THAN BY PROGRAM OFFICE.
- O ONE MAJOR DIFFICULTY WAS THE TENDENCY TO TREAT THE TELECONFERENCE WITH RELATIVELY LOW PRIORITY AT REMOTE SITES (SOME, NOT ALL).
- O ATTENDANCE WOULD HAVE BEEN GREATER IF MATERIAL HAD BEEN RECEIVED SEVEN TO TEN DAYS BEFORE REVIEW.
- O TELECONFERENCE SPEAKERS SHOULD NOT BE ALLOWED TO USE POINTERS.

THE OAST SPACE TECHNOLOGY WORKSHOP BROUGHT TECHNOLOGISTS AND TECHNOLOGY USERS FROM ALL THE NASA CENTERS AND HEADQUARTERS TOGETHER FOR THE PURPOSE OF PLANNING ADVANCED TECHNOLOGY REQUIREMENTS TO MEET FUTURE NEEDS. AS INDICATED BY THE LOGIC FLOW CHART, PRIMARY EMPHASES WERE ON TECHNOLOGY THRUSTS, REQUIREMENTS, PROOF TEST FLIGHT EXPERIMENTS, AND FUNDAMENTAL EXPERIMENTS REQUIRING THE SPACE ENVIRONMENT.

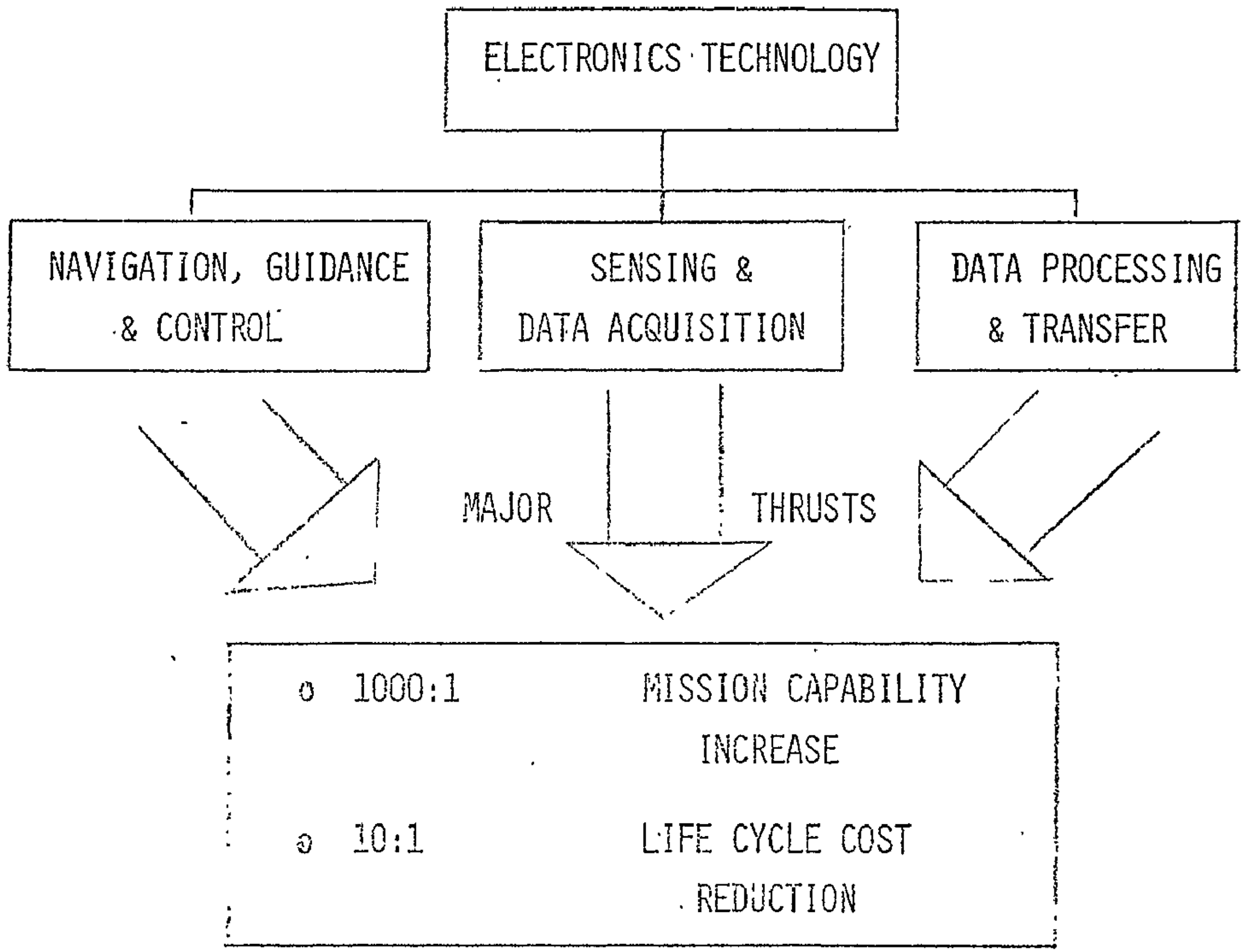
SPACE TECHNOLOGY WORKSHOP LOGIC



AT THE WORKSHOP, PRIMARY EMPHASIS IN THE ELECTRONICS AREA WAS PLACED ON IDENTIFYING MAJOR ADVANCED TECHNOLOGY THRUSTS REQUIRED TO SUPPORT FUTURE SPACE MISSIONS. THE ELEMENTS WHICH MAKE UP THE TWO MAJOR RESULTANT GOALS WILL BE ADDRESSED IN THE SECTIONS COVERING EACH OF THE THREE CATEGORIES OF ELECTRONICS TECHNOLOGY.

THE SPACE ELECTRONICS GOALS ARE THE PRIME CONTRIBUTORS TO THE OVERALL SPACE TECHNOLOGY GOAL OF A 1000-FOLD INCREASE IN FUTURE SPACE SYSTEM CAPABILITY AT REDUCED COST, AS IDENTIFIED THROUGH THE WORKSHOP. BECAUSE THE END PRODUCT OF ESSENTIALLY ALL SPACE SYSTEMS IS INFORMATION, THIS INCREASE IN EFFECT INVOLVES THE CONVERSION OF 1000 TIMES MORE BITS OF NEW DATA TO USEFUL INFORMATION THAN IS DONE TODAY, AT LESS THAN TODAY'S REAL COST. SPACE ELECTRONICS WILL PROVIDE THE KEY TO THE IMPROVED DATA HANDLING CAPABILITY, WHILE ALL SPACE TECHNOLOGIES WILL CONTRIBUTE TO THE REDUCED COST ASPECTS OF THE GOAL.

SPACE TECHNOLOGY WORKSHOP



PROGRAM OUTLINE

THE TECHNICAL PROGRAM PRESENTATION INCLUDES A BRIEF DISCUSSION OF THE PRESENTATION ORGANIZATION, A TABULAR SUMMARY OF NASA's FY 75 ELECTRONICS R&D ACTIVITIES, AND A DESCRIPTION OF THE FORMAT USED IN EACH OF THE DETAILED DISCIPLINE PRESENTATIONS.

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THE DETAILED REVIEW IS ARRANGED BY DISCIPLINE. EACH DISCIPLINE IS SEPARATED INTO CATEGORIES DESCRIPTIVE OF THE OPERATIONAL FUNCTIONS PERFORMED. THESE CATEGORIES ARE SUBSEQUENTLY DIVIDED INTO TECHNICAL AREAS REPRESENTING THE MAJOR THRUSTS OF CURRENT PROGRAM ACTIVITIES AND FUTURE THRUSTS TO MEET ANTICIPATED NASA NEEDS.

SPACE ELECTRONICS TECHNOLOGY REVIEW

ORGANIZATION

DISCIPLINE	DISCIPLINE CATEGORY	TECHNICAL AREA
NAVIGATION, GUIDANCE & CONTROL Dr. Wm. B. Gevarter	1-NAVIGATION & GUIDANCE	a-RADIOMETRIC NAVIGATION b-TARGET & STELLAR REFERENCE c-ONBOARD NAVIGATION d-MANEUVER STRATEGY
	2-POINTING & CONTROL	a-SPACECRAFT STABILIZATION b-EXPERIMENT POINTING c-LARGE STRUCTURES CONTROL
	3-AUTOMATION	a-ROBOTICS b-TELEOPERATORS
SENSING & DATA ACQUISITION Dr. B. Rubin	4-SENSING & DATA ACQUISITION	a-MICROWAVE SENSING b-INFRARED SENSING c-MULTISPECTRAL SENSING d-LASER TECHNIQUES e-DIGITAL IMAGING f-PARTICLES & FIELDS
	5-INSTRUMENTATION	a-MICROELECTRONICS/PHOTONICS b-RADIOMETRIC INSTRUMENTATION c-IN SITU INSTRUMENTATION
DATA PROCESSING, STORAGE & TRANSFER Mr. H. Alsberg	6-DATA PROCESSING	a-METHODS & TECHNIQUES DEVELOPMENT b-SOFTWARE SYSTEMS & DATA MANAGEMENT c-PARALLEL DATA PROCESSING d-DATA SELECTION & COMPRESSION
	7-DATA STORAGE	a-MAGNETIC TAPE b-SOLID STATE DATA STORAGE c-HOLOGRAPHIC/OPTICAL DATA STORAGE
	8-DATA TRANSFER	a-TELECOMMUNICATIONS SYSTEMS b-DATA LINK COMPONENT DEVELOPMENT

THE TABLE ILLUSTRATES THE DISTRIBUTION OF ELECTRONICS R&D ACTIVITIES IN NASA BY DISCIPLINE AND SPONSORING PROGRAM OFFICE. THE DATA PROVIDED INCLUDES THE NUMBER OF INDIVIDUAL RTOPs OR EQUIVALENT WORK UNITS FOLLOWED BY FY 1975 DOLLARS IN THOUSANDS. THE TOTAL PROGRAM CONSISTS OF ALMOST 240 RTOPs VALUED AT OVER $58.0 MILLION. MAJOR EXPENDITURES ARE IN THE AREAS OF SENSING AND DATA ACQUISITION (120 RTOPs AND $22.6 MILLION) AND DATA PROCESSING, STORAGE AND TRANSFER (87 RTOPs AND $27.5 MILLION). THE OFFICE OF APPLICATIONS PROVIDES THE BULK OF THIS SUPPORT WITH 115 RTOPs OR EQUIVALENT WORK UNITS AND OVER $20.0 MILLION IN FUNDING. OAST IS THE NEXT MAJOR SPONSOR IN TERMS OF DOLLARS EXPENDED FOLLOWED CLOSELY BY OTDA. THE LCSO DATA INCLUDES FUNDS ALLOCATED FOR DEVELOPMENT AND ACQUISITION OF THE NASA STANDARD TAPE RECORDERS AND IS, THEREFORE, NOT DIRECTLY COMPARABLE TO THE PROGRAMS OF THE OTHER OFFICES.

SPACE ELECTRONICS TECHNOLOGY REVIEW

RESOURCE SUMMARY

$ in Thousands

PROGRAM OFFICE

DISCIPLINE	OAST	OA	OSS	OMSF	LCSO	OTDA	TOTAL
Navigation, Guid., & Control	7/2851	-/-	8/735	8/1505	5/2250	4/1217	32/8557
Sensing & Data Acquisition	12/3878	78/13910	18/2156	5/680	2/255	5/1748	120/22627
Data Processing, Storage & Transfer	12/5122	37/6622	9/355	3/505	6/8895	20/5980	87/27479
TOTAL	31/11851	115/20532	35/3246	16/2690	13/11400	29/8945	239/58663

LEGEND - # of RTOPs/FY 75 $

THE DETAILED DISCIPLINE PRESENTATIONS COVER THE CURRENT PROGRAMS, ACTION ITEMS AND TECHNOLOGY THRUSTS FOR FUTURE MISSIONS. TIME-ORIENTED ROADMAPS, MILESTONE LISTINGS AND EXAMPLES ARE USED TO DESCRIBE THE CURRENT PROGRAMS AS THEY WERE REVIEWED. RELEVANT ACTION ITEMS DEVELOPED IN EACH DISCIPLINE CATEGORY ARE LISTED AND EXAMPLES DISCUSSED. THE PRESENTATIONS CONCLUDE WITH IDENTIFICATION OF FUTURE SPACE THEMES WHICH DRIVE TECHNOLOGY, THE TECHNOLOGY THRUSTS NEEDED TO SUPPORT THESE THEMES IN EACH DISCIPLINE CATEGORY, AND THE SYSTEM CAPABILITY GOALS OF THAT PARTICULAR DISCIPLINE.

SPACE ELECTRONICS TECHNOLOGY REVIEW

DISCIPLINE PRESENTATIONS

CURRENT PROGRAM

ROADMAPS AND DESCRIPTIVE MATERIAL

RELEVANT ACTION ITEMS

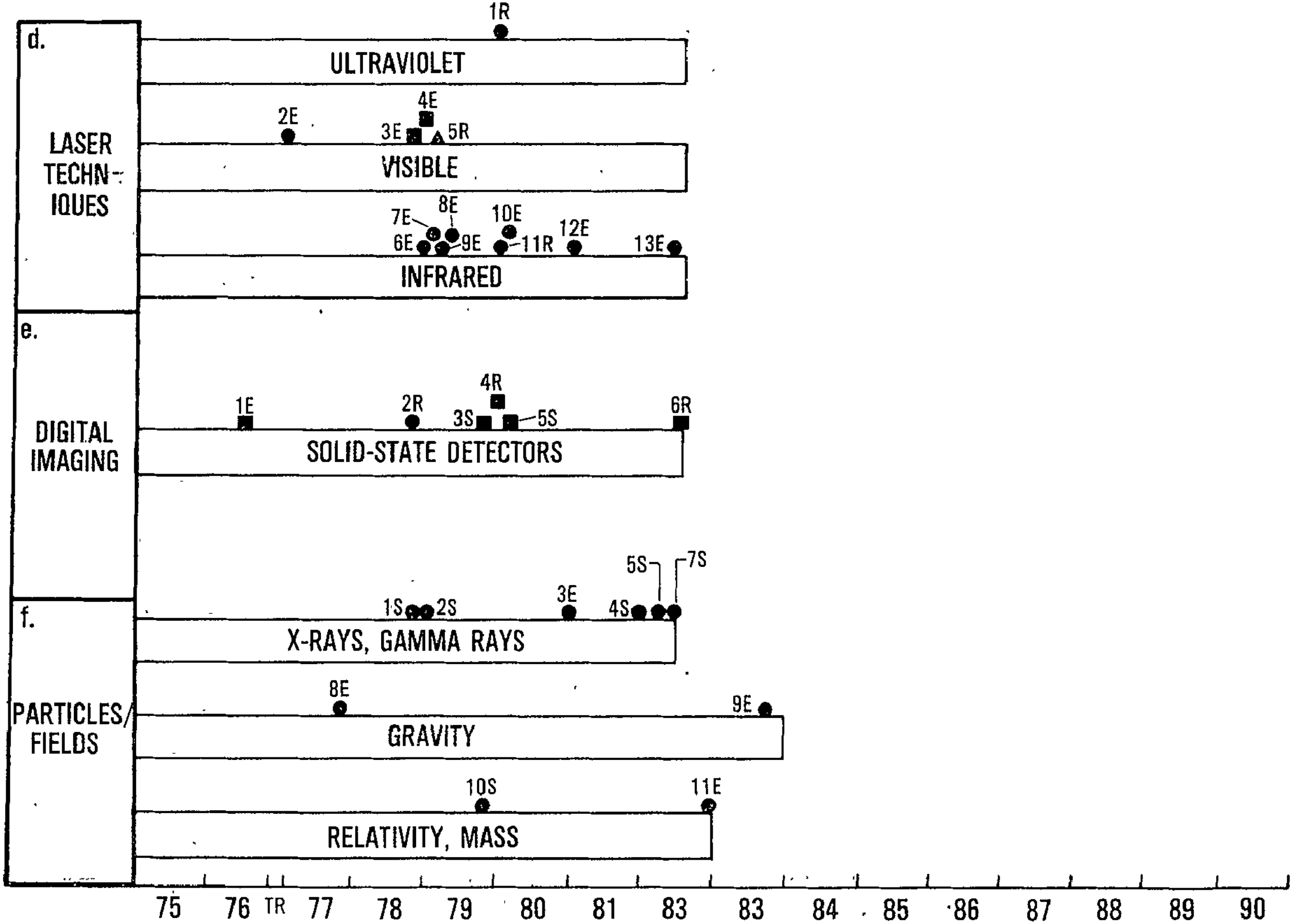
COORDINATION OR JOINT PLANNING ACTIVITIES

FUTURE TECHNOLOGY THRUSTS

TECHNOLOGY REQUIREMENTS AND GOALS TO SUPPORT FUTURE MISSIONS

IN THE ROADMAPS USED TO DESCRIBE THE CURRENT PROGRAM, TECHNICAL AREAS ARE INDICATED ON THE ORDINATE WITH TIME ON THE ABSCISSA. THE HORIZONTAL BARS REPRESENT THE CURRENT THRUST OF R&D ACTIVITIES WITHIN EACH TECHNICAL AREA. THE CIRCLES, SQUARES AND TRIANGLES INDICATE THE TIME AND TYPE OF SYSTEM DELIVERABLE EXPECTED FROM THE COLLECTED TASKS IN EACH TECHNICAL AREA WITH CIRCLES REPRESENTING LABORATORY SYSTEMS; SQUARES, ENGINEERING SYSTEMS; AND TRIANGLES, FLIGHT SYSTEMS. THE NUMBERS IDENTIFY SPECIFIC MILESTONES LISTED IN THE FOLLOWING TABLE. THE LETTER WITH EACH NUMBER IDENTIFIES THE SPONSORING OFFICE OF EACH TASK AND IS EXPLAINED IN THE LEGEND ON THE RIGHT OF THE FIGURE.

4. SENSING AND DATA ACQUISITION



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THE ROADMAP GUIDE LISTS EACH MILESTONE ON THE CORRESPONDING ROADMAP BY TITLE, PERFORMING CENTER AND RTOP NUMBER. THESE GUIDES ARE PROVIDED FOR EACH ROADMAP USED IN THE DESCRIPTION OF THE CURRENT ELECTRONICS TECHNOLOGY PROGRAM AND PROVIDE THE READER A QUICK REFERENCE TO MORE DETAILED INFORMATION ON ANY SELECTED MILESTONE.

4. SENSING & DATA ACQUISITION (Cont.)

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
d. Laser Techniques	1R	A/C Flt. Tests of Laser Water Turbidity Sensor/High Res'n. Sensors	△	78	LaRC	506-18-12
	2E	Laser Instrumentation for Earth Physics	0	76	GSFC	161-05-02
	3E	Laser Radar for Meteor. Meas.	□	78	LaRC	638-10-05*
	4E	Airborne Oceanographic LIDAR	□	78	LaRC	638-40-05
	5R	High Spectral Resolution LIDAR	△	78	WFC	506-18-15
	6E	Remote Sensing Concepts for Tropo. Polln.	0	78	LaRC	176-20-31
	7E	Water Temp. Laser	0	78	KSC	177-22-91
	8E	Laser Absorption Spectrometer	0	78	JPL	638-20-05*
	9E	Stratospheric Gases & Particulates	0	78	LaRC	176-10-31
	10E	ATM Polln. Sensing-Heterodyne Spectrometer	0	79	JPL	176-31-51
	11E	Active/Passive Cloud Meas. from Shuttle	0	80	GSFC	645-10-03
	12e	Pollution Monitoring w/Lasers	0	81	LaRC	645-20-01
	13E	Spaceborne Laser Ranging System	0	81	GSFC	645-40-01
e. Digital Imaging	1E	Hadamard Transform Thermal Mapper	□	76	LaRC	176-30-31
	2R	Electron Devices & Components (IRCCD)	0	78	LaRC	506-18-21
	3S	Imaging System Development	□	79	JPL	186-68-65
	4R	Adv. Imaging Systems Tech.	□	79	JPL	506-18-11
	5S	Imaging System Technology	□	79	ARC	186-68-52
	6R	Astron. Hi Res Sensors	□	81	GSFC	506-18-13
f. Particles & Fields	1S	Radiation & Spectrometric Studies	0	78	GSFC	195-22-06
	2S	Advanced Gamma Ray Spectroscopy	0	78	JPL	195-23-06
	3E	Shuttle Solar Weather Exp. Facility	0	80	GSFC	645-10-05
	4S	X-Ray Spectroscopy	0	81	GSFC	188-41-55
	5S	Development of Solar Physics Experiments (X-Ray)	0	81	GSFC	188-38-51
	6S	Shuttle Payload Development (X-Ray)	0	81	GSFC	188-38-64
	7S	Lunar Gamma Ray Measurements	0	81	HQ	195-20-06

* AAFE

ACTION ITEMS IDENTIFIED DURING THE REVIEW PROCESS ARE LISTED FOR EACH RELEVANT DISCIPLINE CATEGORY. EACH ACTION ITEM LISTING INCLUDES A TITLE, IDENTIFICATION OF DESIRED ACTION, PARTICIPANTS AND A MILESTONE CODE. THE CODE CAN BE USED TO IDENTIFY A SPECIFIC MILESTONE ON THE ROADMAP CHARTS, E.G. 4e7R REFERS TO MILESTONE 7R IN THE (e) DIGITAL IMAGING TECHNICAL AREA OF THE (4) SENSING AND DATA ACQUISITION DISCIPLINE CATEGORY.

ACTION ITEMS

4. SENSING AND DATA ACQUISITION (Cont.)

Title	Action	Participants	Associated Milestones
Lasers	Coordinate LaRC Laser program and MSFC Laser Doppler program	LaRC, MSFC	4d1R, 1b3R
CCD Imager	Determine benefits of application of CCD's to Image Dissector Tube Operation	MSFC, GSFC	4e6R, 4e4R, 5b2S

Milestone Code

4 e 6 R

- R — Sponsoring Office (R-OAST)
- 6 — Milestone (Astronomical High Resolution Sensors)
- e — Technical Area (e. Digital Imaging)
- 4 — Discipline Category (4. Sensing & Data Acquisition)

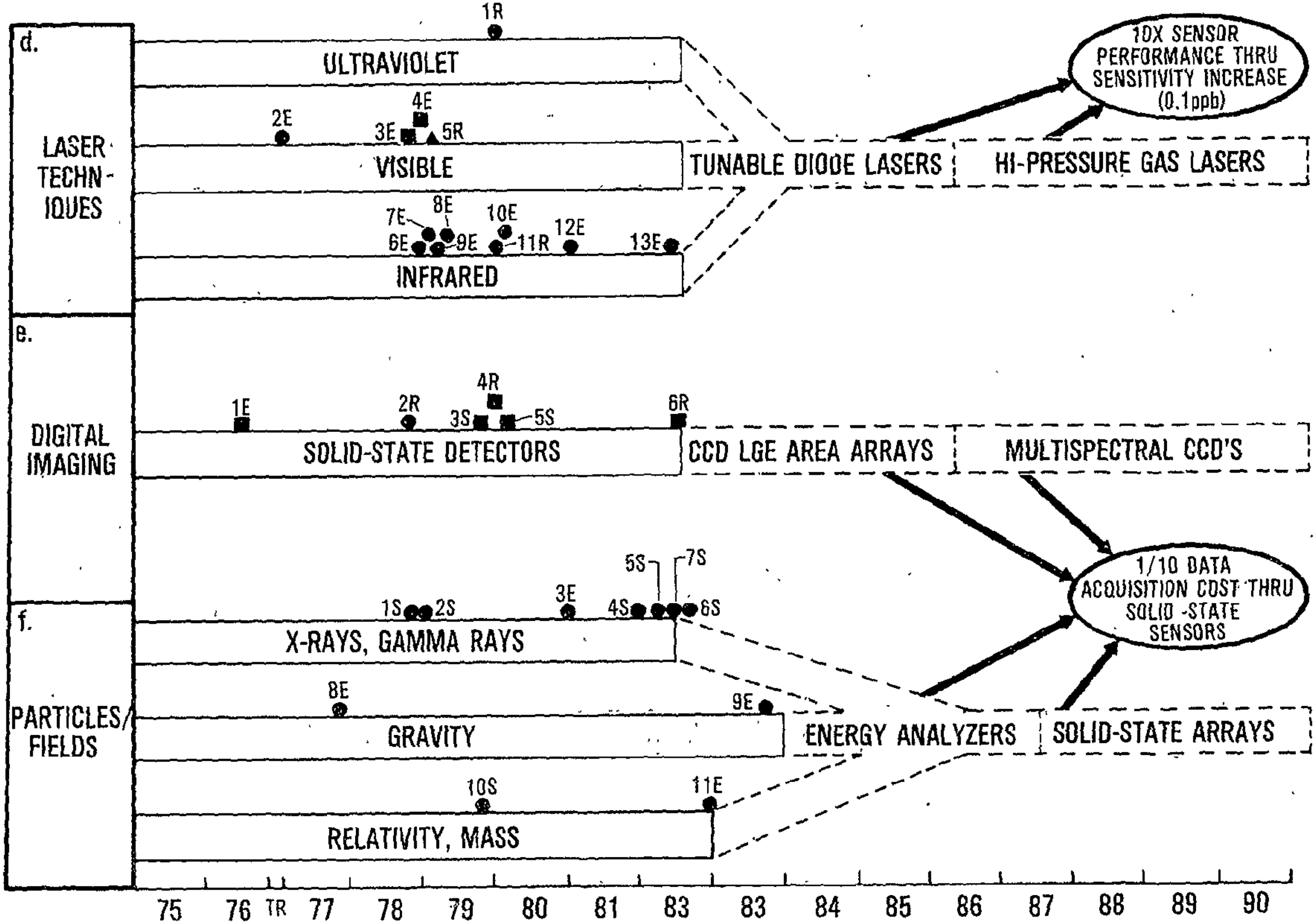
ADVANCED TECHNOLOGY THRUSTS FOR EACH TECHNICAL AREA WERE DEVELOPED FROM AN ANALYSIS OF OUTLOOK FOR SPACE THEMES, FUTURE MISSION REQUIREMENTS AND A TECHNICAL ASSESSMENT OF THE TRENDS IN ELECTRONIC SYSTEMS TECHNOLOGY. THE FIGURE LISTS SOME OF THE KEY OFS THEMES USED IN DEFINING TECHNOLOGY THRUSTS FOR SEVERAL TECHNICAL AREAS IN THE SENSING AND DATA ACQUISITION DISCIPLINE CATEGORY. SIMILAR LISTS ARE PROVIDED FOR EACH DISCIPLINE CATEGORY IN THE CURRENT PROGRAM FOR THE READER's REFERENCE.

4. SENSING AND DATA ACQUISITION (Cont.)

Technical Area	Title	OFS Theme
d. Laser Techniques	Tunable Diode Lasers Hi-Pressure Gas Lasers	014 Living Marine Resources 024 Stratospheric Changes/ Effects 025 Water Quality 031 Local Weather/Severe Storm 032 Tropospheric Pollutants 074 Dynamics/Energetics Lower Atmosphere
e. Digital Imaging	CCD Large Area Arrays Multispectral CCD's	081 How did the Universe begin? 112 How do planets/large satellites and their atmospheres evolve?
f. Particles/Fields	Energy Analyzers Solid-State Arrays	085 What is nature of gravity? 103 Solar activity nature/ cause 114 Origin/history of magnetic fields

THE ROADMAP APPROACH IS AGAIN USED TO DESCRIBE FUTURE TECHNOLOGY THRUSTS. BUILDING ON THE CURRENT PROGRAMS, THE DASHED LINES SUMMARIZE THE PROGRAMMATIC THRUSTS REQUIRED IN EACH TECHNICAL AREA TO SUPPORT FUTURE MISSION OPTIONS. THE TIME PERIODS INDICATED FOR EACH DASHED BAR ARE ROUGH ESTIMATES OF TECHNOLOGY READINESS DATES FOR THE PROGRAMS DESCRIBED IN THE BARS. BUBBLES IDENTIFY SPECIFIC SYSTEM OR PROGRAM GOALS ESTABLISHED IN EACH DISCIPLINE TO PROVIDE THE MISSION CAPABILITY REQUIRED FOR LONG RANGE SPACE ACTIVITIES.

4. SENSING AND DATA ACQUISITION



NASA HQ RE76-601 A (1)
2-17-76

NAVIGATION, GUIDANCE AND CONTROL

NAVIGATION, GUIDANCE AND CONTROL INVOLVES THOSE MISSION FUNCTIONS ASSOCIATED WITH THE CHANGE OF A CURRENT STATE TO THE STATE REQUIRED FOR SPACECRAFT OPERATIONS AND SCIENTIFIC OBSERVATIONS. THESE FUNCTIONS COMPRISE THE DETERMINATION OF THE CURRENT STATE (NAVIGATION), DERIVATION OF CORRECTIVE COMMANDS TO CHANGE THE CURRENT STATE TO THE REQUIRED STATE (GUIDANCE), AND IMPLEMENTATION OF THESE COMMANDS (CONTROL).

THREE DISCIPLINE CATEGORIES, COVERING THE TECHNOLOGY NEEDED TO ADDRESS THESE FUNCTIONS, ARE:

1. NAVIGATION AND GUIDANCE
2. POINTING AND CONTROL
3. AUTOMATION

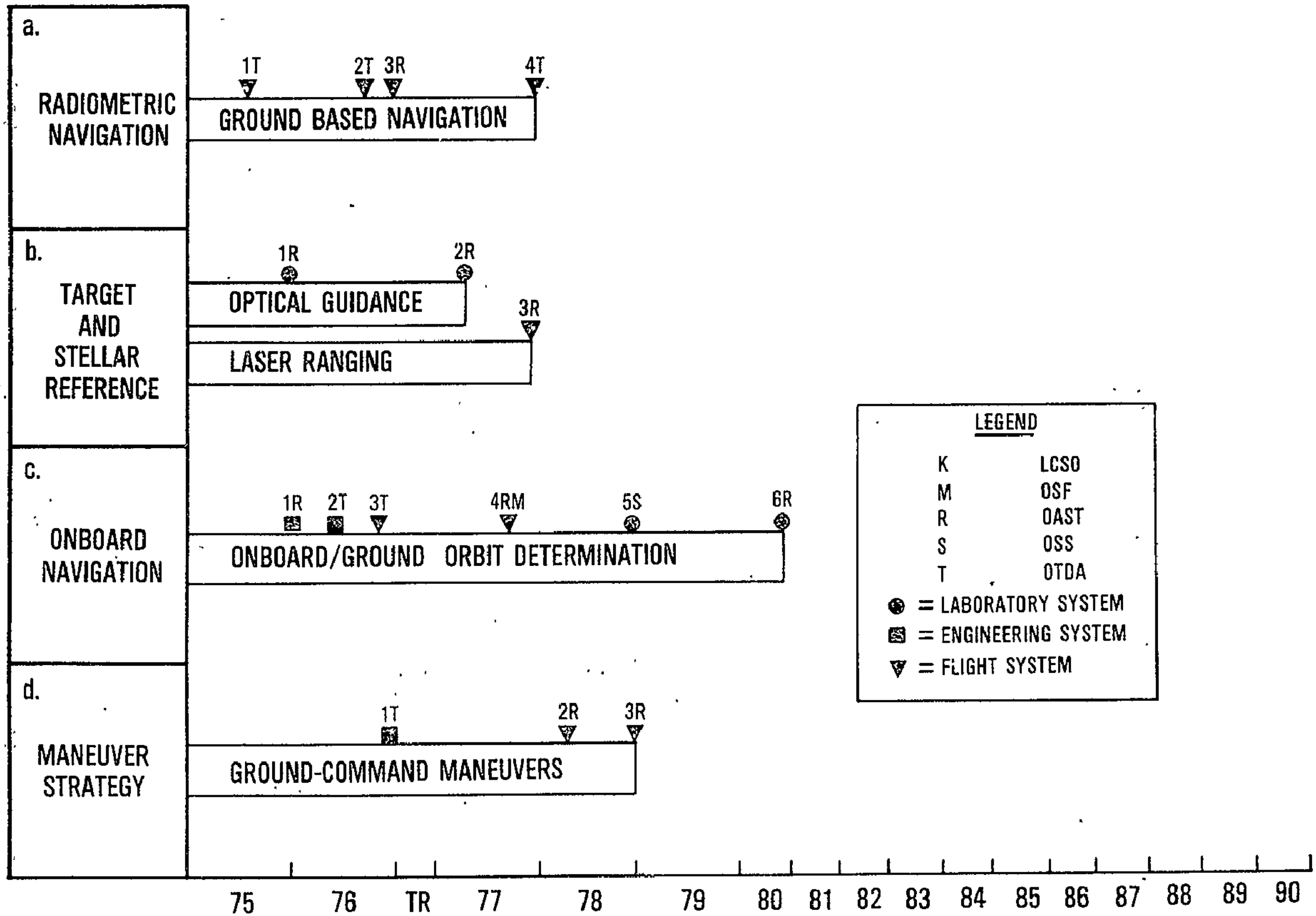
SPECIFIC TECHNOLOGY ACTIVITIES FALLING UNDER THESE CATEGORIES ARE SUMMARIZED IN THIS SECTION.

SPACE ELECTRONICS TECHNOLOGY

INTRODUCTION	PETER R. KURZHALS
APPROACH	ARTHUR HENDERSON
PROGRAM OUTLINE	CHARLES E. PONTIOUS
GUIDANCE, NAVIGATION & CONTROL	WILLIAM B. GEVARTER
SENSING & DATA ACQUISITION	BERNARD RUBIN
DATA PROCESSING, STORAGE & TRANSFER	HAROLD ALSBERG
PROGRAM GOALS	CHARLES E. PONTIOUS
CONCLUSION	PETER R. KURZHALS

NAVIGATION AND GUIDANCE IS DIVIDED INTO THE 4 TECHNICAL AREAS SHOWN ON THE ROADMAP. THESE AREAS ARE RADIOMETRIC NAVIGATION, TARGET AND STELLAR REFERENCE, ONBOARD NAVIGATION, AND MANEUVER STRATEGY. EXISTING EFFORTS ARE PRIMARILY SUPPORTED BY OTDA AND OAST, AND FOCUS ON GROUND-BASED NAVIGATION AND COMMAND OF SPACECRAFT, WITH LIMITED APPLICATION OF ONBOARD OPTICAL MEASUREMENTS FOR DETERMINING DIRECTION AND RANGE.

1. NAVIGATION AND GUIDANCE



NASA HQ RE76-725A (1)
2-17-76

THE ROADMAP GUIDE LISTS THE ROADMAP MILESTONES IDENTIFIED FOR THESE TECHNICAL AREAS DURING THE JOINT PROGRAM REVIEWS. EACH MILESTONE IS DESCRIBED BY TITLE, STATUS, YEAR OF COMPLETION, PERFORMING CENTER, AND THE RTOP NUMBER. MOST OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT AND FLIGHT VALIDATION OF NEW NAVIGATION ALGORITHMS AND SYSTEMS.

ROADMAP GUIDE

1. NAVIGATION AND GUIDANCE

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
a. Radiometric Navigation	1T	MVM'73 S/X Demo.	▽	75	JPL	310-10-60
	2T	VLBI Viking Demo.	▽	76	JPL	310-10-60
	3R	Viking '75 Multi-Station Demo.	▽	76	JPL	506-19-21
	4T	SITT Nav. Demo. w/Viking'75 Complete	▽	77	JPL	310-10-60
b. Target and Stellar Reference	1R	Demonstrate Capability of VGLIS to Select Landing Sites	0	75	LaRC	506-19-22
	2R	Optical Guidance Preliminary Lab. Demo.	0	77	LaRC	506-19-21
	3R	Qualification Testing of Scanning Laser Radar for Upper Stages	▽	77	MSFC	910-10-02
c. Onboard Navigation	1R	MVM Bright Object/Dim Star Optical Nav. Demo.	□	75	JPL	506-19-21
	2T	Auto. Nav. Implement & Test with Mini-Computer Constraints	□	76	GSFC	310-10-22
	3T	Attitude-Orbit Determination with Landmark Data	▽	76	GSFC	310-10-26
	4RM	Flight Test of Redundant Laser Gyro IMU System	▽	77	MSFC	506-19-11 910-10-01
	5S	Solar Elec. Prop. Navigation Study	0	78	JPL	186-67-74
	6R	Lab. Demo. of Auto. G&N Breadboard	0	80	JPL	506-19-21
d. Maneuver Strategy	1T	Shuttle Payload Flight Maneuver Mission Requirements	□	76	GSFC	310-10-22
	2R	Orbit Control	▽	78	JPL	506-19-21
	3R	Rendezvous Control	▽	78	JPL	506-19-21

RTOP #506-19-21 ON ADVANCED NAVIGATION IS AN EXAMPLE OF THE NAVIGATION AND GUIDANCE EFFORTS COVERED BY THE ROADMAP. THIS RTOP HAS MULTIPLE TASKS RELATING TO MILESTONES 1a3R, 1b2R, 1c1R, 1c6R, 1d2R AND 1d3R AND ADDRESSES THE DEVELOPMENT OF ONBOARD OPTICAL MEASUREMENT AND MANEUVER SYSTEMS TO IMPROVE SPACECRAFT PERFORMANCE.

51

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506-19-21	ADVANCED NAVIGATION

JPL
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OAST

B

HQ
MR. C. E. PONTIOUS
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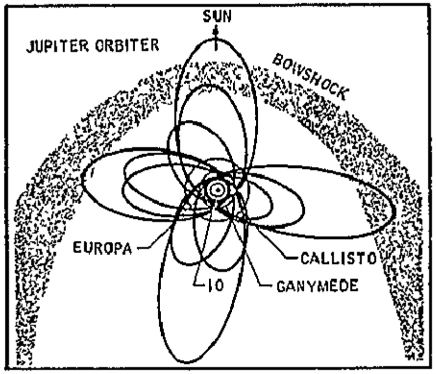
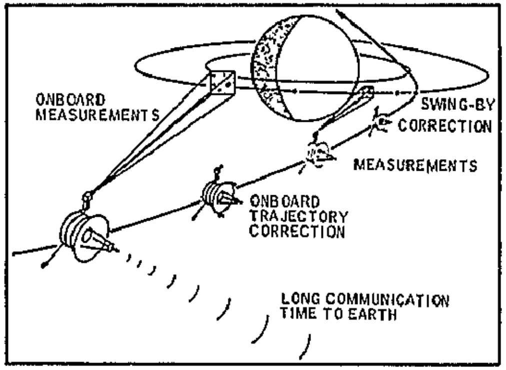
MANEUVER AND ORBIT DETERMINATION



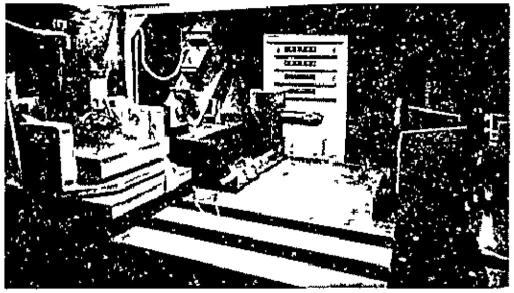
- OUTER PLANET
  - SATEL TOURS
  - FLOWER ORBIT
- ADV GRAVITY ORBIT CONTROL
- OPTIMIZE ΔV

AUTONOMOUS G&N SYSTEM



- ONBOARD FLIGHT PATH CONTROL
- ADAPTIVE NAV AND SCIENCE SEQUENCE CONTROL
  - TARGET TRACKING
  - INSTRUMENT POINTING

OPTICAL GUIDANCE LAB



- SIMULATE NAV SCENES
- SENSOR EVALUATION
- DATA SOURCE FOR PRE-PROC, CALIBRATION

WORK IN NAVIGATION AND GUIDANCE IS CONCENTRATED PRIMARILY AT JPL FOR PLANETARY AND GSFC FOR NEAR-EARTH MISSIONS WITH LITTLE OVERLAP. THE ONLY ACTION ITEM IDENTIFIED HERE CONCERNED THE POTENTIAL EXTENSION OF VIDEO GUIDANCE LANDING AND IMAGING CONCEPTS TO AUTOMATED RENDEZVOUS AND DOCKING.

ACTION ITEMS

1. NAVIGATION AND GUIDANCE

Title	Action	Participants	Associated Milestones
Video Guidance Landing and Imaging System	Determine applicability of video guidance to automated spacecraft rendezvous & docking	MSFC, JPL, OAST, LaRC, OSS, OMSF	1b1R, 1b3R

THE CURRENT OBJECTIVE OF VGLIS IS TO DEMONSTRATE THE CAPABILITY OF AUTONOMOUS PLANETARY LANDING USING VIDEO SENSORS. RELATED ALGORITHMS AND MECHANIZATIONS COULD AID CLOSE-RANGE IUS/SPACECRAFT AND SPACECRAFT/SPACECRAFT OPERATIONS. AS A RESULT OF THE ACTION ITEM, USE OF VIDEO GUIDANCE FOR RENDEZVOUS AND DOCKING HAS BEEN IDENTIFIED AS POTENTIALLY FEASIBLE. APPLICABILITY OF THE CONCEPT TO LANDMARK TRACKING IS ALSO BEING PURSUED.

LANGLEY RESEARCH CENTER

506-19-22	VIDEO GUIDANCE, LANDING, AND IMAGING SYSTEM-VGLIS

LaRC

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OAST

B

HQ
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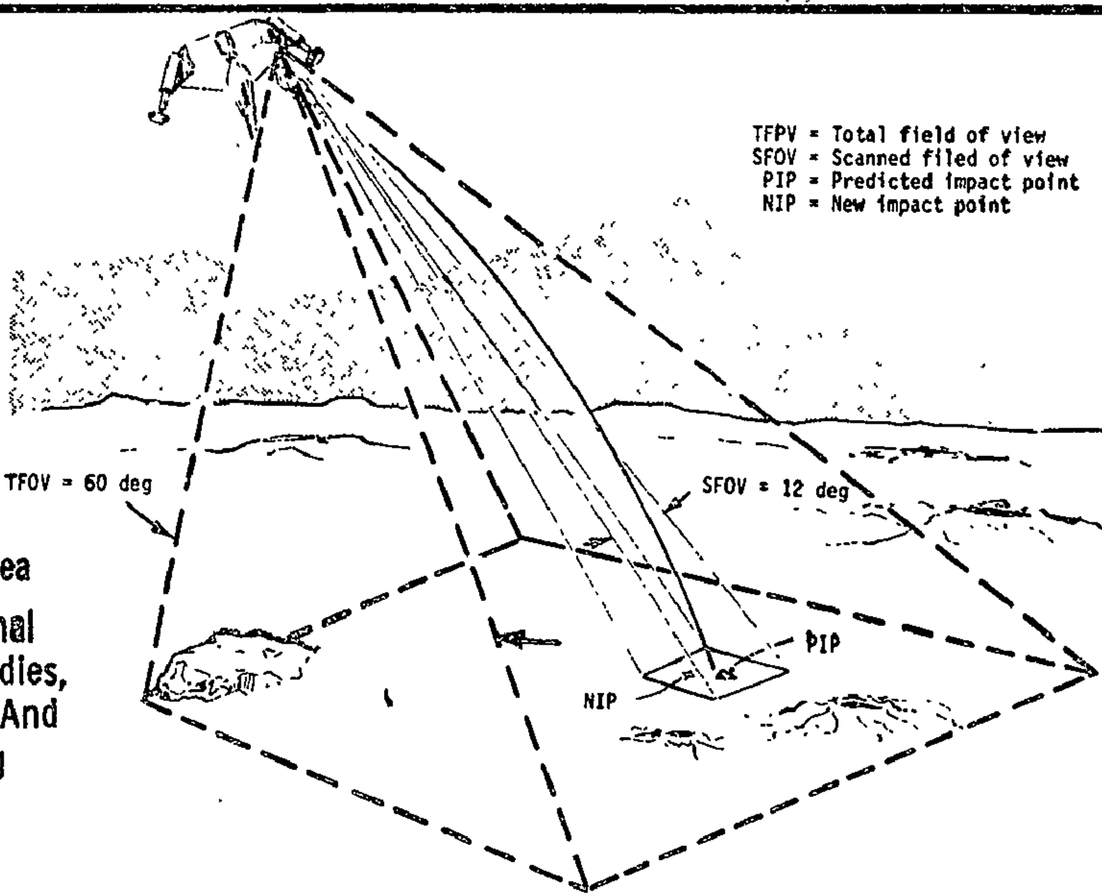
OBJECTIVES

PHASE I - CY 74

- Breadboard VGLIS Hardware
- Demonstrate Capability of System To Select Safe Landing Sites

PHASE II - CY 75

- Demonstrate Capability of VGLIS To Select Safe and Most Scientifically Interesting Sites Within Range
- Demonstrate Capability of VGLIS To Obtain Nested Images Of Landing Area
- Study Potential of VGLIS For Terminal Rendezvous Guidance With Solar Bodies, Landmark Navigation During Entry, And Tracking of Surface Features During Imagery Missions



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NASA HQ RE76-1237 (1)
11-12-75

FUTURE TECHNOLOGY NEEDS DRIVING NAVIGATION AND GUIDANCE TECHNOLOGY GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER GROUP REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON EFFICIENT LOW-COST TRANSFER OF SYSTEMS TO SPACE, EARTH RESOURCES, AND EVOLUTION OF THE SOLAR SYSTEM THROUGH INCREASED NAVIGATION AND MANEUVER AUTONOMY AND MORE PRECISE SPACECRAFT POSITION AND ATTITUDE DETERMINATION.

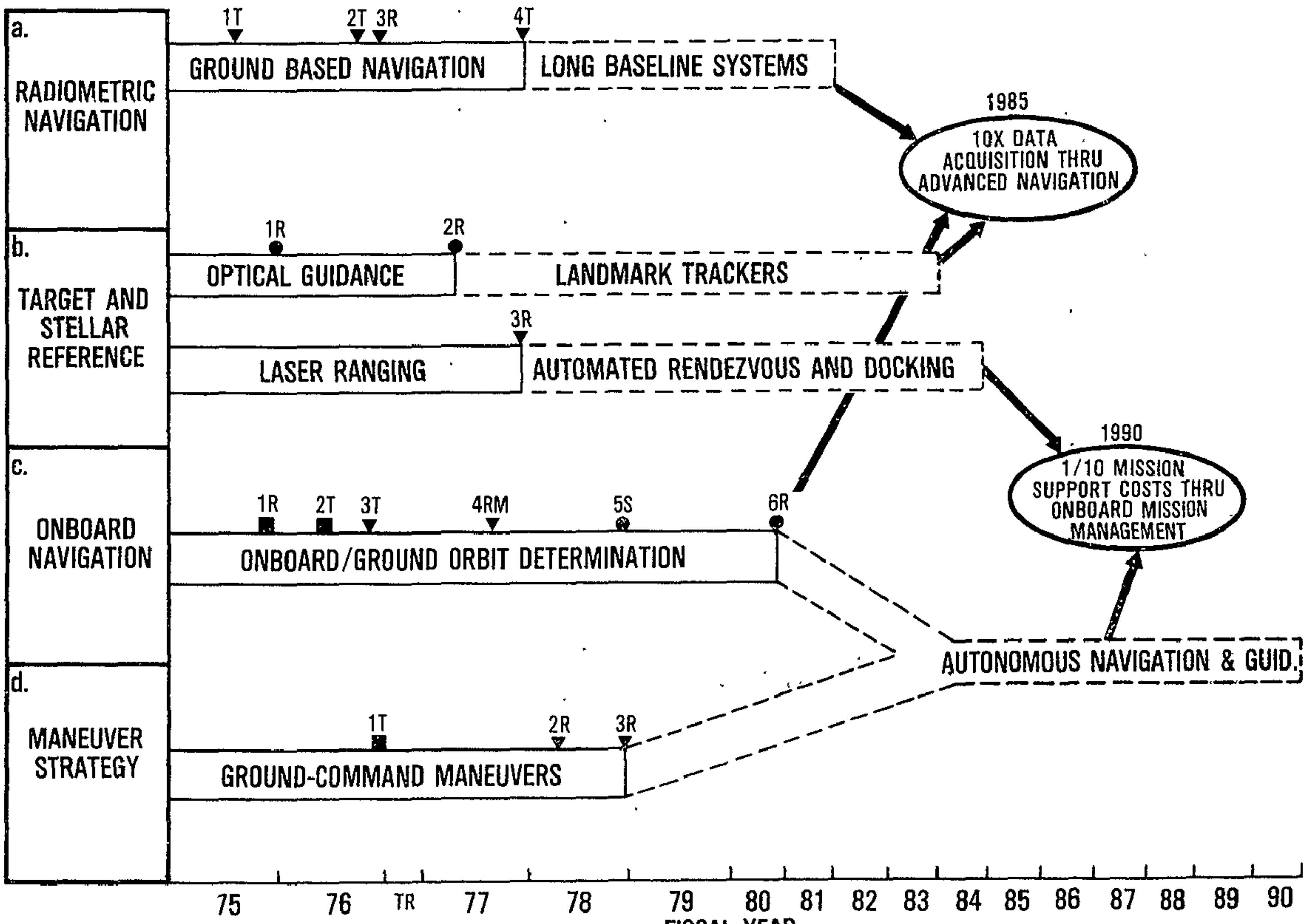
TECHNOLOGY THRUSTS

1. NAVIGATION AND GUIDANCE

Technical Area	Title	OFS Theme
a. Radiometric Navigation	Long Baseline Systems	150: Efficient Low-Cost Transfer of Systems to Space 11: Evolution of the Solar System
b. Target and Stellar Reference	Landmark Trackers	150: Efficient Low-Cost Transfer of Systems to Space 01: Production and Management of Food and Forestry Resources 11: Evolution of the Solar System 035: Earthquake Prediction and Warning 044: World Geologic Atlas
	Automated Rendezvous and Docking	150: Efficient Low-Cost Transfer of Systems to Space 066: Man Living & Working in Space
c. Onboard Navigation d. Maneuver Strategy	Autonomous Navigation and Guidance	05: Transfer of Information 150: Efficient Low-Cost Transfer of Systems to Space 130: Space Station 11: Evolution of the Solar System 034: Communication - Navigation

THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN NAVIGATION AND GUIDANCE ARE SHOWN AS DASHED BARS ON THE ROADMAP. ASSOCIATED MAJOR GOALS ARE A TEN-FOLD INCREASE IN DATA ACQUISITION CAPABILITY THROUGH IMPROVED NAVIGATION SYSTEMS WHICH MAXIMIZE DATA GATHERING OPPORTUNITIES AND MINIMIZE TRAJECTORY CORRECTION FUEL REQUIREMENTS TO INCREASE USEABLE SCIENCE PAYLOAD; AND A TEN-FOLD DECREASE IN MISSION SUPPORT COSTS THROUGH AUTONOMOUS NAVIGATION AND GUIDANCE WHICH SIGNIFICANTLY REDUCES THE NEED FOR GROUND STATION SUPPORT.

1. NAVIGATION AND GUIDANCE



NASA HQ RE76-725C (1)
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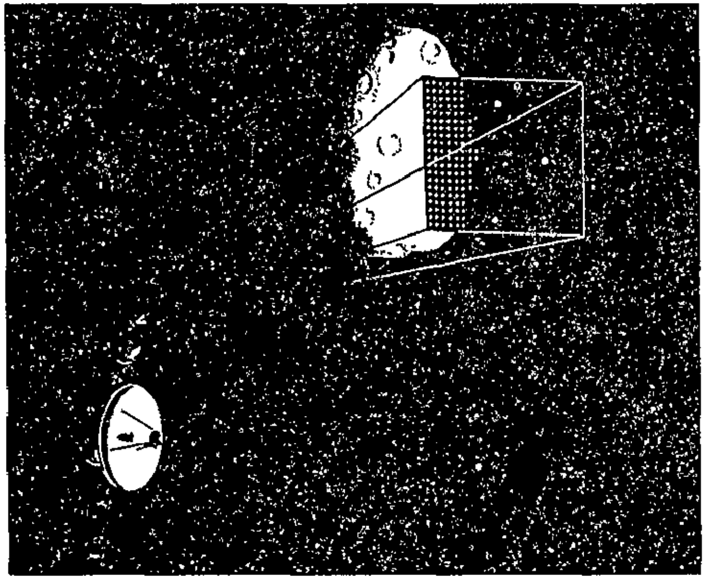
AUTONOMOUS NAVIGATION IS REPRESENTATIVE OF THE TECHNOLOGY THRUSTS NEEDED TO REDUCE MISSION SUPPORT COSTS BY A FACTOR OF TEN. AUTOMATED NAVIGATION AND SCIENCE OBSERVATION FUNCTIONS PERMIT NEW CLASSES OF MISSION OPTIONS, SUCH AS FLOWER ORBITS AND ADAPTIVE SCIENCE COVERAGE WHICH MINIMIZE THE TOTAL TIME AND COST REQUIRED FOR GLOBAL PLANET AND SATELLITE OBSERVATIONS AND CAN DRASTICALLY REDUCE RELATED GROUND SUPPORT TASKS FOR PLANETARY EXPLORATION.

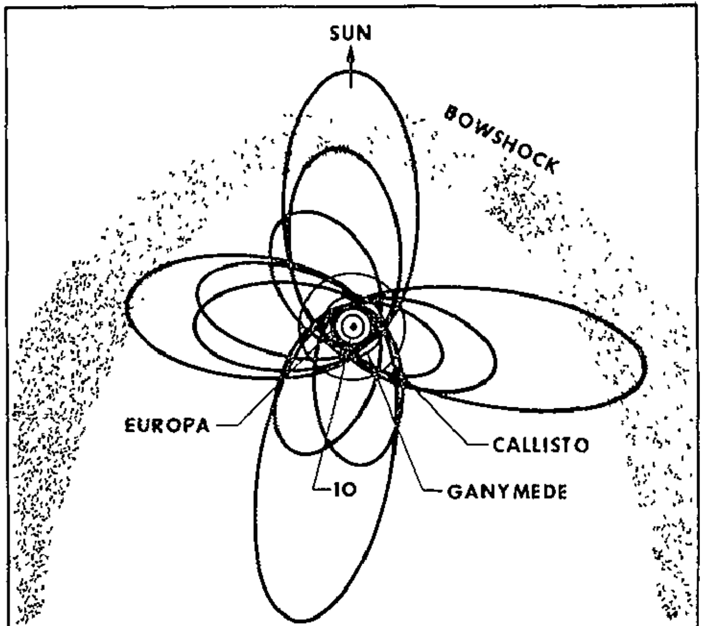
ADVANCED NAVIGATION BENEFITS

PRECISION NAVIGATION



ENABLES ⇨

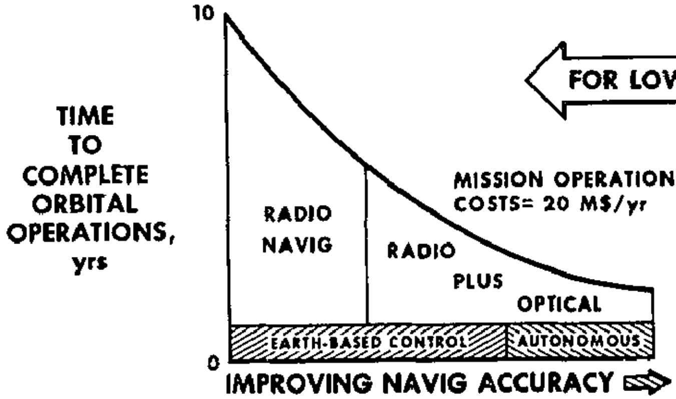
JUPITER ORBITER



MISSION HIGHLIGHTS

- 40 SATELLITE ENCOUNTERS
- EXTENSIVE FIELD EXPLORATION
- GLOBAL JUPITER COVERAGE
  - PLANET STRUCTURE
  - ATMOSPHERE PROPERTIES
  - METEOROLOGY

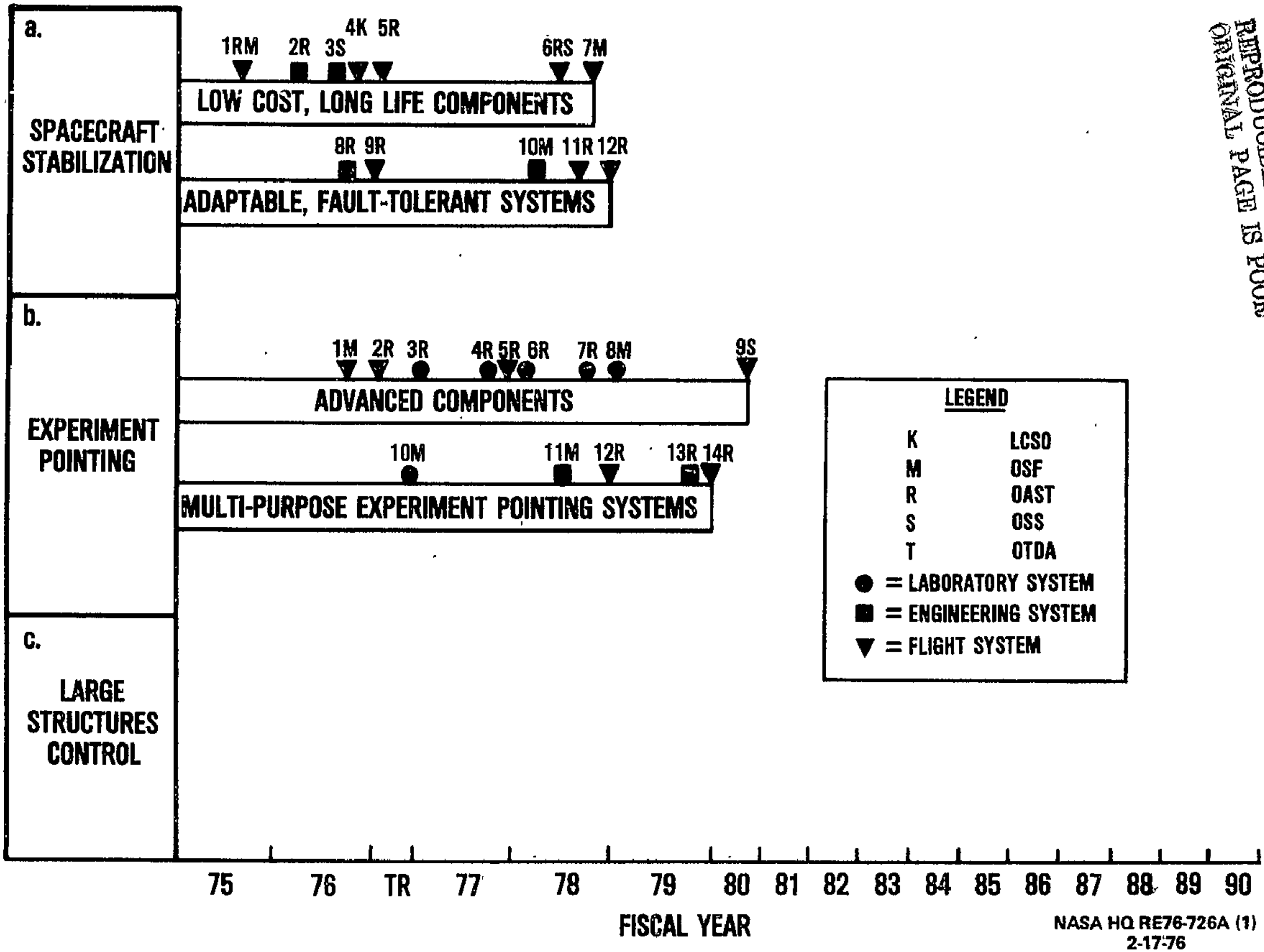
⇦ FOR LOWER COST



NASA HQ RE75-15314 (1)
Rev. 11-12-75

POINTING AND CONTROL IS DIVIDED INTO THE 3 TECHNICAL AREAS SHOWN ON THE ROADMAP. THESE AREAS ARE SPACECRAFT STABILIZATION, EXPERIMENT POINTING AND LARGE STRUCTURES CONTROL. EXISTING EFFORTS ARE PRIMARILY SUPPORTED BY OAST AND OSF AND FOCUS ON LOW COST, LONG LIFE COMPONENTS AND ADAPTABLE MULTI-PURPOSE SYSTEMS. EXPERIMENT POINTING EFFORTS SUPPORT THE SHUTTLE INSTRUMENT POINTING SYSTEM (IPS) AND EXPLORE COMPLEMENTARY SYSTEMS.

2. POINTING AND CONTROL



NASA HQ RE76-726A (1)
2-17-76

THE ROADMAP GUIDE LISTS THE ROADMAP MILESTONES IDENTIFIED FOR THESE TECHNICAL AREAS DURING THE JOINT PROGRAM REVIEWS. EACH MILESTONE IS DESCRIBED BY TITLE, STATUS, YEAR OF COMPLETION, PERFORMING CENTER AND RTOP NUMBER. THESE MILESTONES FOCUS ON REPLACEMENT OF MECHANICAL HARDWARE WITH ELECTRONIC COMPONENTS SUCH AS LASER GYROS AND MAGNETIC BEARINGS AND ON COST REDUCTION THROUGH MULTIPLE-USE EQUIPMENT AND SOFTWARE. IN THE EXPERIMENT POINTING AREA, END ITEMS ARE ADVANCED COMPONENTS AND SYSTEMS CONCEPTS AND HARDWARE SUCH AS THE AMCD (ANNULAR MOMENTUM CONTROL DEVICE), VIPS (VIDEO INERTIAL POINTING SYSTEM) AND EPM (EXPERIMENT POINTING MOUNT).

2. POINTING AND CONTROL

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
a. Spacecraft Stabilization	1RM	3 Axis Laser IMU System Operational Tests	▽	75	MSFC	910-10-01 506-19-11
	2R	Breadboard of VIPS Stellar Tracker	□	76	JPL	506-19-15
	3S	Pulse Rebalance Tuned-Rotor Gyro Test	□	76	MSFC	180-17-53
	4K	Standard MJS DRIRU Prototype	▽	76	JPL	323-54-20
	5R	Laser Rate Gyro Package Hardware	▽	76	MSFC	506-19-11
	6RS	ELACS STELLAR Tracker Readiness	▽	78	JPL	186-68-54 506-19-14
	7M	Standardized Electronic Packaging	▽	78	JSC	910-13-03
	8R	Programmable Step-Scan Controller	□	76	GSFC	506-19-12
	9R	Implement Adaptable Software Package	▽	76	LaRC	506-19-13
	10M	Test of Fault-Tolerant SUMC Navigation Computer	□	78	MSFC	910-33-01
	11R	ELACS Programmable Attitude Control Electronics with Fault-Tolerant Capability	▽	78	JPL	506-19-14
	12R	Standardized Software Library	▽	78	LaRC	506-19-13
b. Experiment Pointing	1M	D.C. Brushless Actuator Prototype	▽	76	JSC	909-44-36
	2R	Final Testing of Second Generation CMG	▽	76	LaRC	506-19-13
	3R	AMCD Hardware Test Complete	0	77	LaRC	506-19-13
	4R	Platform Soft Magnetic Isolator Evaluation	0	77	GSFC	506-19-12
	5R	Magnetic Bearing Reaction Wheel Technical Readiness	▽	77	JPL	506-19-14
	6R	Evaluate AMCD for Vernier Pointing	0	77	LaRC	506-19-13
	7R	High Resolution Laser Gyros	0	78	MSFC	506-19-11
	8M	Rotor Testing for Integrated Power/ Attitude Control System Complete	□	78	GSFC	909-74-35 910-35-02
	9S	High Tolerance Cryo Gyro Available	▽	79	MSFC	188-41-54
	10RM	Experiment Pointing Mount Study Final Report	0	76	JPL	506-19-16 910-08-04
	11M	Define IPS Digital Controller Design	□	78	MSFC	910-08-12
	12R	VIPS Stage III Systems Test	▽	78	ARC	506-19-15
	13R	Test 3 Gimbal AMCD	□	79	LaRC	506-19-13
	14R	Rate Settling Control Algorithms	▽	79	JPL	506-19-14

AN EXAMPLE OF AN RTOP INCLUDED ON THE ROADMAP IS #910-08-02 ON STABILIZATION AND CONTROL, ASSOCIATED WITH MILESTONE 2b11M. ONE TASK UNDER THIS RTOP IS TO ANALYZE THE IPS INTERACTION WITH THE SHUTTLE AND USE THE RESULTS IN THE DESIGN OF A DIGITAL CONTROLLER TO MAXIMIZE POINTING ACCURACY. ANOTHER TASK IS TO DERIVE EQUATIONS OF MOTION FOR THE IPS/PALLET/ORBITER SYSTEM AND TO DEVELOP GUIDELINES CONCERNING ALLOWABLE PAYLOAD FLEXIBILITY FOR THE DEVELOPERS OF THESE PAYLOADS. A THIRD TASK IS TO DETERMINE GENERALIZED TECHNIQUES FOR MULTIPLE SPACECRAFT DEPLOYMENT THAT WILL ACCOMODATE VARIOUS CONFIGURATIONS.

910-08-02	**STABILIZATION AND CONTROL**

MSFC
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MR. H. J. BUCHANAN
205/453-4580

OMSF

HQ
P. SCHROCK
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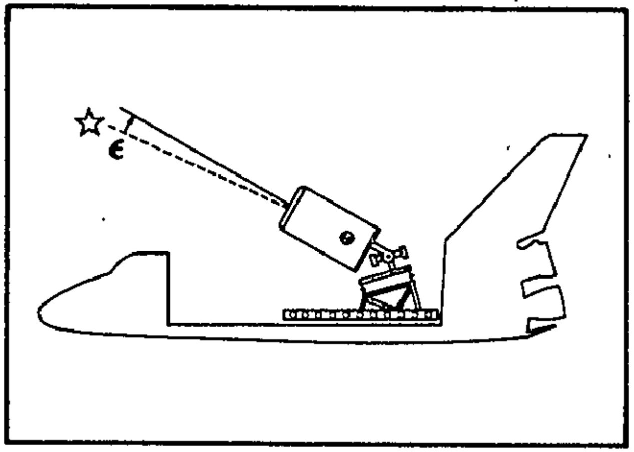
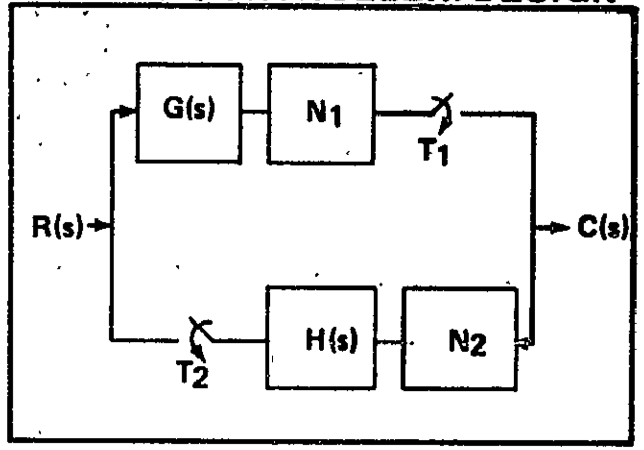
IPS ANALYSIS



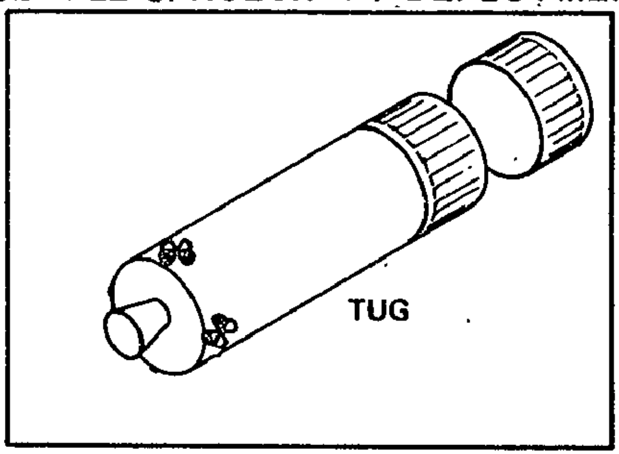
- VEHICLE FLEXIBILITY
- SENSOR & ACTUATOR PLACEMENT
- OPTIMIZE POINTING PERFORMANCE

IPS DIGITAL CONTROLLER DESIGN



- ACCOMODATE NON LINEARITIES
- MINIMIZE LIMIT CYCLE EFFECTS

MULTIPLE SPACECRAFT DEPLOYMENT



- DEPLOYMENT SYSTEM REQUIREMENTS/TECHNIQUES
- LARGE C. M. SHIFTS
- VARIOUS CONFIGURATIONS

NASA HQ RE76-1240 (1)
11-12-75

POINTING AND CONTROL ACTION ITEMS RESULTING FROM THE ELECTRONICS PROGRAM REVIEWS CENTERED ON COMPARING MERITS OF COMPONENTS; DETERMINING APPLICATIONS AND INSURING COORDINATION BETWEEN CENTERS AND PROGRAM OFFICES. THERE WERE 7 ACTION ITEMS INVOLVING 6 CENTERS AND 4 HEADQUARTERS PROGRAM OFFICES. THESE INVOLVED COMPARING STANDARD AND FIXED HEAD STAR TRACKERS, HONEYWELL AND SPERRY LASER GYROS, EXTENDING THE USE OF MAGNETIC SUSPENSION SYSTEMS AND OBTAINING AN OVERVIEW OF ELACS COMPONENT TECHNOLOGY AND TUNED-ROTOR GYROS FOR IMPROVED PLANNING AND COORDINATION.

ACTION ITEMS

2. POINTING AND CONTROL

Title	Action	Participants	Associated Milestones
Comparison of Standard Tracker and STELLAR	Compare Standard Fixed-Head Star Tracker and STELLAR	MSFC, JPL, LCSO, OAST	2a2R, 2a6RS
Adaptable Software Standardization	Coordinate requirements and outputs with LCSO standardization activities and determine applicability of adaptable S/W to Spacelab experiment S/W requirements	LaRC, LCSO, OAST, OMSF	2a9R, 2a12R
Magnetic Suspension	Develop magnetic suspension program plan keyed to Shuttle experiment pointing requirements	GSFC, JPL, LaRC, MSFC, OAST, OMSF, OSS	2b3R, 2b4R, 2b5R, 2b6R, 2b10RM, 2b11M, 2b13R
ELACS Component Technology	Develop integrated overview of sponsored & proposed program activities	JPL, OAST, OSS, LCSO	2a7RS, 2a11R 2b5R, 2b14R
Tuned-Rotor Gyro Improvement and Testing	Provide NASA overview & coordinate tuned-rotor gyro activities	MSFC, JPL, OAST, OSS, LaRC, JPL	2a3S, 2a4K
Laser Gyro Testing	Provide comparative performance test data for Honeywell & Sperry laser gyros	MSFC, ARC, LaRC, OAST, OMSF	2a5R
Magnetic Systems & Components	Develop a plan for programmable step-scan drive system development coordinating with potential users	GSFC, OAST, LaRC, JPL	2a8R

ONE OF THE ACTION ITEMS IS TO COMPARE THE SOLID STATE CHARGE COUPLED DEVICE (CCD) STAR TRACKER (STELLAR) WITH A CONVENTIONAL FIXED-HEAD STAR TRACKER TO DETERMINE HOW STELLAR CAN FIT INTO OUR CURRENT PROGRAMS. THIS FIGURE SUMMARIZES THE PRINCIPLE FEATURES AND PROPOSED APPLICATIONS OF THE NEW STAR TRACKER. NOTE THE USE OF A MICROPROCESSOR TO PREPROCESS THE DATA ONBOARD, WHICH IS PART OF A GENERAL TREND TO UTILIZE ONBOARD MICROPROCESSORS FOR MORE AUTONOMOUS OPERATIONS. THE COMPARISON RESULTING FROM THE ACTION ITEM INDICATED THAT STELLAR HAD GREATER ACCURACY, LOWER WEIGHT, A DIGITAL VERSUS AN ANALOG INTERFACE, SOMEWHAT LOWER COSTS AND A HIGHER POTENTIAL RELIABILITY. IT IS THUS EXPECTED THAT STELLAR WILL EVENTUALLY REPLACE FIXED-HEAD STAR TRACKERS IN FUTURE MISSIONS.

186-68-54	GUIDANCE AND CONTROL TECHNOLOGY FOR PLANETARY MISSIONS

OSS

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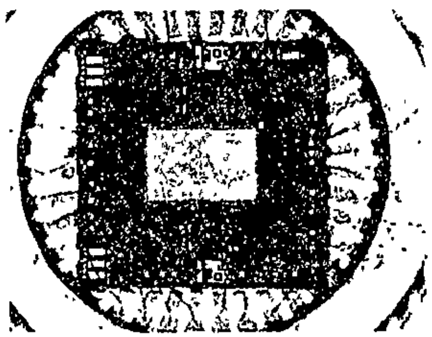
B

STELLAR STAR TRACKER

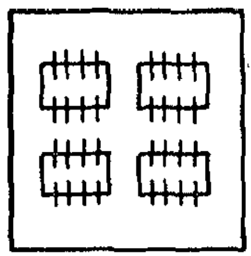
STAR TRACKER FOR ECONOMICAL LONG LIFE ATTITUDE REFERENCE

CCD



17.8 mm

\+ MICROPROCESSOR



\+ MODULAR DESIGN = STELLAR

FEATURES
- HIGH RELIABILITY - THROUGH STANDARD LOW VOLTAGE LSI CIRCUIT ELEMENTS
- STANDARDIZATION - THROUGH USE OF MODULAR DESIGN AND PROGRAMABILITY
- LOW COST - THROUGH STANDARD DESIGN AND LSI UTILIZATION
- IMPROVED PERFORMANCE AND NEW CAPABILITIES THROUGH USE OF CCD AND μP

APPLICATIONS
- PLANETARY PROGRAMS/MJU 1979 FIRST USE
- SHUTTLE - PAYLOADS VIP/ORBITER, 2nd GENERATION STAR TRACKER
- MOST OTHER NEEDS FOR STAR TRACKERS

FY76
- DESIGN AND FABRICATION OF AN ENGINEERING MODEL

NASA HQ RE76-1238 (2)
11-12-75

FUTURE TECHNOLOGY NEEDS DRIVING POINTING AND CONTROL TECHNOLOGY GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER GROUP REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON EFFICIENT LOW-COST TRANSFER OF SYSTEMS TO SPACE THRU LOWER COST STABILIZATION; AND ENHANCED EARTH APPLICATIONS AND STUDY OF THE SOLAR SYSTEM AND UNIVERSE VIA IMPROVED EXPERIMENT POINTING AND THE CONTROL OF LARGE STRUCTURES.

TECHNOLOGY THRUSTS

2. POINTING AND CONTROL

Technical Area	Title	OFS Theme
a. Spacecraft Stabilization	Standard Electronic Modules	01: Production and Management of Food and Forestry Resources
		03: Protection of Life and Property
		05: Transfer of Information
		08: Nature of Universe
		11: Evolution of the Solar System
		150: Efficient Low-Cost Transfer of Systems to Space
		130: Space Station
	Configuration Insensitive Systems	01: Production and Management of Food and Forestry Resources
		150: Efficient Low-Cost Transfer of Systems to Space
		07: Earth Science
		08: The Nature of the Universe
		11: Evolution of the Solar System
b. Experiment Pointing	Precise Experiment Pointing	013: Land Use & Environmental Assessment
		034: Communication - Navigation
		042: Power Relay
		051: Personal Communications Satellite
		072: Crustal Dynamics
		081: How Did the Universe Begin
		112: How Do Planets Evolve?
		150: Efficient Low-Cost Transfer of Systems to Space

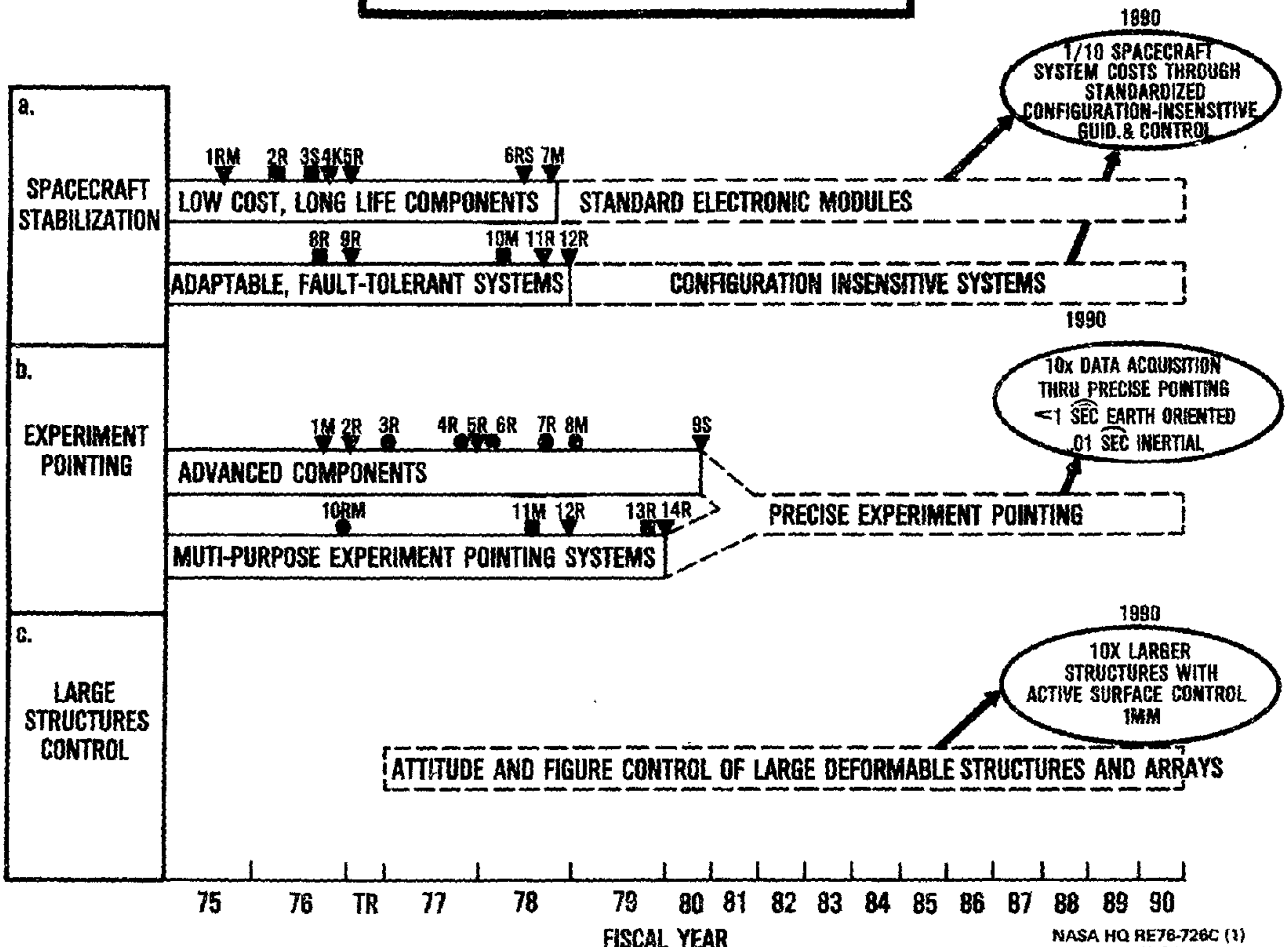
TECHNOLOGY THRUSTS

2. POINTING AND CONTROL

Technical Area	Title	OFS Theme
c. Large Structures Control	Attitude & Figure Control of Large Deformable Bodies and Arrays	041: Solar Power 051: Domestic Communications 081: How Did the Universe Begin 122: Is There Extraterrestrial Life? 130: Space Station 150: Efficient Low-Cost Transfer of Systems to Space

THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN POINTING AND CONTROL ARE SHOWN AS DASHED BARS ON THE ROADMAP. ASSOCIATED MAJOR GOALS ARE A TEN-FOLD DECREASE IN SPACECRAFT SYSTEM COSTS THROUGH STANDARDIZED CONFIGURATION-INSENSITIVE MODULES AND SYSTEMS, A TEN-FOLD INCREASE IN DATA ACQUISITION THROUGH PRECISE EXPERIMENT POINTING, AND PRACTICAL LARGE STRUCTURES AND ARRAYS ACTIVELY STABILIZED, POINTED AND CONFIGURATION CONTROLLED. DESIRED SHAPES MAY BE ACHIEVED BY ACTIVE SURFACE CONTROL OR BY SLAVING COMPONENTS TOGETHER USING ACTIVE STATION KEEPING SYSTEMS.

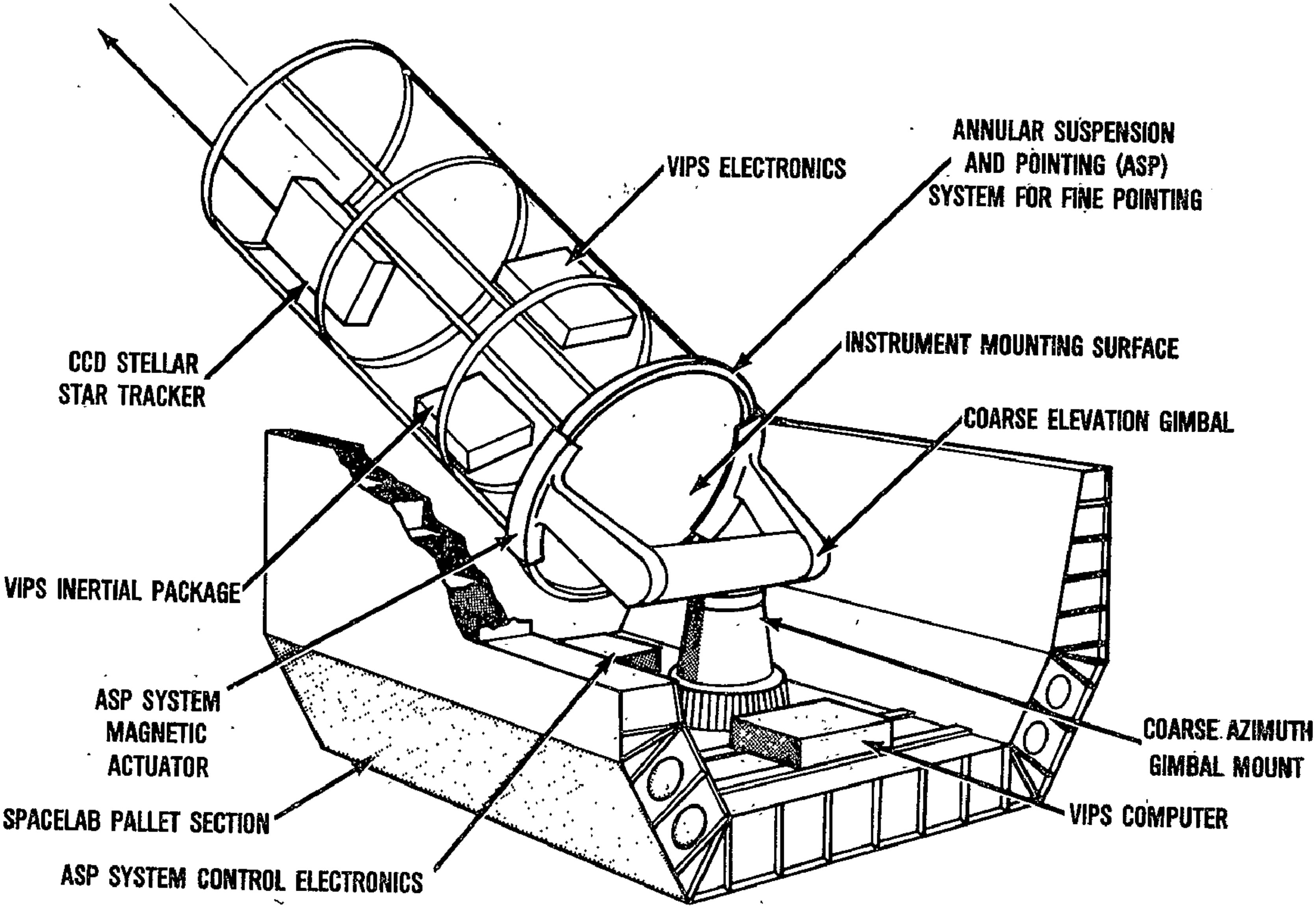
2. POINTING AND CONTROL



NASA HQ RE76-726C (1)
2-17-76

A KEY VEHICLE TO AID IN THE DEVELOPMENT OF LOW-COST AND HIGH ACCURACY POINTING DEVICES AND SYSTEMS IS MIPTL WHICH CAN SIGNIFICANTLY ACCELERATE DEVELOPMENT TIME BY PROVIDING FOR TESTING IN SPACE UNDER CONDITIONS APPROPRIATE TO THE FINAL APPLICATION. SHOWN ON THE MIPTL ARE SOME OF THE COMPONENTS AND DEVICES CURRENTLY BEING CONSIDERED. THESE INCLUDE A VIDEO INERTIAL POINTING SYSTEM (VIPS) WHICH COULD PROVIDE ACCURATE ($<$ 1SEC) INERTIAL REFERENCE AT LESS THAN 1/3 THE COST OF COMPARABLE EXISTING SYSTEMS AND A LOW-COST MAGNETIC ANNULAR SUSPENSION AND CONTROL SYSTEM (ASPS) FOR VERY PRECISE ($<$ .01 SEC) EXPERIMENT CONTROL.

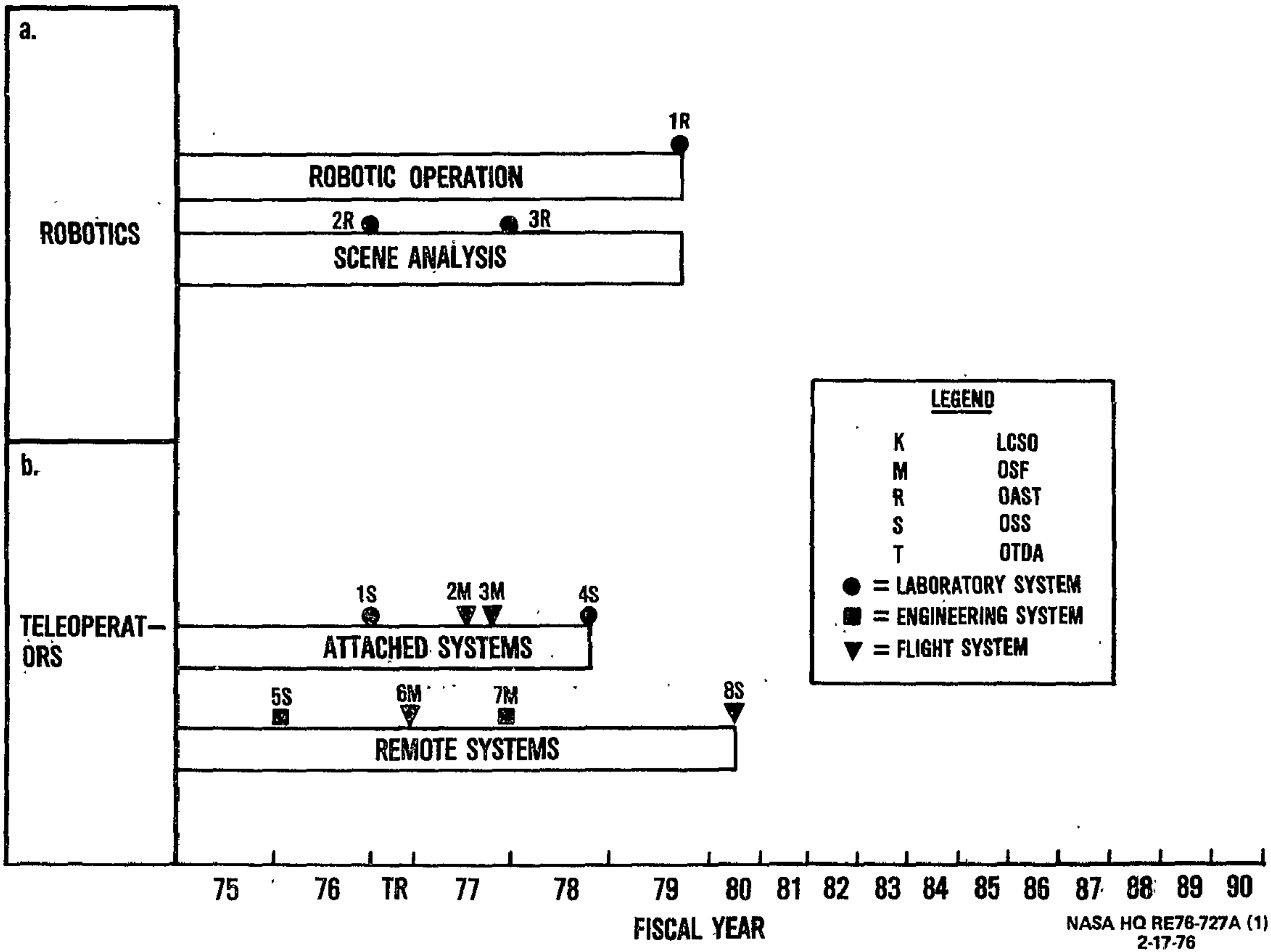
MODULAR INSTRUMENT POINTING TECHNOLOGY LABORATORY-MIPTL



NASA HQ RE76-2212 (1)
2-17-76

AS SHOWN ON THE ROADMAP, AUTOMATION HAS 2 PRIMARY TECHNICAL AREAS, ROBOTICS AND TELEOPERATORS. THE ROBOTICS EFFORT IS SUPPORTED BY OAST AND IS CENTERED AROUND JPL'S ROVER AND AUTOMATED PERCEPTION ACTIVITIES. THE TELEOPERATOR EFFORT SUPPORTED BY OSS AND OSF, IS DIRECTED AT MANIPULATION OF SHUTTLE PAYLOADS, AND TECHNOLOGY TO SERVICE AND REPAIR SPACECRAFT.

3. AUTOMATION

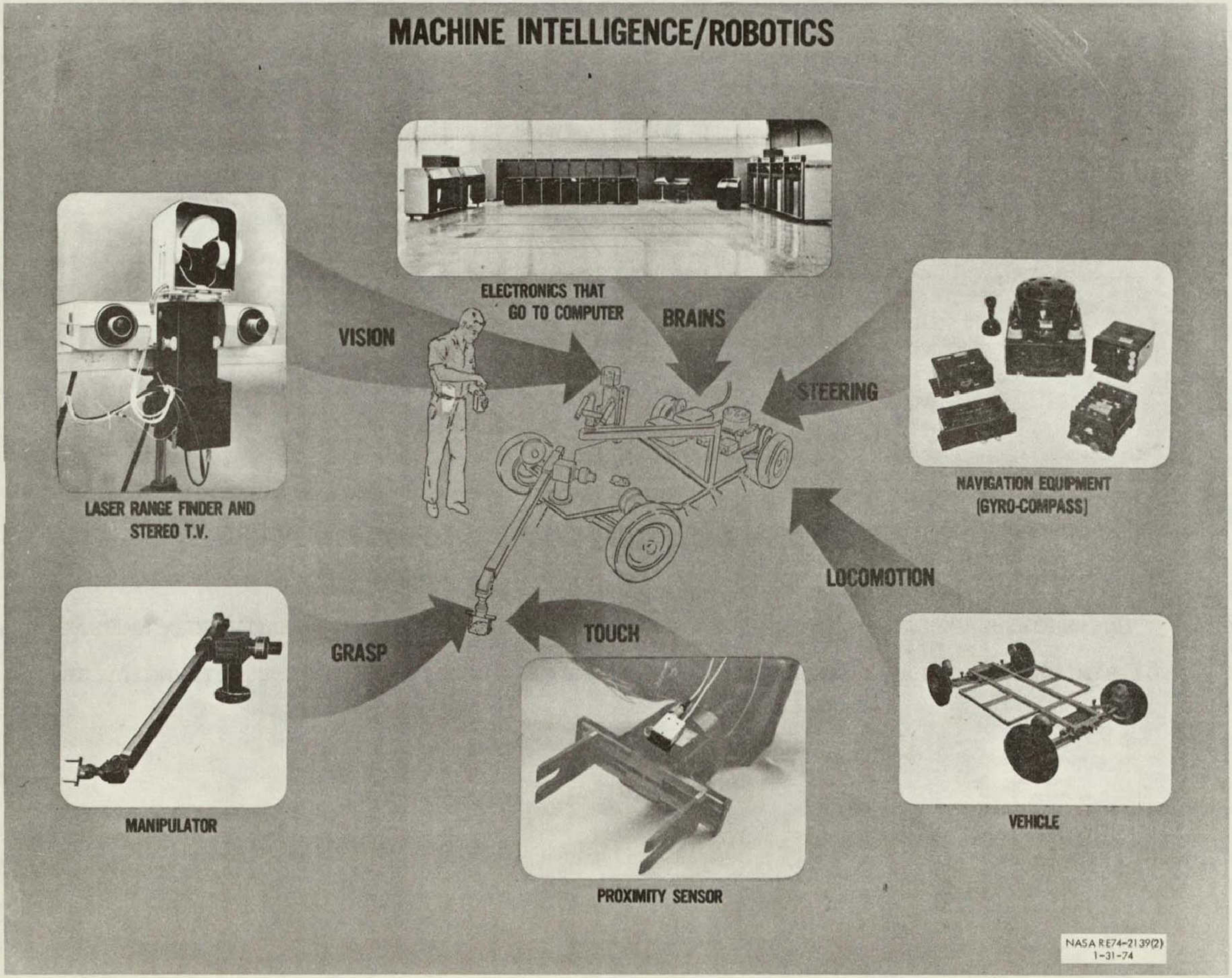


THE ROADMAP GUIDE LISTS THE ROADMAP MILESTONES IDENTIFIED FOR THESE TECHNICAL AREAS DURING THE JOINT PROGRAM REVIEWS. EACH MILESTONE IS DESCRIBED BY TITLE, STATUS, YEAR OF COMPLETION, PERFORMING CENTER, AND THE RTOP NUMBER. MOST OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT AND GROUND OR FLIGHT VALIDATION OF NEW AUTOMATION ALGORITHMS AND SYSTEMS. THESE INCLUDED THE COMPLETE DEMONSTRATION OF THE ROVER NAVIGATING AND PERFORMING IN A NATURAL ENVIRONMENT, AND ACTUAL DEMONSTRATIONS OF TELEOPERATOR PAYLOAD-SERVICING.

3. AUTOMATION

Technical Area	Mile-Stone #	Title	Status	/FY	Center	RTOP #
a. Autonomous Operations	1R	Technology Demonstration of Robotics for a Rover Vehicle Complete	0	79	JPL	506-19-32
	2R	Optimize Scene Interpretation Process Using Symbolic and Graphic Modes	0	76	SRI	506-19-31
	3R	Initial Outdoor Vision On Rover	0	77	JPL	506-19-32
b. Teleoperators	1S	Advanced Teleoperator	0	76	ARC	199-51
	2M	Manned Maneuvering Unit Completion	▽	77	JSC	975-50-01
	3M	Flight Space Shuttle Manipulator	▽	77	Canada	------
	4S	Computer-Aided Teleoperators and Man-Machine Interface	0	78	JPL	970-82-20
	5S	Earth Orbital Teleoperator Simulator	□	76	MSFC	970-63-20
	6M	Develop Space Teleoperators	▽	77	MSFC	906-63-20
	7M	Proto Flight Manipulator Stereo Camera & Viewing System	□	77	MSFC	906-63-20
	8S	Shuttle Bay Experiment of Payload Servicing Teleoperator (TOBE)	▽	80	MSFC	970-63-20

THIS FIGURE SHOWS THE COMPONENTS THAT ARE TO BE INTEGRATED IN THE ROVER VEHICLE SUPPORTED BY RTOP 506-19-32. THE ROVER, ASSOCIATED WITH MILESTONE 3a1R, PROVIDES AN INTEGRATED FACILITY FOR TESTING OUT ARTIFICIAL INTELLIGENCE ALGORITHMS ASSOCIATED WITH THE VARIOUS ASPECTS OF ROBOTICS, PROVIDING FINDINGS HELPFUL TO OTHER ROBOTIC APPLICATIONS AS WELL.


MACHINE INTELLIGENCE/ROBOTICS
ELECTRONICS THAT GO TO COMPUTER
BRAINS
VISION
STEERING
LASER RANGE FINDER AND STEREO T.V.
NAVIGATION EQUIPMENT (GYRO-COMPASS)
LOCOMOTION
GRASP
TOUCH
MANIPULATOR
VEHICLE
PROXIMITY SENSOR
NASA RE74-2139(2)
1-31-74

THE AUTOMATION ACTION ITEM RESULTING FROM THE ELECTRONICS PROGRAM REVIEW WAS TO DEVELOP A DETAILED INTEGRATED OVERVIEW OF AGENCY EFFORTS IN TELEOPERATORS AND ROBOTICS. THIS ACTION, CURRENTLY UNDERWAY, WILL ALLOW THE DIRECT COORDINATION AND JOINT PLANNING OF SPECIFIC TASKS RELATED TO AUTOMATED EFFECTOR MECHANIZATION AND NEAR-AUTONOMOUS REMOTE SYSTEMS.

ACTION ITEMS

3. AUTOMATION

Title	Action	Participants	Associated Milestones
Robotics/Machine Intelligence	Develop an integrated overview of agency work in Robotics/Artificial Intelligence/Remote Manipulator Systems	OMSF, OAST	All 3a, 3b

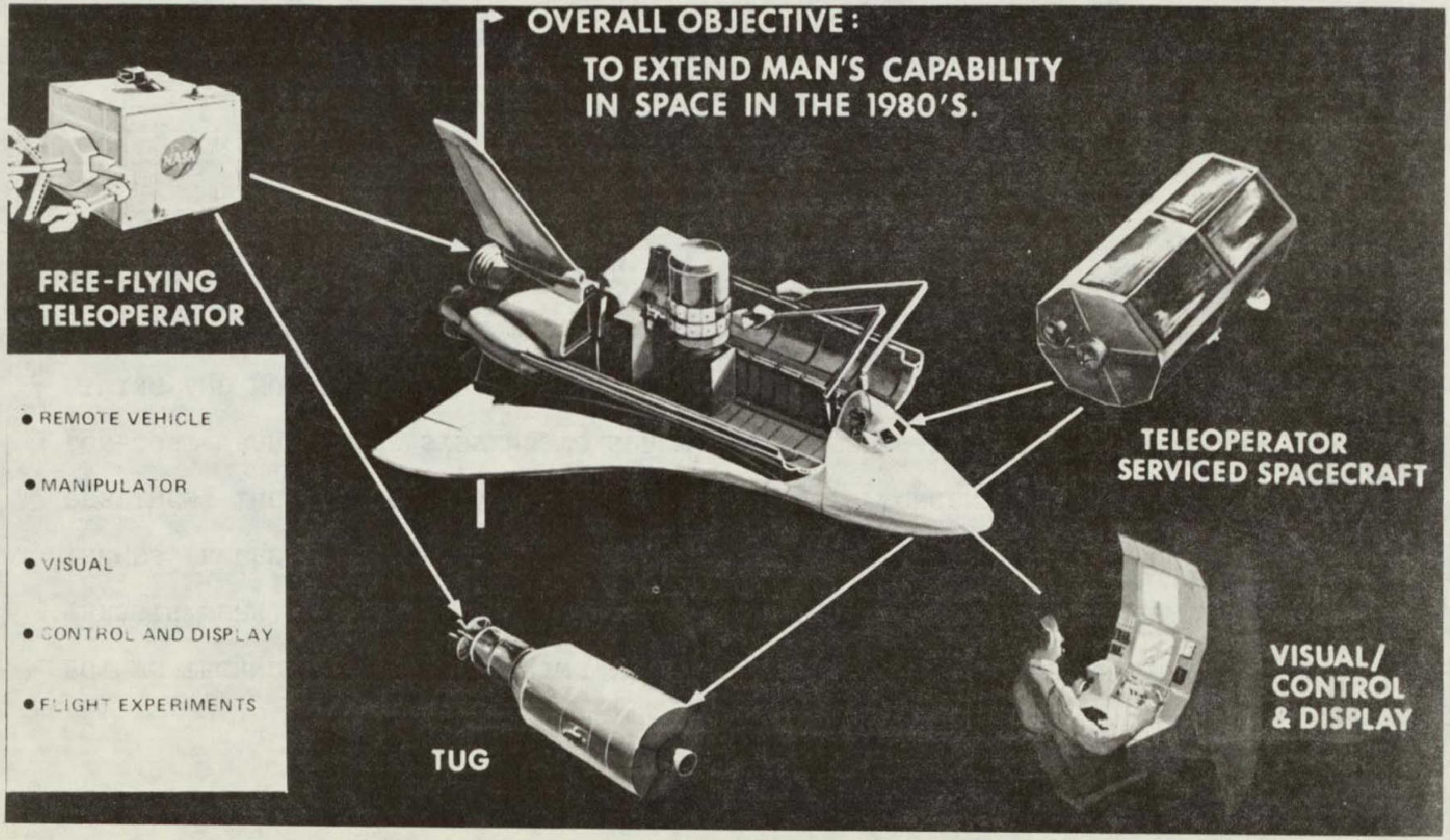
AN EXAMPLE OF THE TELEOPERATOR WORK ASSOCIATED WITH THE ACTION ITEM IS GIVEN BY RTOP 970-63-20 ON EARTH-ORIENTED TELEOPERATOR SYSTEMS. TASKS UNDER THIS RTOP INCLUDE DEVELOPING TELEOPERATOR CONTROL SCHEMES AND DESIGNING FLIGHT EXPERIMENTS TO DEMONSTRATE TELEOPERATOR SPACECRAFT-SERVICING CAPABILITY. RECENT NASA REORGANIZATION HAS SPLIT THE TELEOPERATOR EFFORT AMONG OSS AND OSF. THE WORK IS CONTINUING TO BE EXAMINED TO INSURE THAT THE OVERALL NASA EFFORT IN ROBOTICS, ARTIFICIAL INTELLIGENCE AND TELEOPERATOR ACHIEVES THE PROPER BALANCE AND ORIENTATION TO BEST SERVE NASA'S FUTURE NEEDS.

970-63-20	EARTH ORIENTED TELEOPERATOR SYSTEM

MSFC
Mr W. G. THORNTON
205/453-4367

OMSF
B

HQ
Dr. STANLEY DEUTSCH
202/755-3300



NASA HQ RE76-1246 (2)
11-12-75

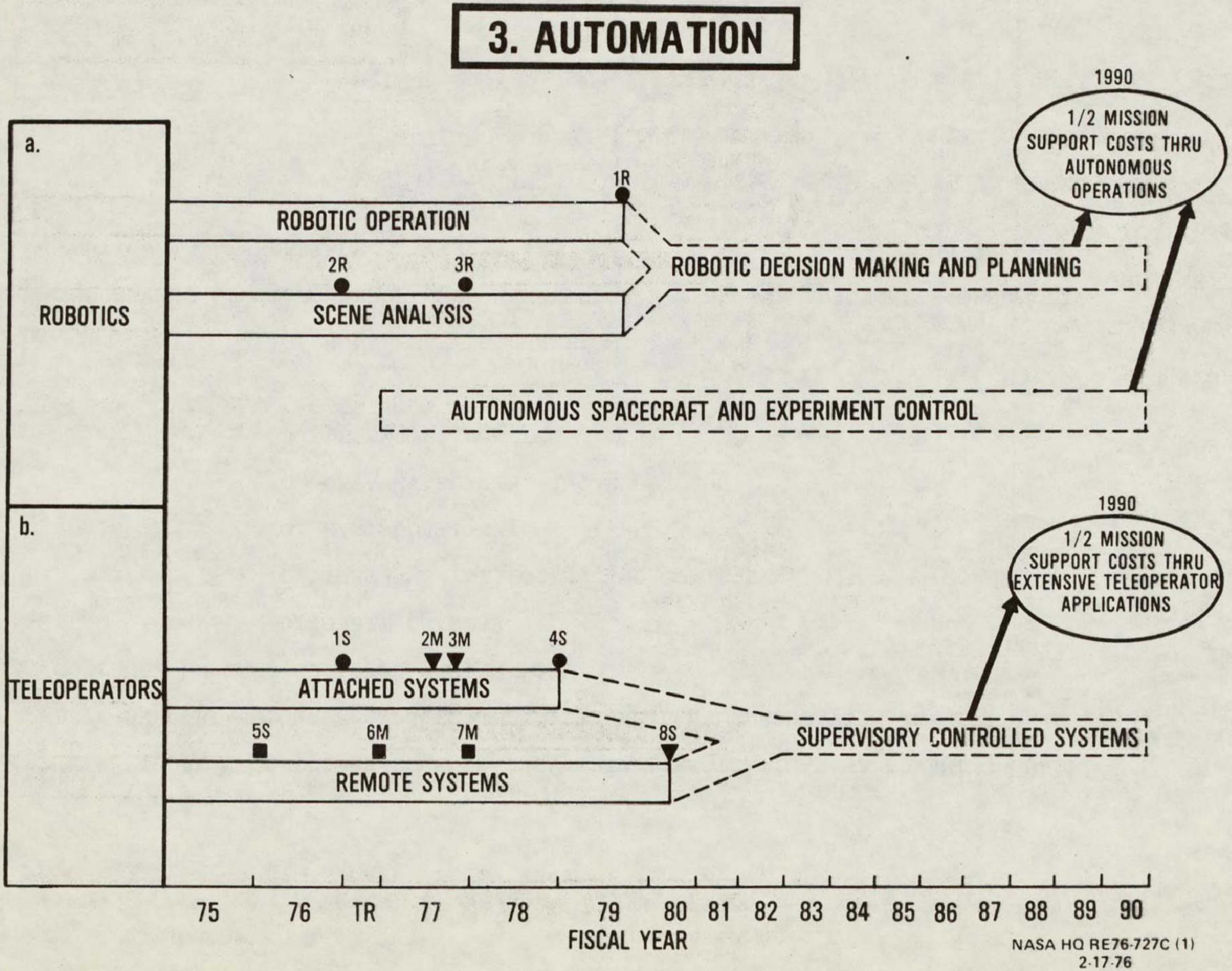
FUTURE TECHNOLOGY NEEDS DRIVING AUTOMATION TECHNOLOGY GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER GROUP REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON EFFICIENT LOW-COST TRANSFER OF SYSTEMS TO SPACE, AUTOMATED DATA ANALYSIS, AND MAN LIVING AND WORKING IN SPACE THRU THE USE OF SUPERVISORY CONTROLLED TELEOPERATOR SYSTEMS, ROBOTIC DECISION MAKING AND PLANNING, AND AUTONOMOUS SPACECRAFT AND EXPERIMENT CONTROL.

TECHNOLOGY THRUSTS

3. AUTOMATION

Technical Area	Title	OFS Theme
a. Robotics	Robotic Decision Making & Planning	140: Automated Data Analysis & Management Systems 150: Efficient Low-Cost Transfer of Systems to Space 11: Evolution of the Solar System 01: Production and Management of Food and Forestry Resources 021: Large Scale Weather 033: Hazard Warnings
	Autonomous Spacecraft and Experiment Control	140: Automated Data Analysis & Management Systems 01: Production and Management of Food and Forestry Resources 02: Prediction and Protection of the Environment 03: Protection of Life and Property 07: Earth Science 066: Man Living & Working in Space
b. Teleoperators	Supervisory Controlled Systems	066: Man Living & Working in Space 01: Production and Management of Food and Forestry Resources 02: Prediction and Protection of the Environment 03: Protection of Life and Property 07: Earth Science 011: Evolution of the Solar System 130: Space Station 150: Efficient Low-Cost Transfer of Systems to Space

THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN AUTOMATION ARE SHOWN AS DASHED BARS ON THE ROADMAP. ASSOCIATED MAJOR GOALS ARE HALVING MISSION SUPPORT COSTS THRU AUTONOMOUS OPERATIONS AND EXTENSIVE TELEOPERATOR APPLICATIONS WHICH INCREASE MISSION CAPABILITY, REDUCE THE TIME REQUIRED FOR ACCOMPLISHMENT OF MISSION OBJECTIVES, AND EXTEND SPACECRAFT LIFETIMES BY SERVICING THEM WITH FREE-FLYING TELEOPERATORS.

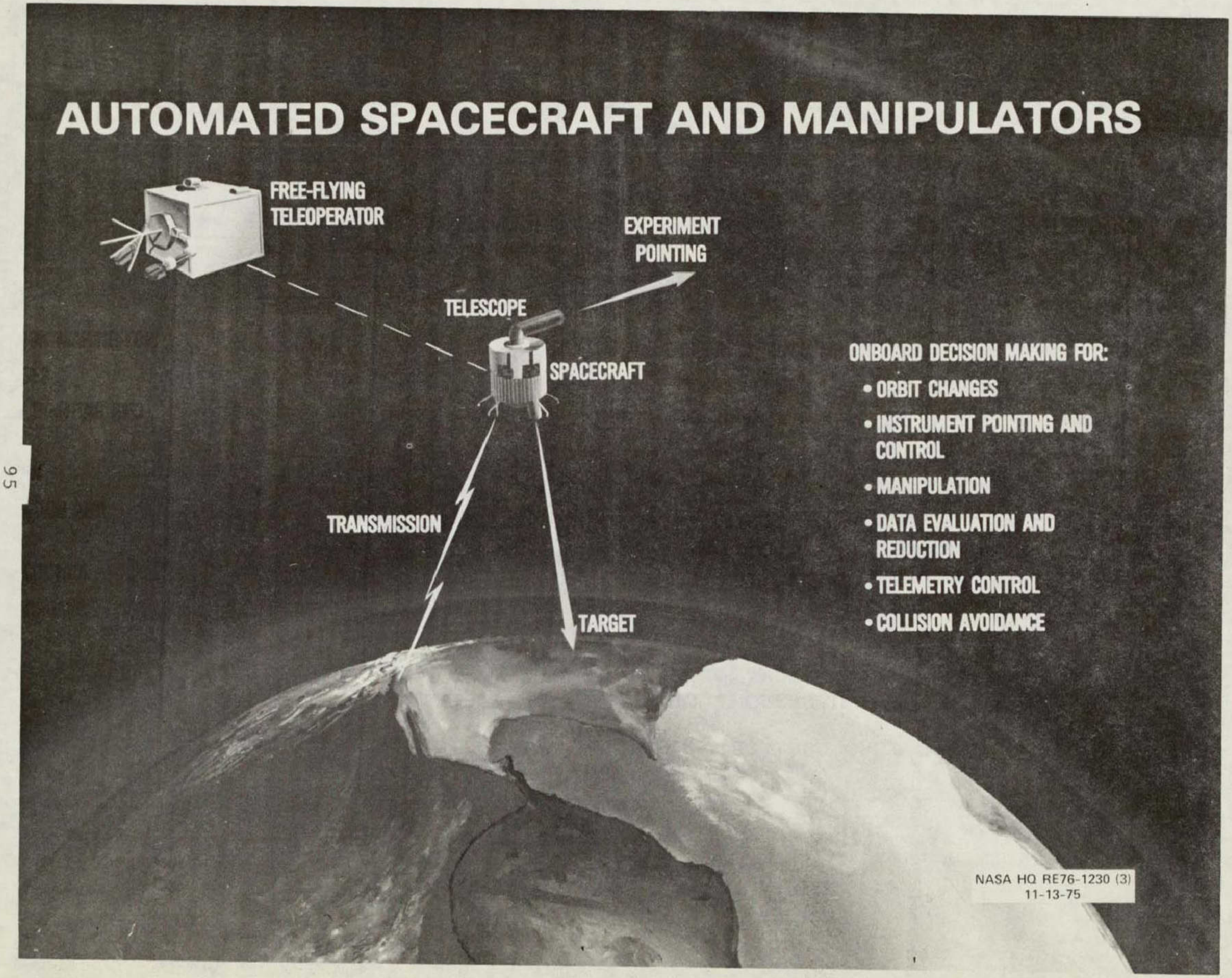


3. AUTOMATION
1990
1/2 MISSION SUPPORT COSTS THRU AUTONOMOUS OPERATIONS
a.
ROBOTICS
1R
ROBOTIC OPERATION
ROBOTIC DECISION MAKING AND PLANNING
2R
3R
SCENE ANALYSIS
AUTONOMOUS SPACECRAFT AND EXPERIMENT CONTROL
1990
1/2 MISSION SUPPORT COSTS THRU EXTENSIVE TELEOPERATOR APPLICATIONS
b.
TELEOPERATORS
1S
2M 3M
4S
ATTACHED SYSTEMS
5S
6M
7M
8S
SUPERVISORY CONTROLLED SYSTEMS
REMOTE SYSTEMS
75 76 TR 77 78 79 80 81 82 83 84 85 86 87 88 89 90
FISCAL YEAR
NASA HQ RE76-727C (1)
2-17-76

THIS FIGURE ILLUSTRATES SOME OF THE ACTIVITIES THAT CAN BE ADVANTAGEOUSLY PERFORMED BY AUTOMATED SPACECRAFT. THESE INCLUDE REDUCTION IN MISSION SUPPORT COSTS BY ONBOARD DECISION MAKING FOR:

- ORBIT CHANGES
- INSTRUMENT POINTING AND CONTROL
- MANIPULATION
- DATA EVALUATION AND REDUCTION
- TELEMETRY CONTROL
- COLLISION AVOIDANCE
- HOUSEKEEPING FUNCTIONS

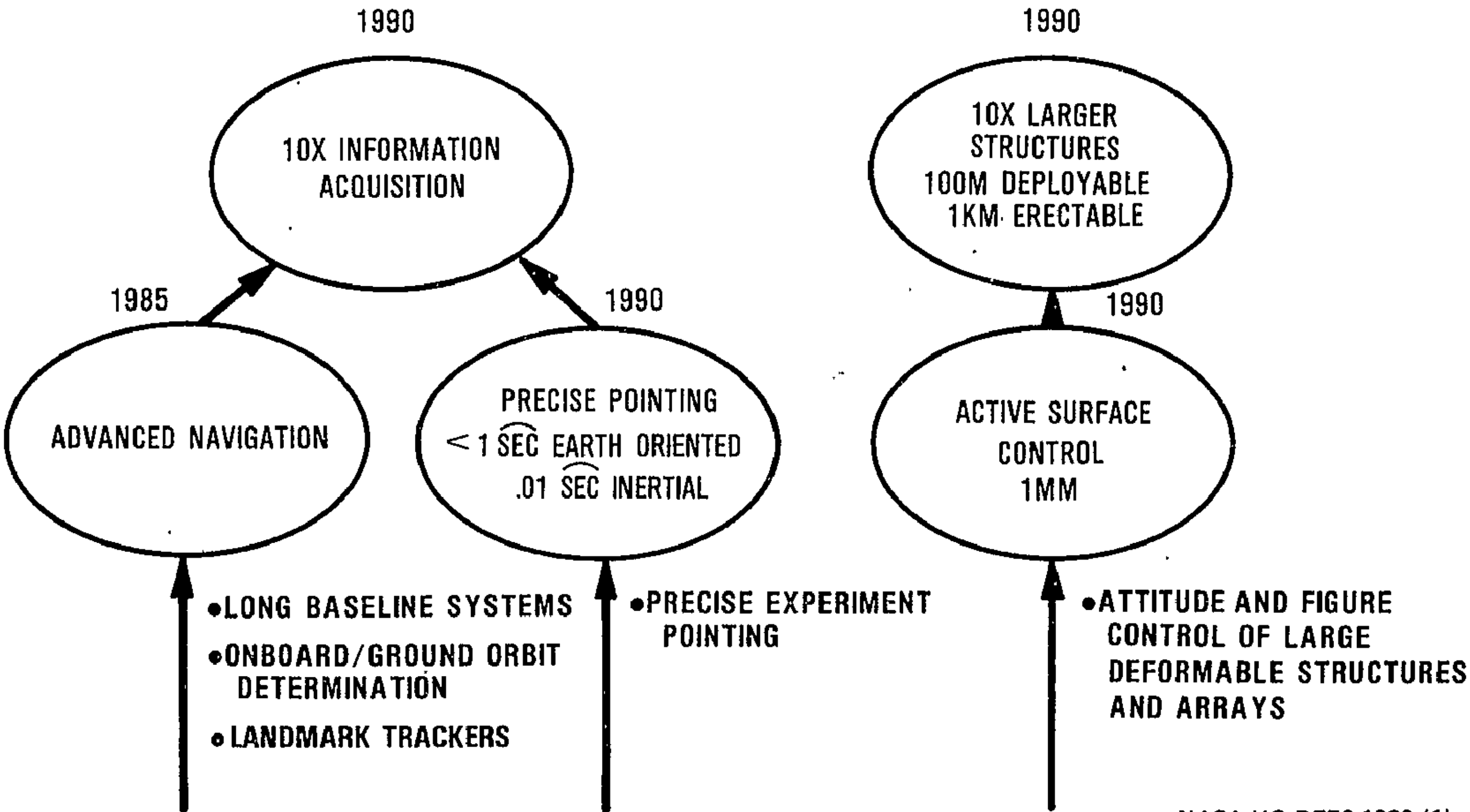
THE ADVENT OF MICRO-PROCESSORS MAKE THESE ATTRACTIVE AUTONOMOUS OPERATIONS PARTICULARILY FEASIBLE.



AUTOMATED SPACECRAFT AND MANIPULATORS
FREE-FLYING TELEOPERATOR
EXPERIMENT POINTING
TELESCOPE
SPACECRAFT
TRANSMISSION
TARGET
ONBOARD DECISION MAKING FOR:
• ORBIT CHANGES
• INSTRUMENT POINTING AND CONTROL
• MANIPULATION
• DATA EVALUATION AND REDUCTION
• TELEMETRY CONTROL
• COLLISION AVOIDANCE
NASA HQ RE76-1230 (3)
11-13-75

THIS FIGURE RELATES THE FUTURE THRUSTS TO TWO OF THE 1990 OAST GOALS. THUS, ADVANCED NAVIGATION AND PRECISE POINTING SUPPORT INCREASED INFORMATION ACQUISITION THRU IMPROVED POSITIONING OF THE SPACECRAFT RELATIVE TO THE TARGET AND REDUCED RELATIVE MOTION DURING DATA-TAKING. TO MAKE LARGE STRUCTURES AND ARRAYS PRACTICABLE, IT IS NECESSARY NOT ONLY TO CONTROL THEIR DYNAMICS AND VIBRATIONS, BUT ALSO TO CONTROL THEIR SHAPE. IN ADDITION, SLAVING FREE-FLYING COMPONENTS AND ARRAY ELEMENTS TO EACH OTHER PROVIDES A UNIQUE MEANS FOR CONSTRUCTING AND DEPLOYING VERY LARGE EXPERIMENTS, ANTENNAS, COLLECTORS, AND OTHER STRUCTURES.

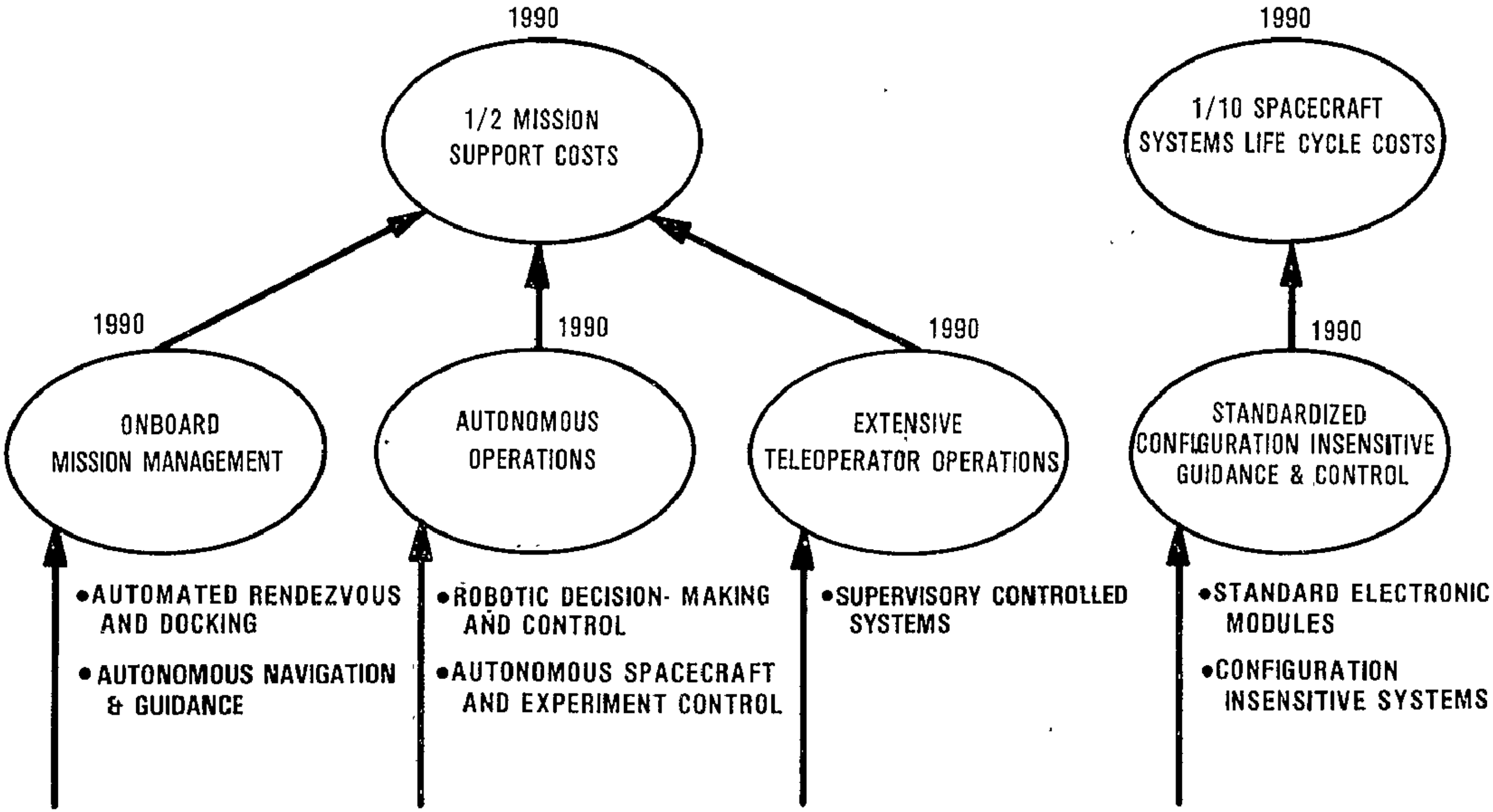
NAVIGATION, GUIDANCE AND CONTROL



NASA HQ RE76-1229 (1)
2-17-76

THIS FIGURE RELATES FUTURE THRUSTS TO THE OAST GOALS OF REDUCING COSTS. ONBOARD MANEUVER STRATEGY, WHICH OPTIMIZES THE SPACECRAFT TRAJECTORY IN REAL TIME, AUTONOMOUS OPERATIONS BY WHICH THE SPACECRAFT CONTROLS ITS OWN FUNCTIONS AS WELL AS THE EXPERIMENTS, AND ADVANCED TELEOPERATOR OPERATIONS WHICH REDUCE THE NEED FOR EVA'S, SPEED MISSION ACCOMPLISHMENT AND FACILITATE THE SERVICING AND REPAIR OF SPACECRAFT, ALL CONTRIBUTE TO SUBSTANTIAL REDUCTIONS IN MISSION SUPPORT COSTS. STANDARDIZED LONG-LIFE COMPONENTS AND MULTI-PURPOSE FAULT-TOLERANT SYSTEMS PROVIDE A MEANS FOR ACHIEVING A SUBSTANTIAL REDUCTION IN SPACECRAFT SYSTEMS LIFE CYCLE COSTS.

NAVIGATION, GUIDANCE AND CONTROL



NASA HQ RE76-1228 (1)
2-17-76

IN SUMMARY, THE NAVIGATION, GUIDANCE AND CONTROL PROGRAM WAS FOUND TO BE GENERALLY WELL BALANCED WITH LITTLE OVERLAP BETWEEN CENTERS. WEAK AREAS WERE FOUND TO BE IN CONFIGURATION CONTROL OF LARGE STRUCTURES AND ARRAYS, AND EARTH-ORIENTED TRACKERS. FUTURE THRUSTS ARE AIMED AT REDUCING COSTS, INCREASING INFORMATION ACQUISITION, CONTROLLING LARGE STRUCTURES AND ARRAYS, AND INCREASING MISSION CAPABILITY. TRENDS ARE TOWARD ELECTRONICS REPLACING MECHANICAL COMPONENTS, STANDARDIZATION, AND INCREASED PERFORMANCE, WITH AUTOMATION AND AUTONOMOUS OPERATIONS BECOMING INCREASINGLY PERVASIVE IN ALL AREAS.

SUMMARY

NAVIGATION, GUIDANCE AND CONTROL

1. BALANCED PROGRAM WITH LITTLE OVERLAP BETWEEN CENTERS
2. WEAK AREAS:
    - o CONFIGURATION CONTROL OF LARGE STRUCTURES AND ARRAYS
    - o EARTH-ORIENTED TRACKERS
3. FUTURE THRUSTS:
    - o REDUCE COSTS
    - o INCREASE INFORMATION ACQUISITION
    - o CONTROL LARGE STRUCTURES AND ARRAYS
    - o INCREASE MISSION CAPABILITY
4. TRENDS ARE TOWARD:
    - o MECHANICAL DEVICES BEING REPLACED BY ELECTRONIC DEVICES WHEREVER FEASIBLE
    - o INCREASED AUTOMATION AND AUTONOMOUS OPERATIONS IN ALL AREAS
    - o INCREASED ACCURACY, PRECISION AND FAULT-TOLERANCE
    - o STANDARDIZATION AND MULTIPURPOSE COMPONENTS AND SYSTEMS

SENSING AND DATA ACQUISITION INVOLVES THOSE MISSION FUNCTIONS ASSOCIATED WITH DETECTION, MEASUREMENT, AND STATUS MONITORING OF INFORMATION REQUIRED FOR APPLICATION AND SCIENCE OBSERVATIONS ON SPACECRAFT. THE FUNCTIONS COMPRISE THE DETECTION OF ENERGY SOURCES IN VARIOUS PARTS OF THE ELECTROMAGNETIC SPECTRUM, AS WELL AS PARTICLES AND FIELDS, AND THEIR CONVERSION INTO ELECTRONS THAT ARE ULTIMATELY PROCESSED INTO USEFUL INFORMATION.

TWO DISCIPLINE CATEGORIES COVERING THE TECHNOLOGY NEEDED TO ADDRESS THESE FUNCTIONS ARE:

1. SENSING AND DATA ACQUISITION
2. INSTRUMENTATION

SPECIFIC TECHNOLOGY ACTIVITIES FALLING UNDER THESE CATEGORIES ARE SUMMARIZED IN THIS SECTION.

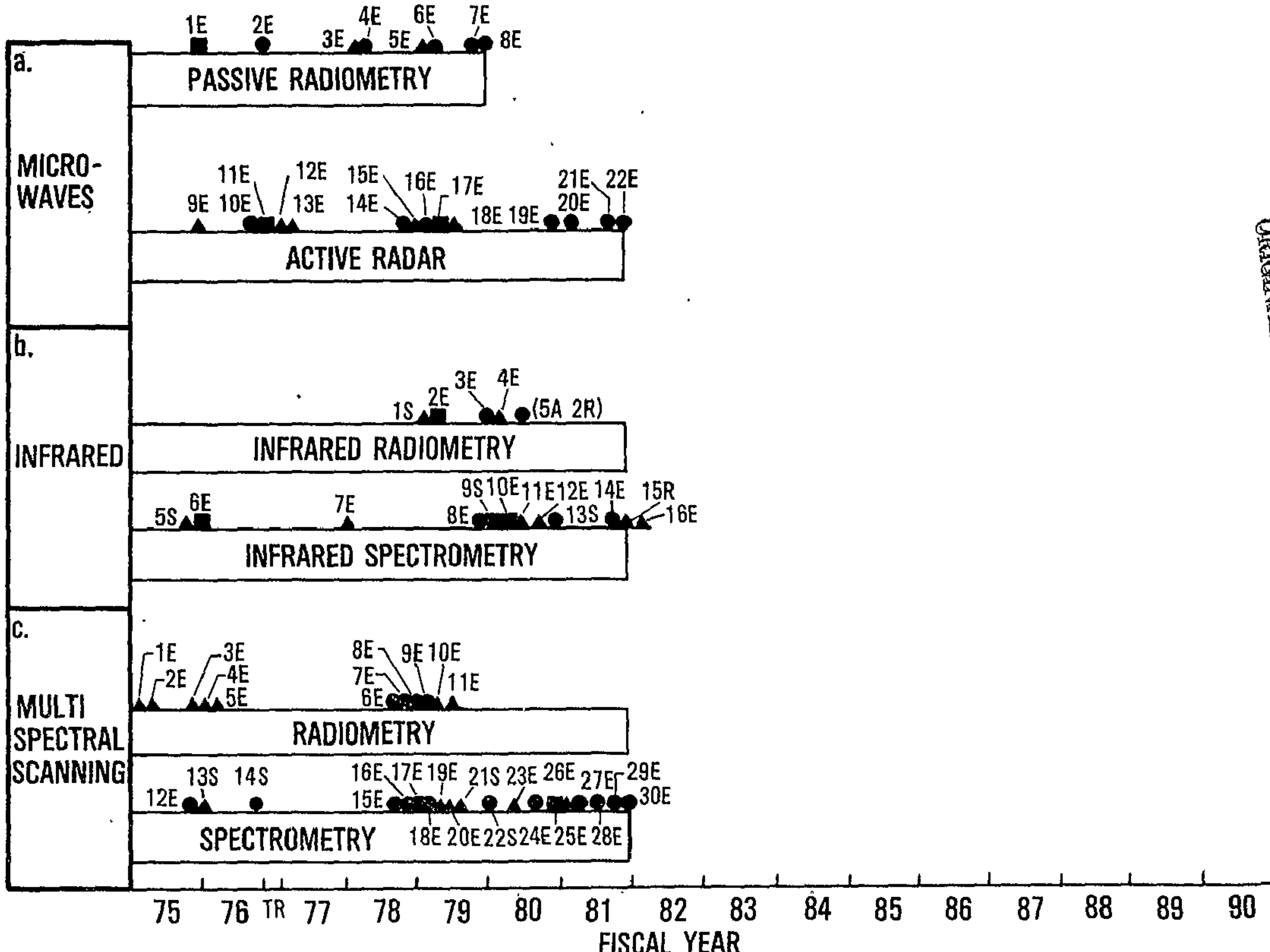
SPACE ELECTRONICS TECHNOLOGY

INTRODUCTION	PETER R. KURZHALS
APPROACH	ARTHUR HENDERSON
PROGRAM OUTLINE	CHARLES E. PONTIOUS
GUIDANCE, NAVIGATION & CONTROL	WILLIAM B. GEVARTER
SENSING & DATA ACQUISITION	BERNARD RUBIN
DATA PROCESSING, STORAGE & TRANSFER	HAROLD ALSBERG
PROGRAM GOALS	CHARLES E. PONTIOUS
CONCLUSION	PETER R. KURZHALS

NASA HQ RE76 1323 (1)
11-15-75

SENSING AND DATA ACQUISITION IS DIVIDED INTO 6 TECHNICAL AREAS, 3 OF WHICH ARE SHOWN ON THE ROADMAP. THESE AREAS ARE MICROWAVES, INFRARED AND MULTI-SPECTRAL SCANNING AND ARE SUPPORTED AT GSFC, JPL, LaRC, WFC, AND JSC. MULTISPECTRAL SCANNING IS CONCENTRATED PRIMARILY AT GSFC, WITH THE REMAINING TWO ACTIVITIES DIVIDED AMONG THE OTHER CENTERS. THE EFFORTS ARE PRIMARILY SUPPORTED BY OA AND FOCUS ON REMOTE SENSING OF TERRESTRIAL, OCEANOGRAPHIC, METEOROLOGIC AND ATMOSPHERIC PARAMETERS.

4. SENSING AND DATA ACQUISITION



NASA HQ RE76-602 C (1)
2-17-76

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ROADMAP GUIDE

4. SENSING & DATA ACQUISITION

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
a. Microwave Sensing	1E	Ocean Surface Measurement	□	75	GSFC	161-05-07
	2E	MW Temp. Sounder	△	76	JPL	630-10-01*
	3E	Shuttle MW Radiometer	△	77	GSFC	642-00-00
	4E	Microwave Meteorology	0	77	GSFC	175-31-43
	5E	MW Limb Sounder	△	78	JPL	638-20-05*
	6E	Passive MW Limb Sounder	0	78	JPL	645-20-03
	7E	ATM Remote Sensing Techniques	0	79	GSFC	175-21-41
	8E	MW Radiometry/Ocean/ATM Interface	0	79	LaRC	175-31-31
	9E	Coherent Imaging Radar	0	75	JPL	638-40-04*
	10E	Ocean Physics Coherent Radar	0	76	JPL	161-06-03
	11E	Flight Instrument Development	□	76	GSFC	369-06-03
	12E	Radar Altimeter	△	76	WFC	638-40-04*
	13E	Surface Profile Radar	△	76	WFC	638-40-04*
	14E	X-L Band Radar Applications	0	78	KSC	177-23-91
	15E	MW Imaging System	△	78	LaRC	638-10-04*
	16E	Tornado Detection & Warning	0	78	GSFC	175-21-45
	17E	Earth Physics/Network Densitication System	□	78	JPL	644-03-14
	18E	Synthetic Aperture Radar	△	78	JPL	914-19-20
	19E	Shuttle Imaging MW Systems	0	80	JPL	645-30-02
	20E	Meteorology Shuttle Radar	0	80	GSFC	645-10-02
	21E	Advanced Synthetic Aperture Radar	0	81	JPL	645-40-08
	22E	ERS Shuttle Radar	0	81	JSC	645-30-07
b. Infrared Sensing	1S	Radiometric Temp. Sounder	△	78	GSFC	638-10-04*
	2E	Vertical Temp. Profile Radiometer Improvement	□	78	GSFC	601-XX-XX
	3E	Remote Sensing for ATM Structure	0	79	GSFC	175-21-41
	4E	IR Heterodyne Radiometry	△	77	LaRC	638-20-04*
	5S	IR Spectrometer	△	75	GSFC	188-41-55
	6E	Limb Radiance Inversion (LACATE)	△	75	LaRC	638-20-02*
	7E	IR Absorption Spectrometry	△	78	GSFC	176-20-51

*- AAFE

4. SENSING & DATA ACQUISITION (Cont.)

Technical Area	Mile-Stone #	Title	Status	FY	Center	RTOP #
b. Infrared Sensing (Continued)	8E	ATM Pollution Sensing (Correlation Interferometry)	0	79	GSFC	176-20-31
	9S	IR Astronomy	0	79	GSFC	188-41-55
	10E	Hi-Speed Interferometer	□	79	JPL	176-31-52
	11E	Gas Correlation Interferometry/ ATM Gases	△	78	LaRC	638-20-04*
	12E	Limb Scanning IR Measurement Sensor (LIMS)	△	79	LaRC	642-12-11
	13S	IR Spectroscopy	0	81	HQ	188-78-56
	14E	Shuttle Interferometry	0	81	JPL	645-20-02
	15R	Tunable IR Heterodyne Spect'r.	△	81	LaRC	506-18-12
	16E	Limb Scanning IR Radiometer (LSIR)	△	81	LaRC	176-10-31
c. Multispectral Scanning	1E	VISSR ATM Sounder	△	74	GSFC	601-XX-XX
	2E	ITOS Sensor System Eval.	△	74	GSFC	601-XX-XX
	3E	Long-Term Zonal Energy Budget	△	75	LaRC	175-21-32
	4E	Heat Capacity Mapper	△	75	GSFC	177-44-41
	5E	Active Cavity Radiometer	□	75	GSFC	175-40-50
	6E	Cloud Top Scanning Radiometer	0	78	GSFC	175-21-48
	7E	Severe Storm Surveillance	0	78	GSFC	175-21-43
	8E	Sensor Subsystem Anal. & Des.	0	78	GSFC	175-31-41
	9E	VIS/IR Sensor Subsystem	0	78	GSFC	177-22-41
	10E	AVHRR - 5th Channel	△	78	GSFC	601-XX-XX
	11E	Adv. ATM Sounding & Imaging	△	78	GSFC	638-10-04*
	12E	Shuttle UV/Ozone Mapping	0	75	GSFC	645-10-06
	13S	High Resolution UV Spectrometer	△	75	GSFC	OSO-1
	14S	Ultraviolet Spectrometry	△	77	GSFC	MJS
	15E	Strat. Meas. of Solar Spectral IR	0	78	GSFC	175-21-44
	16E	Sensor Calibn. Test&Simulation	0	78	GSFC	177-26-41
	17E	Remote Sensing Concepts for Tropo. Pollutants	0	78	GSFC	176-21-41
	18E	Techniques for Meas. Strat. Constituents	0	78	GSFC	175-21-42
	19E	Active/Passive MSS	△	78	JSC	638-80-05*
	20E	Aerosol Physical Properties	△	78	LaRC	638-20-05*
	21S	Programmable Ultraviolet Spectrometer	△	78	GSFC	Pioneer Venus Orbit

4. SENSING & DATA ACQUISITION (Cont.)

Technical Area	Mile-Stone	Title	Status/FY		Center	RTOP #
c. Multispectral Scanning (Continued)	22E	Cloud Physics Optical and Imaging Res	0	79	MSFC	175-41-71
	23E	Strat. Aerosol Measurement (SAM)	△	79	LaRC	642-12-13
	24E	Sensing of Clouds & Aerosols from Metsats	□	80	JPL	175-21-52
	25E	Shuttle Calibn. Fac/Solar & Earth Albedo	□	80	GSFC	645-10-04
	26E	Strat. Aerosol/Gas Experiment (SAGE)	△	80	LaRC	659-12-10
	27E	Specialized M/S Imaging System	0	81	JPL	177-28-51
	28E	E/Obs'g Permanent Shuttle Pkge.	0	81	JSC	645-30-05
	29E	Shuttle Modular Scanning Spectrom.	0	81	JSC	645-30-06
	30E	Zero-G Cloud Physics Lab.	0	80	MSFC	645-10-01

RTOP #638-10-04 ON MICROWAVE IMAGING, DESCRIBED BY MILESTONE 4a15E, IS AN EXAMPLE OF THE ACTIVE MICROWAVE SENSING EFFORTS COVERED BY THE ROADMAP AND ADDRESSES RADAR SURFACE CHARACTERISTICS DETECTION. THIS RTOP IS RELATED TO MILESTONES IN THE PASSIVE MICROWAVE AREA SUCH AS 4a2E, 4a3E, AND 4a8E WHICH ADDRESS THE DEVELOPMENT OF TECHNIQUES FOR THE REMOTE SENSING OF FUNDAMENTAL METEOROLOGICAL, CLIMATOLOGICAL, AND TERRESTRIAL CHARACTERISTICS.

LANGLEY RESEARCH CENTER

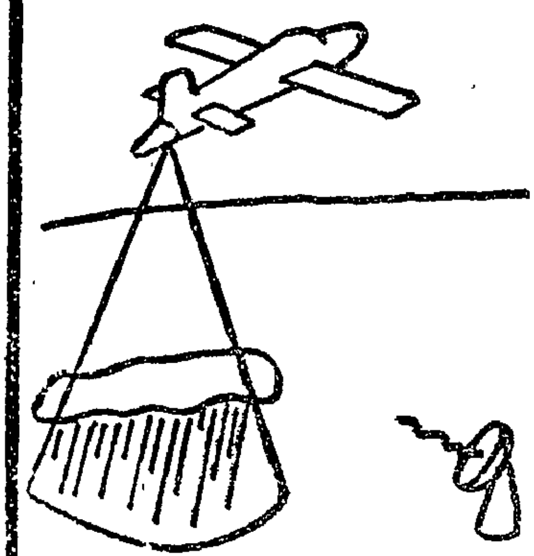
638-10-04	AAFE MICROWAVE IMAGING

OA

LaRC
Dr. Leo Staton
804 / 827-3631

C

HQ
Mr. J. Lehmann
202/755-8596



OBJECTIVES

Develop airborne multifrequency radar satisfying, inter alia, fundamental meteorological and climatological data requirements:

rainfall intensity, melting level, cloud heights and thicknesses

Use radar instrument, along with passive microwave and other instruments, in aircraft experiment program to reveal capabilities and limitations of downward-looking remote sensing of above items and to obtain such surface related information as

soil moisture, crop development and vigor

TWO ACTION ITEMS WERE IDENTIFIED; ONE IS RELATED TO THE COORDINATION OF CHARGE-COUPLED DEVICE TECHNOLOGY AS IT IS APPLIED TO ASTRONOMY AMONG OSS, OAST, AND THE NIGHT VISION LABORATORY. THE OTHER CONCERNS THE COORDINATION OF LaRC AND JPL ACTIVITIES IN THE AREA OF CLOUD/AEROSOL SENSING. BOTH OF THESE ACTIONS HAVE BEEN COMPLETED.

ACTION ITEMS

4. SENSING AND DATA ACQUISITION

Title	Action	Participants	Associated Milestones
Astronomical Sensors	Develop Roadmap for ICCD Program for OAST/OSS/NVL Roles	GSFC	4c13S, 4e6R
Aerosol Sensing	Establish Inter-Center Liaison and coordination for Cloud/Aerosol Sensing Program	LaRC, JPL	4c24E, 4c19E

THE ACTION ITEM RELATES TO THE REMOTE SENSING OF CLOUDS AND AEROSOLS AND TO DEVELOPING TECHNIQUES FOR MEASURING IN REAL TIME PARTICLE SIZE DISTRIBUTION, REFRACTIVE INDEX AND WAVE LENGTH VARIATIONS, AND NUMBER DENSITY AND SHAPE OF PARTICULATES. TWO APPROACHES WERE IDENTIFIED; ONE, A SOLAR TECHNIQUE; THE OTHER A LASER TECHNIQUE. THESE HAVE BEEN COORDINATED AND THEIR DIFFERENCES IDENTIFIED. THE ACTION HAS BEEN COMPLETED.

175-21-52	REMOTE SENSING OF CLOUDS AND AEROSOLS

JPL
A. L. FYMAT
213/354-2397

O.A

C

HQ
R. G. TERWILLIGER
202/755-8596

I. OBJECTIVES

A. TO DEVELOP TECHNIQUES FOR REMOTELY SENSING IN REAL TIME THE PARAMETERS OF CLOUD AND AEROSOL PARTICLES:

- PARTICLE SIZE DISTRIBUTION (PSD)
- REFRACTIVE INDEX (RI) AND WAVELENGTH VARIATIONS
- CLOUD TYPE
- NUMBER DENSITY AND TOTAL ATMOSPHERIC LOADING
- SHAPE

B. TO PROVIDE OPTIMIZED DESIGNS OF PARTICLE SIZE SPECTROMETERS AND REFRACTOMETERS COMPATIBLE WITH METEOROLOGICAL REQUIREMENTS

C. TO DEVELOP CORRESPONDING PROTOTYPE INSTRUMENTATION

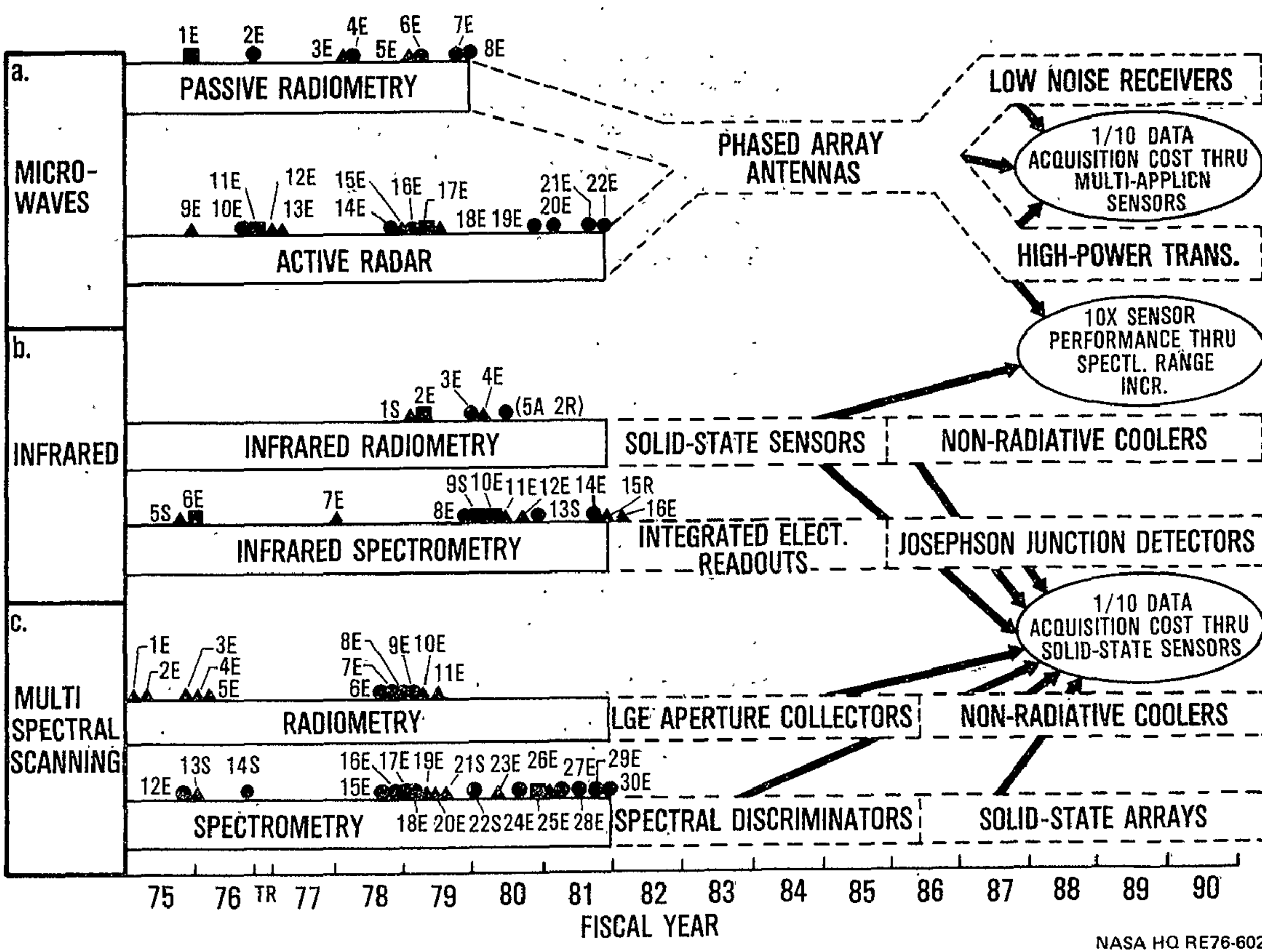
FUTURE TECHNOLOGY NEEDS DRIVING MICROWAVE, INFRARED, AND MULTISPECTRAL SCANNING GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER GROUP REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON THE SENSING OF TROPOSPHERIC POLLUTANTS AND CLIMATE CHARACTERISTICS, AND ENVIRONMENTAL ASSESSMENT THROUGH THE USE OF SOLID-STATE DETECTOR ARRAYS, INTEGRATED ELECTRONIC READOUTS, AND PHASED ARRAY ANTENNAS.

4. SENSING AND DATA ACQUISITION

Technical Area	Title		OFS Theme
a. Microwaves	Phased Array Antennas	012	Water Availability
		013	Land Use/Env. Assessment
	Low Noise Receivers	021	Large Scale Weather
		023	Climate
	High Power Transmitters	031	Local Weather/Severe Storms
		032	Tropospheric Pollutants
b. Infrared	Integrated Electronics Readouts	023	Climate
	Josephson Junction Detectors	024	Stratospheric Changes/Effects
	Solid-State Sensors	026	Global Marine Weather
	Non-Radiative Coolers	032	Tropospheric Pollutants
c. Multispectral Scanning	Large Aperture Collectors	011	Global Crop Production
	Non-Radiative Coolers	013	Land Use/Env. Assessment
	Spectral Discriminators	014	Living Marine Resource Assessment
	Solid-State Detector Arrays	015	Timber Inventory
		016	Rangeland Assessment

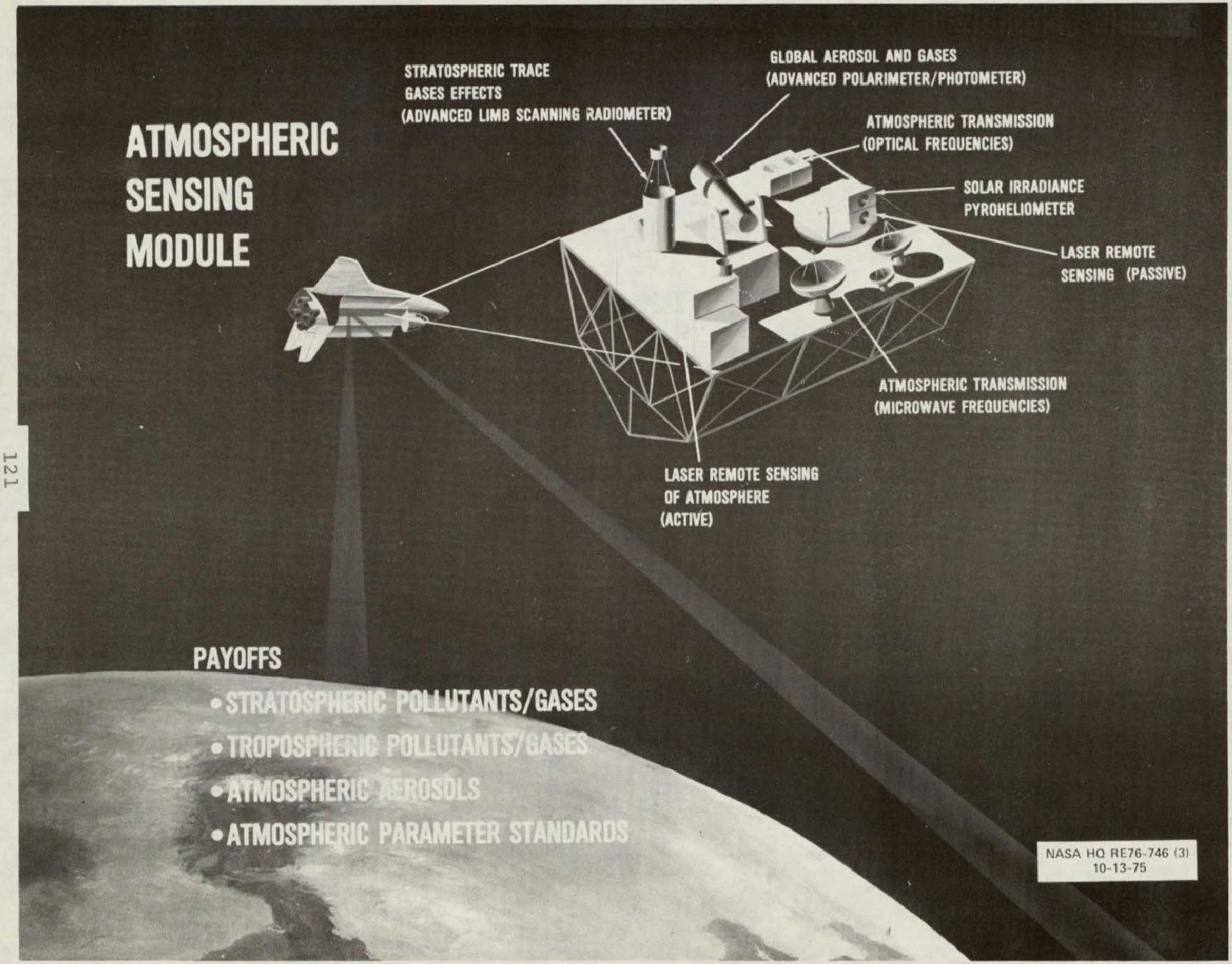
THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN MICROWAVE AND INFRARED SENSING AND MULTISPECTRAL SCANNING ARE SHOWN AS DASHED BARS ON THE ROADMAP. ASSOCIATED MAJOR GOALS ARE (1) A TEN-FOLD DATA ACQUISITION COST REDUCTION THROUGH MULTIAPPLICATION SENSORS WHICH USE THE SAME PHASED ARRAY ANTENNAS AND OTHER MICROWAVE COMPONENTS IN BOTH AN ACTIVE AND PASSIVE MODE FOR THE REMOTE SENSING OF VARIOUS ENVIRONMENTAL PARAMETERS (2) A TEN-FOLD INCREASE IN SENSOR PERFORMANCE THROUGH SPECTRAL RANGE INCREASE BY DEVELOPING SOLID-STATE SENSORS AND MICROWAVE COMPONENTS CAPABLE OF DETECTING IN THE SUBMILLIMETER, MILLIMETER AND FAR INFRARED PARTS OF THE SPECTRUM AND (3) A TEN-FOLD REDUCTION IN DATA ACQUISITION COST THROUGH SOLID-STATE SENSORS AS THEY APPLY TO SPECTRAL DISCRIMINATORS AND OTHER DETECTOR COMPONENTS IN MULTISPECTRAL SCANNERS.

4. SENSING AND DATA ACQUISITION



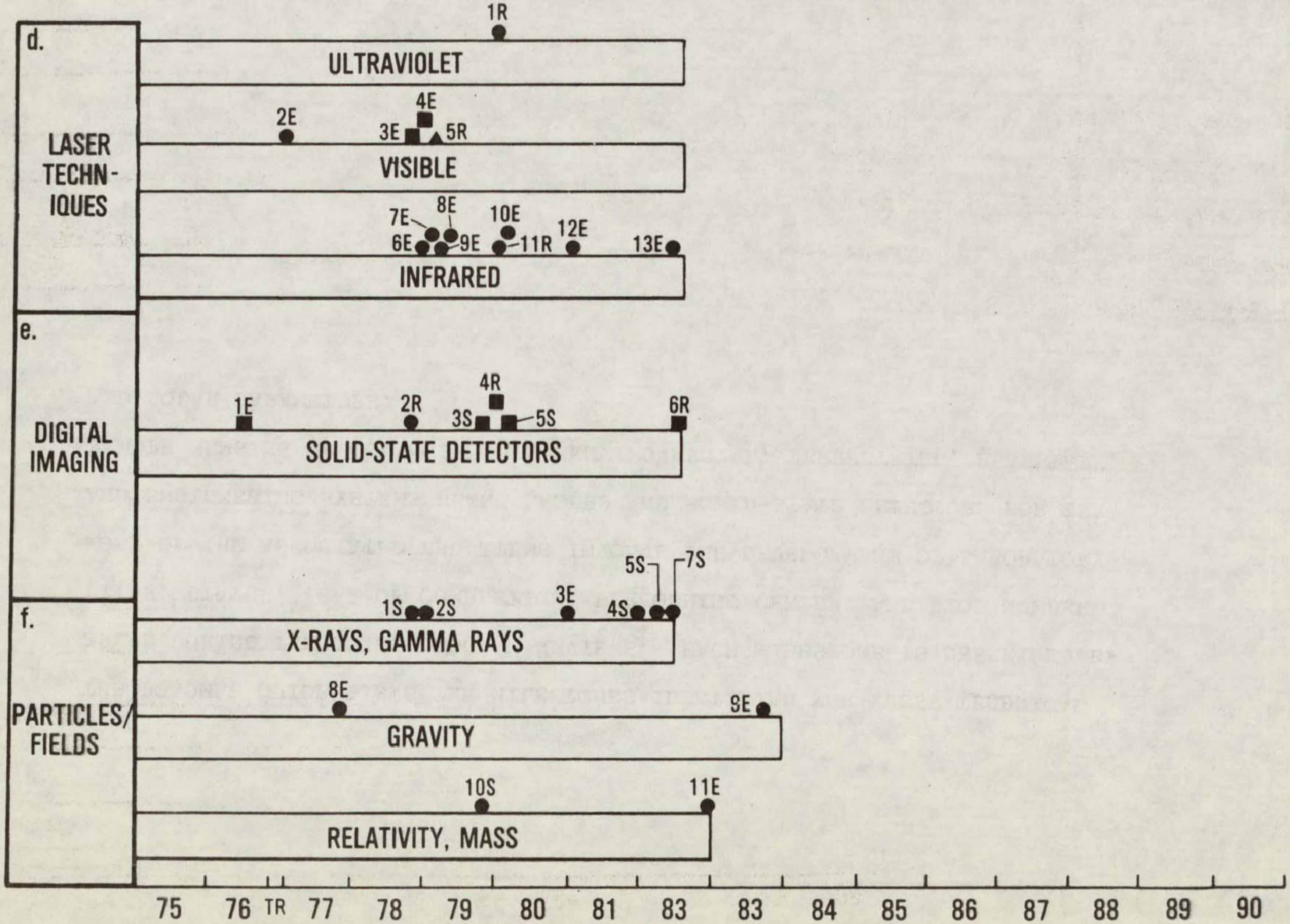
NASA HQ RE76-602 C (1)
2-17-76

PHASED ARRAY ANTENNAS, LOW-NOISE RECEIVERS, AND HIGH-POWER TRANSMITTERS AS THEY APPLY TO BOTH ACTIVE AND PASSIVE MICROWAVE SENSING ARE REPRESENTATIVE OF THE TECHNOLOGY THRUSTS NEEDED TO REDUCE DATA ACQUISITION COSTS BY A FACTOR OF TEN. USE OF ONE MICROWAVE SYSTEM WITH THE SAME COMPONENTS CAN ALLOW MINIMAL COST, CONCURRENT DETERMINATION OF ATMOSPHERIC TRANSMISSION, TEMPERATURE PROFILE, MOISTURE CONTENT, AND STRATOSPHERIC COMPONENTS AND POLLUTANTS, THROUGH MUCH SIMPLER MECHANIZATIONS THAN THOSE FOR CURRENT SEPARATE DETECTING SYSTEMS.


ATMOSPHERIC
SENSING
MODULE
STRATOSPHERIC TRACE
GASES EFFECTS
(ADVANCED LIMB SCANNING RADIOMETER)
GLOBAL AEROSOL AND GASES
(ADVANCED POLARIMETER/PHOTOMETER)
ATMOSPHERIC TRANSMISSION
(OPTICAL FREQUENCIES)
SOLAR IRRADIANCE
PYROHELIOMETER
LASER REMOTE
SENSING (PASSIVE)
ATMOSPHERIC TRANSMISSION
(MICROWAVE FREQUENCIES)
LASER REMOTE SENSING
OF ATMOSPHERE
(ACTIVE)
PAYOFFS
• STRATOSPHERIC POLLUTANTS/GASES
• TROPOSPHERIC POLLUTANTS/GASES
• ATMOSPHERIC AEROSOLS
• ATMOSPHERIC PARAMETER STANDARDS
NASA HQ RE76-746 (3)
10-13-75

SENSING AND DATA ACQUISITION IS DIVIDED INTO 6 TECHNICAL AREAS, THE LAST 3 OF WHICH ARE SHOWN ON THE ROADMAP. THESE AREAS ARE LASER TECHNIQUES, DIGITAL IMAGING, AND PARTICLES AND FIELDS. EXISTING EFFORTS ARE PRIMARILY SUPPORTED BY OA, OSS, AND OAST AND FOCUS ON REMOTE SENSING OF EARTH, PLANETARY, AND SOLAR CHARACTERISTICS. A RECENT SURVEY INDICATED THAT OVER 300 SENSORS ARE BEING DEVELOPED BY THE VARIOUS NASA OFFICES.

4. SENSING AND DATA ACQUISITION



NASA HQ RE76-601 A (1)
2-17-76

THE ROADMAP GUIDE LISTS THE MILESTONES IDENTIFIED FOR THESE TECHNICAL AREAS DURING THE JOINT PROGRAM REVIEWS. EACH MILESTONE IS DESCRIBED BY TITLE, STATUS, YEAR OF COMPLETION, PERFORMING CENTER, AND RTOP NUMBER. MOST OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT OF LABORATORY AND ENGINEERING SYSTEMS USING LASERS AND SOLID-STATE DETECTORS FOR THE REMOTE SENSING OF OCEANOGRAPHIC, ENVIRONMENTAL, TERRESTRIAL, PLANETARY, AND SOLAR PARAMETERS.

4. SENSING & DATA ACQUISITION (Cont.)

Technical Area	Mile-Stone #	Title	Status	FY	Center	RTOP #
d. Laser Techniques	1R	A/C Flt. Tests of Laser Water Turbidity Sensor/High Res'n. Sensors	△	78	LaRC	506-18-12
	2E	Laser Instrumentation for Earth Physics	0	76	GSFC	161-05-02
	3E	Laser Radar for Meteor. Meas.	□	78	LaRC	638-10-05*
	4E	Airborne Oceanographic LIDAR	□	78	LaRC	638-40-05
	5R	High Spectral Resolution LIDAR	△	78	WFC	506-18-15
	6E	Remote Sensing Concepts for Tropo. Polln.	0	78	LaRC	176-20-31
	7E	Water Temp. Laser	0	78	KSC	177-22-91
	8E	Laser Absorption Spectrometer	0	78	JPL	638-20-05*
	9E	Stratospheric Gases & Particulates	0	78	LaRC	176-10-31
	10E	ATM Polln. Sensing-Heterodyne Spectrometer	0	79	JPL	176-31-51
	11E	Active/Passive Cloud Meas. from Shuttle	0	80	GSFC	645-10-03
	12e	Pollution Monitoring w/Lasers	0	81	LaRC	645-20-01
	13E	Spaceborne Laser Ranging System	0	81	GSFC	645-40-01
e. Digital Imaging	1E	Hadamard Transform Thermal Mapper	□	76	LaRC	176-30-31
	2R	Electron Devices & Components (IRCCD)	0	78	LaRC	506-18-21
	3S	Imaging System Development	□	79	JPL	186-68-65
	4R	Adv. Imaging Systems Tech.	□	79	JPL	506-18-11
	5S	Imaging System Technology	□	79	ARC	186-68-52
	6R	Astron. Hi Res Sensors	□	81	GSFC	506-18-13
f. Particles & Fields	1S	Radiation & Spectrometric Studies	0	78	GSFC	195-22-06
	2S	Advanced Gamma Ray Spectroscopy	0	78	JPL	195-23-06
	3E	Shuttle Solar Weather Exp. Facility	0	80	GSFC	645-10-05
	4S	X-Ray Spectroscopy	0	81	GSFC	188-41-55
	5S	Development of Solar Physics Experiments (X-Ray)	0	81	GSFC	188-38-51
	6S	Shuttle Payload Development (X-Ray)	0	81	GSFC	188-38-64
	7S	Lunar Gamma Ray Measurements	0	81	HQ	195-20-06

* AAFE

SENSING & DATA ACQUISITION (Cont.)

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
F. Particles & Fields (Continued)	8E	Gravsat Satellite System Config. Study (Gravity)	O	77	GSFC	681-01-01
	9E	Gravity Gradiometer Mission Study	O	83	GSFC	681-01-01
	10S	Relativity	O	79	MSFC	188-41-54
	11E	Geopause Satellite System Config. Study (Mass)	O	82	GSFC	681-01-02

RTOP #195-22-06 ON RADIATION EFFECTS AND SPECTROMETER STUDIES IS AN EXAMPLE OF THE PARTICLES AND FIELDS EFFORTS COVERED BY THE ROADMAP. THIS RTOP IS RELATED TO MILESTONE 4f2S AND 4f7S AND ADDRESSES THE DEVELOPMENT OF ON-BOARD AUTOMATED TECHNIQUES FOR PULSE-HEIGHT ANALYSIS OF GAMMA RAY SPECTRA.

195-22-06	RADIATION EFFECTS AND SPECTROMETER STUDY

6-1

GSFC

DR.J.TROMBKA

301-982-5941

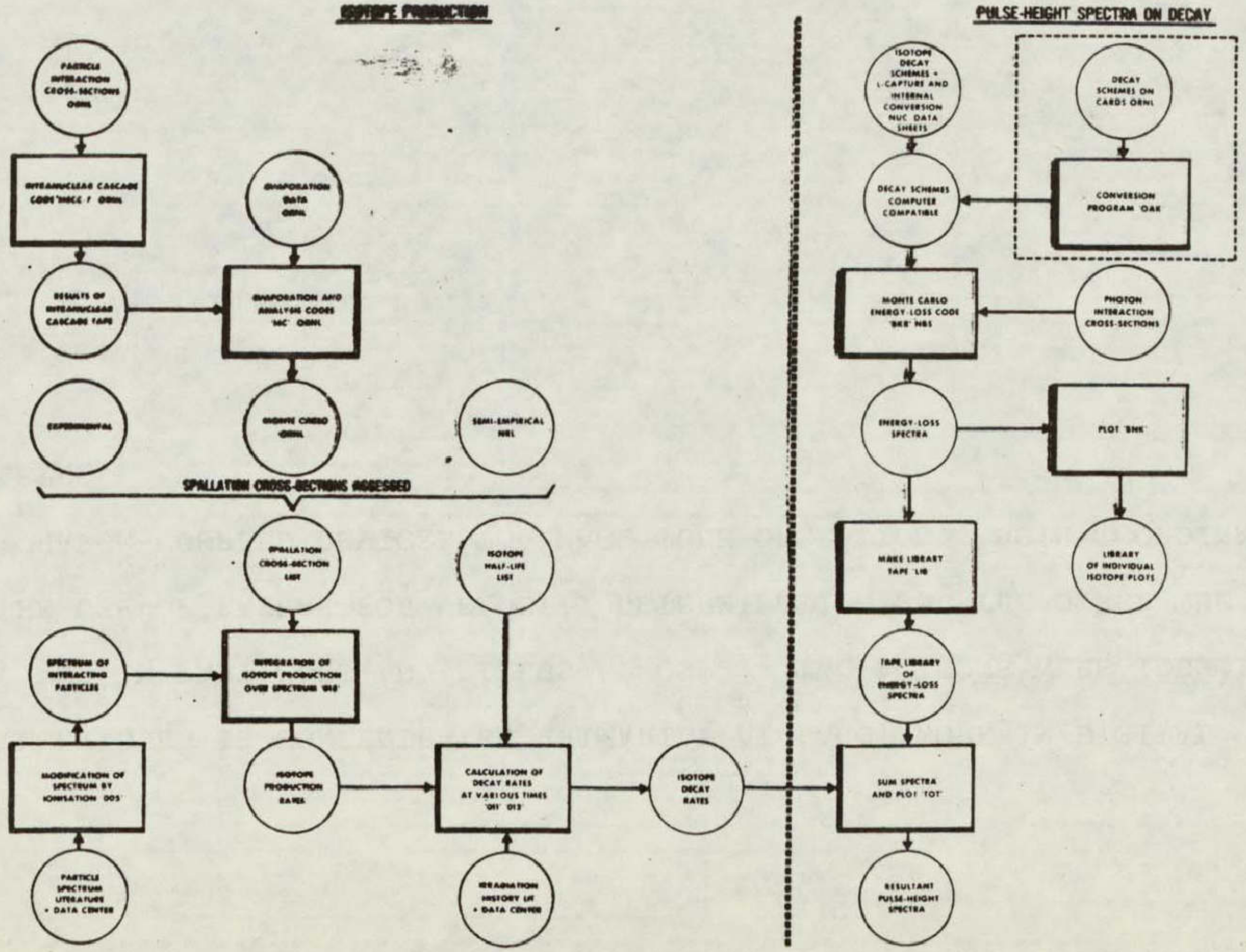
SM

C

HQ

F.C.ROBERSON

202-775-1602



WORK IN LASER TECHNIQUES IS CONCENTRATED PRIMARILY AT LARC, WORK IN DIGITAL IMAGING AT JPL, AND IN PARTICLES AND FIELDS AT GSFC. TWO ACTIONS WERE IDENTIFIED, ONE INVOLVING THE USE OF LASERS FOR VELOCITY DETERMINATION AND THE OTHER THE APPLICATION OF CHARGE-COUPLED DEVICES TO IMAGE TUBE OPERATION. BOTH COORDINATIONS HAVE BEEN COMPLETED.

ACTION ITEMS

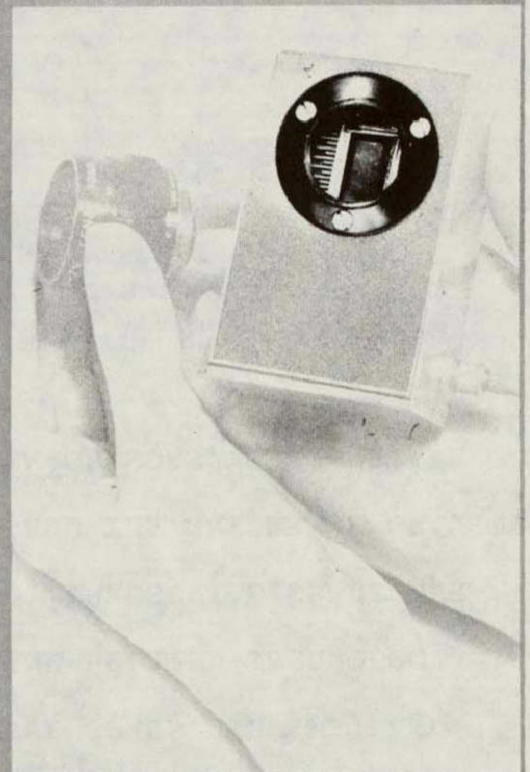
4. SENSING AND DATA ACQUISITION (Cont.)

Title	Action	Participants	Associated Milestones
Lasers	Coordinate LaRC Laser program and MSFC Laser Doppler program	LaRC, MSFC	4d1R, 1b3R
CCD Imager	Determine benefits of application of CCD's to Image Dissector Tube Operation	MSFC, GSFC	4e6R, 4e4R, 5b2S

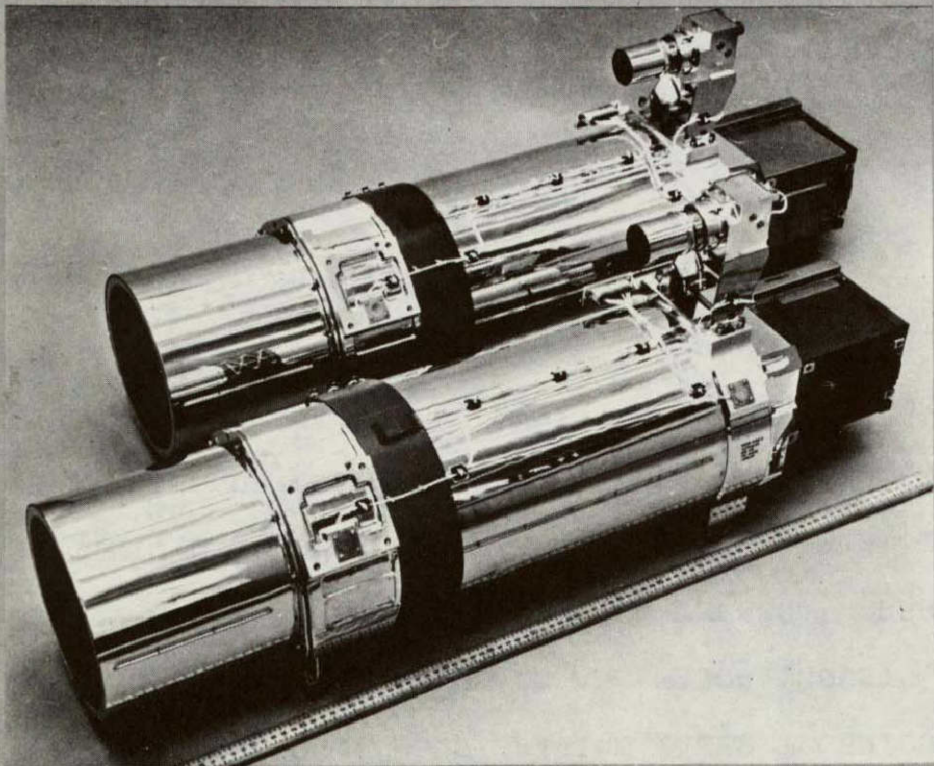
THE ACTION ITEM ADDRESSES THE BENEFITS OF CHARGE-COUPLED DEVICES TO IMAGE DISSECTOR TUBE TECHNOLOGY. THE APPLICATION OF CHARGE-COUPLED DEVICES TO VIDICON TECHNOLOGY RESULTS IN REDUCED WEIGHT, POWER CONSUMPTION, PARTS COUNT, AND ENHANCED SENSITIVITY. SIMILAR ADVANTAGES WILL BE DERIVED FOR THE IMAGE DISSECTOR TUBE CITED IN THE ACTION ITEM.

PLANETARY TV CAMERA COMPARISON

CHARGE-COUPLED DEVICE CAMERA



MARINER 10 CAMERA



Mariner 10 Camera		Charge-Coupled Device Camera
60	WEIGHT (LBS)	15
40	POWER (WATTS)	10
2000	PARTS COUNT	600
10^{-3}	MINIMUM DETECTABLE LIGHT (FOOT-CANDLE-SECONDS)	5×10^{-4}

NASA RE74-2140(3)
1-25-74

FUTURE TECHNOLOGY NEEDS DRIVING LASER TECHNIQUES, DIGITAL IMAGING AND PARTICLES AND FIELDS TECHNOLOGY GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER GROUP REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON DETECTION OF ENVIRONMENTAL AND TERRESTRIAL CHARACTERISTICS OF THE EARTH, PLANETARY FEATURES AND ORIGINS, AND THE NATURE OF GRAVITY AND MAGNETISM THROUGH THE USE OF IMPROVED LASER SYSTEM SENSORS, SOLID-STATE ARRAYS, AND CHARGE-COUPLED DEVICES.

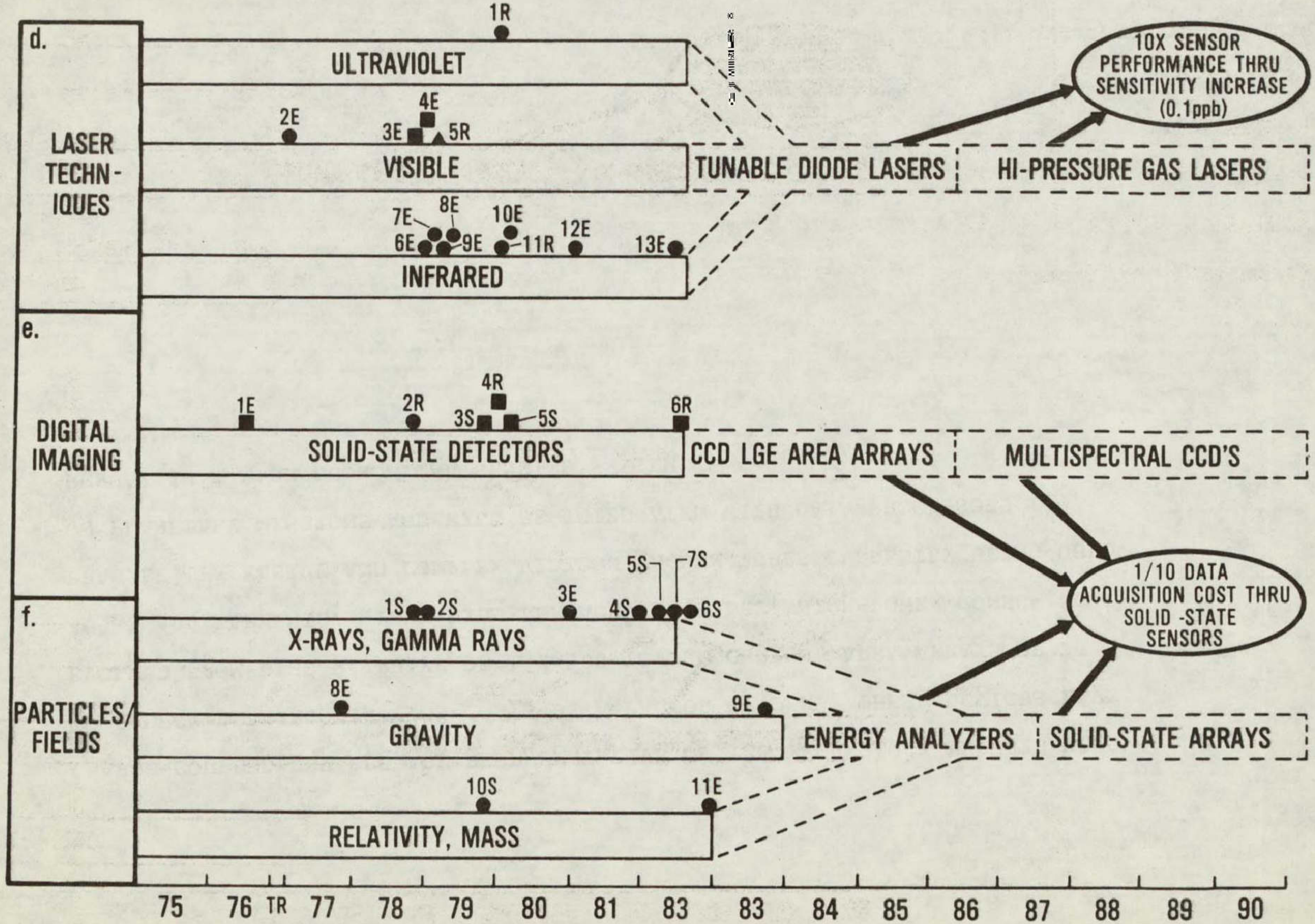
TECHNOLOGY THRUSTS

4. SENSING AND DATA ACQUISITION (Cont.)

Technical Area	Title	OFS Theme
d. Laser Techniques	Tunable Diode Lasers Hi-Pressure Gas Lasers	014 Living Marine Resources 024 Stratospheric Changes/ Effects 025 Water Quality 031 Local Weather/Severe Storm 032 Tropospheric Pollutants 074 Dynamics/Energetics Lower Atmosphere
e. Digital Imaging	CCD Large Area Arrays Multispectral CCD's	081 How did the Universe begin? 112 How do planets/large satellites and their atmospheres evolve?
f. Particles/Fields	Energy Analyzers Solid-State Arrays	085 What is nature of gravity? 103 Solar activity nature/ cause 114 Origin/history of magnetic fields

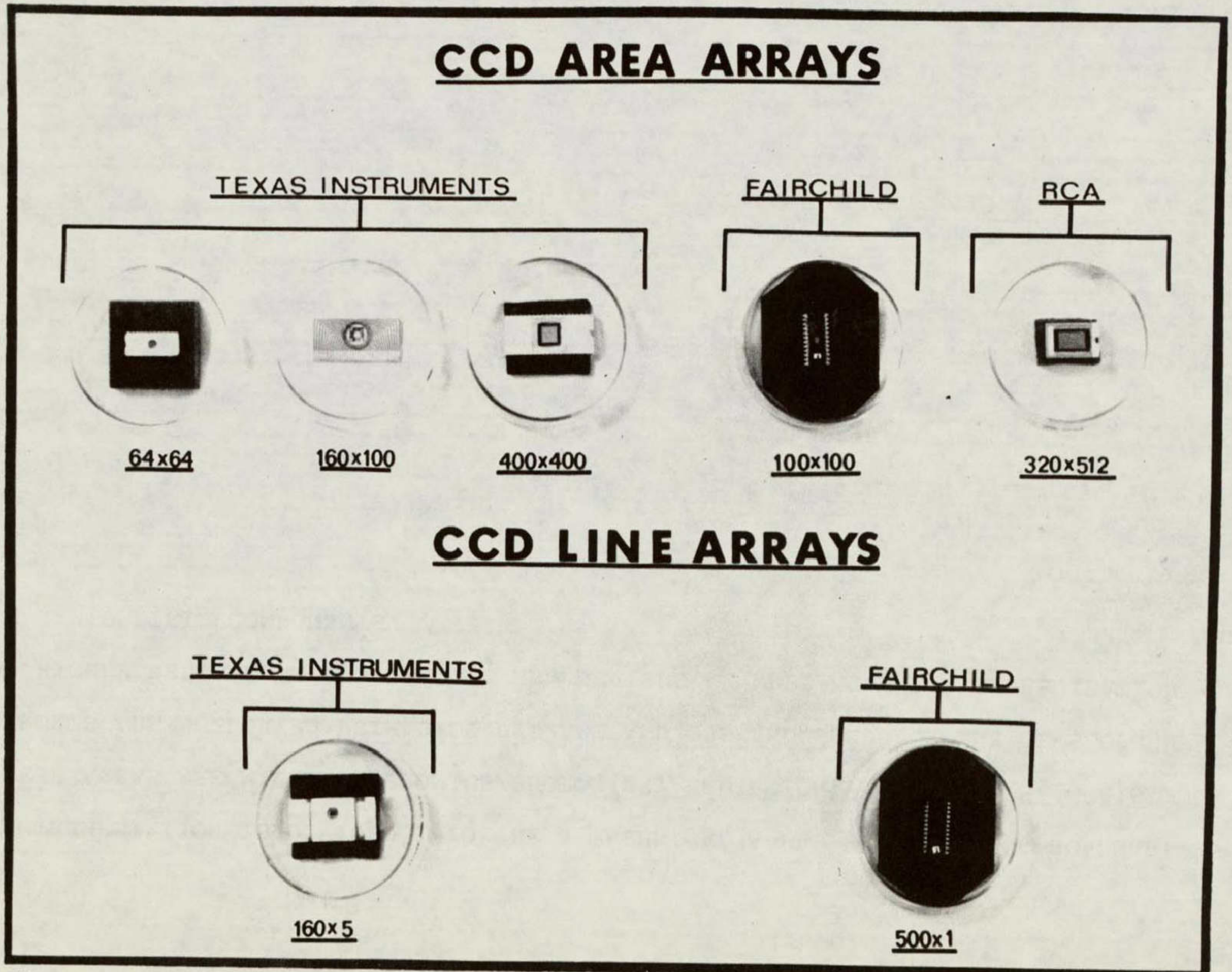
THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN LASER TECHNIQUES, DIGITAL IMAGING, AND PARTICLES AND FIELDS ARE SHOWN AS DASHED BARS ON THE ROADMAP. ASSOCIATED MAJOR GOALS ARE A TEN-FOLD IMPROVEMENT IN SENSOR PERFORMANCE THROUGH AN INCREASE IN SENSITIVITY WHICH RESULTS FROM THE USE OF TUNABLE DIODE LASERS AND TUNABLE HIGH-ENERGY/PRESSURE LASERS; AND A TEN-FOLD REDUCTION IN DATA ACQUISITION COSTS THROUGH THE USE OF SOLID-STATE SENSORS AND CHARGE-COUPLED DEVICES WHICH ARE SMALLER, LIGHTER, LESS COMPLEX, AND LOWER POWER CONSUMING THAN VIDICONS AND VACUUM TUBES.

4. SENSING AND DATA ACQUISITION



NASA HQ RE76-601 A (1)
2-17-76

CHARGE-COUPLED DEVICES ARE REPRESENTATIVE OF THE TECHNOLOGY THRUSTS NEEDED TO REDUCE DATA ACQUISITION COSTS BY A FACTOR OF TEN. THESE DEVICES HAVE EVOLVED FROM LINEAR ARRAYS OF 1 X 500 TO THE CURRENT AREA ARRAYS OF 400 X 400 ELEMENTS. THEY WILL REPLACE THE BULKY, HIGH-POWER CONSUMING, FRAGILE, EXPENSIVE AND COMPLEX VIDICON VACUUM TUBES CURRENTLY BEING USED ON PLANETARY MISSIONS AND WILL BE INTEGRATED WITH DATA PROCESSORS TO RESULT IN A MORE ECONOMICAL SENSING SYSTEM.

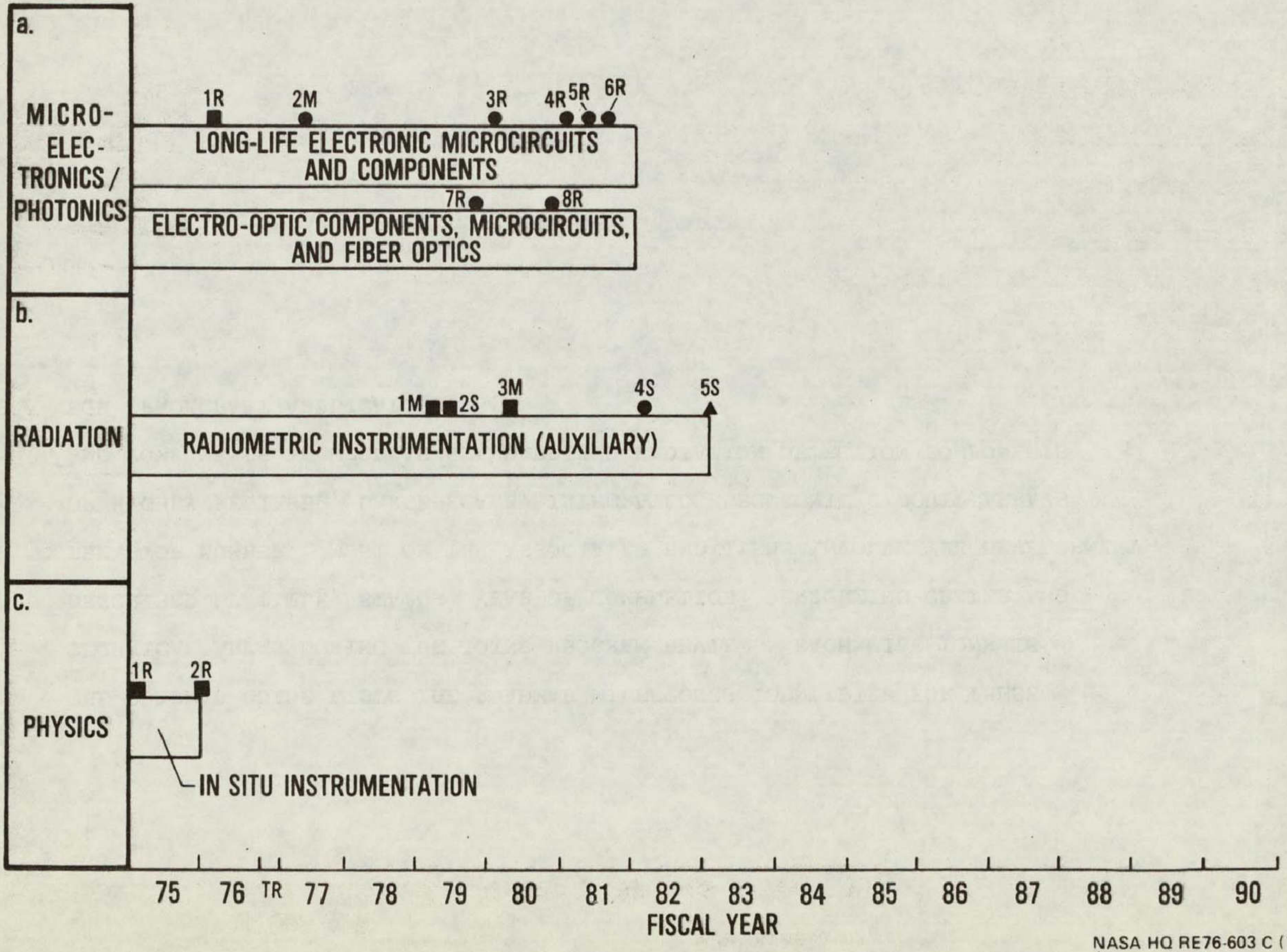


JPL

MIS/4-17-75

INSTRUMENTATION IS DIVIDED INTO THE 3 TECHNICAL AREAS SHOWN ON THE ROADMAP. THESE AREAS ARE MICROELECTRONICS/PHOTONICS, RADIATION, AND PHYSICS. EXISTING EFFORTS ARE SUPPORTED PRIMARILY BY OAST AND OSS AND FOCUS ON THE DEVELOPMENT OF HIGHLY RELIABLE MICROCIRCUITS AND DEVICES AS WELL AS THE STANDARDIZATION OF RADIOMETRIC COMPONENTS.

5. INSTRUMENTATION



NASA HQ RE76-603 C (1)
2-17-76

THE ROADMAP GUIDE LISTS THE ROADMAP MILESTONES IDENTIFIED FOR THESE TECHNICAL AREAS DURING THE JOINT PROGRAM REVIEW. EACH MILESTONE IS DESCRIBED BY TITLE, STATUS, YEAR OF COMPLETION, PERFORMING CENTER AND THE RTOP NUMBER. MOST OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT OF HIGHLY RELIABLE, LARGE-SCALE, INTEGRATED ELECTRONIC CIRCUIT ARRAYS AND COMPONENTS AS WELL AS STANDARDIZED RADIATION DETECTION COMPONENTS FOR SPACECRAFT APPLICATION.

ROADMAP GUIDE

5. INSTRUMENTATION

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
a. Microelectronics/ Photonics	1R	Long-Life Reliable Elec. Circuits	□	75	GSFC	506-18-34
	2M	Non-Volatile Semiconductor Memory	0	77	JSC	909-47-32
	3R	Electron Devices & Components	0	79	LaRC	506-18-21
	4R	Predictable Long-Life Component Technology	0	80	JPL	506-18-33
	5R	Design, Processing and Test of LSI Arrays	0	80	MSFC	506-18-31
	6R	Screening, Reliability, Testing of Microcircuits	0	80	MSFC	506-18-32
	7R	Integrated Optics	0	79	LaRC	506-18-21
	8R	Fiber Optics	0	80	JPL	506-18-23
b. Radiometric Instrumentation	1M	Fluidic Contamination Monitoring	□	78	KSC	909-64-13
	2S	Astronomical Instrumentation	□	78	GSFC	356-46-01
	3M	Space Systems Instrumentation	□	80	JSC	909-44-13
	4S	Solar Physics Instrumentation		81	GSFC	188-38-51
	5S	Gratings, Filters	△	82	GSFC	188-41-56
c. In Situ Instrumentation	1R	Fuel Gauging	□	74	JSC	502-33-85
	2R	Fuel Gauging Instrumentation	□	75	MSFC	506-18-14

RTOP #356-46-01 ON NIM/CAMAC APPLICABILITY INVESTIGATIONS IS AN EXAMPLE OF THE RADIOMETRIC INSTRUMENTATION COVERED BY THE ROADMAP. NIM AND CAMAC ARE DIFFERENT VERSIONS OF NUCLEAR INSTRUMENTATION MODULES USED IN RADIATION DETECTION. THIS RTOP ADDRESSES THE DEVELOPMENT OF MORE ECONOMICAL AND LOWER POWER STANDARDIZED INSTRUMENTATION MODULES FOR HIGH ENERGY ASTROPHYSICS APPLICATIONS FOR USE ON ADVANCED SPACECRAFT.

356-46-01	NIM/CAMAC APPLICABILITY INVESTIGATIONS

4-1

GSFC
DR. J. H. TRAINOR
301/982-6282

OSS
C

HQ
MR. F. W. GAETANO
212/755-8490

1. UTILIZATION STUDY OF NIM/CAMAC IN OUR EXPERIMENTS
2. UTILIZATION STUDY OF NIM/CAMAC IN EXPERIMENTS SUGGESTED BY HIGH ENERGY ASTROPHYSICS MANAGEMENT OPERATIONS WORKING GROUP
3. CONTRACT WITH MANUFACTURERS TO INVESTIGATE PERFORMANCE AND COST OF LOWER POWER NIM AND CAMAC FOR SPACELAB EXPERIMENTS
4. WRITE "PRIMER" FOR USAGE AND CONTROL OF HIGH VOLTAGE FOR SPACELAB
5. NIM/CAMAC MECHANICAL STUDIES

WORK IN MICROELECTRONICS/PHOTONICS INSTRUMENTATION IS CARRIED OUT PRIMARILY AT MSFC, LARC, AND JPL WHILE RADIOMETRIC INSTRUMENTATION IS BEING DEVELOPED AT GSFC AND JSC. SEVEN ACTION ITEMS WERE IDENTIFIED WITH THE LARGEST NUMBER FALLING IN THE AREA OF MICROELECTRONICS/PHOTONICS. OF THE VARIOUS ACTION ITEMS, THE ONE RELATING TO STANDARD INSTRUMENTATION IS PARTIALLY FINALIZED, AND THE REST ARE COMPLETED WITH THE EXCEPTION OF THE CCD PROCESSORS.

ACTION ITEMS

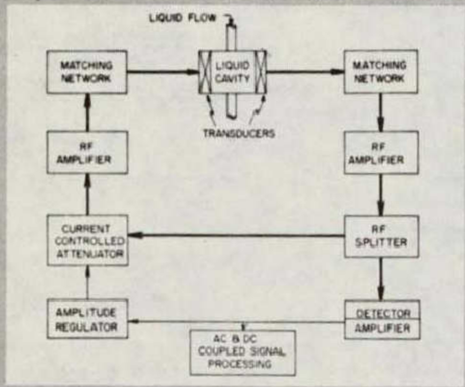
5. INSTRUMENTATION

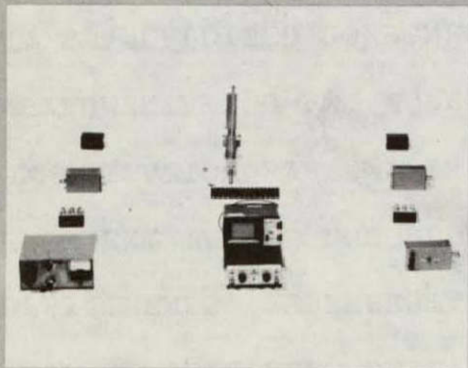
Title	Action	Participants	Associated Milestones
Standard Instrumentation	Identify design requirements for general purpose instrumentation standards	GSFC, JSC	5b2S, 5b3M
Solar Cells	Relate graded-band gap solar cell development to NASA's solar cell programs	LaRC	5a3R
Failure Mechanisms	Provide method for transferring results of progress in failure mechanisms investigations to user community	JPL, MSFC, GSFC	5a4R, 5a6R, 5a1R
Particulate Sensors	Coordinate LaRC particulate sensor program with KSC/OMSF efforts for hydraulic systems	LaRC, KSC	5b1M, 4d1R
CCD Processors	Determine requirements for analog CCD processors in future NASA programs	LaRC, JPL	5a3R, 6d6E
Zero-"G" Gauging	Compare RF and Nuclear Zero-G gauging systems performance	JSC, MSFC	5c1R, 5c2R
Solid State Instrumentation	Establish requirements for solid-state on-going program	LaRC	5a3R

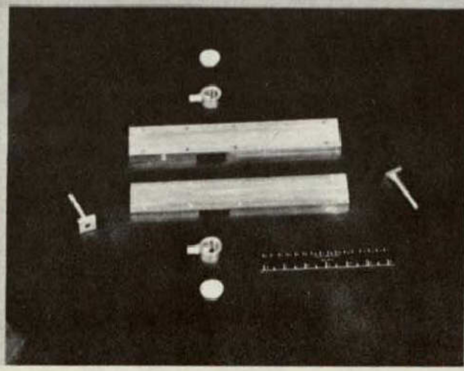
THE ACTION ITEM ENTITLED "PARTICULATE SENSORS" IS GIVEN AS AN EXAMPLE. RTOP #909-64-13 AT KSC IS INVESTIGATING TECHNIQUES FOR DETECTING AND MEASURING PARTICLES IN HYDRAULIC SYSTEMS. AN INSTRUMENT AT LARC CALLED A TRANSMISSION OSCILLATOR ULTRASONIC SPECTROMETER (TOUS) HAS SEVERAL APPLICATIONS IN THIS AREA INCLUDING SENSING PARTICLES IN BLOOD, WATER, AND OTHER FLUIDS INCLUDING OILS. IT PROVIDES A TECHNIQUE THAT IS CAPABLE OF OPERATION EVEN IN OPAQUE FLUIDS, IS SMALLER, LIGHTER, LESS POWER CONSUMING, AND 25 TIMES LESS EXPENSIVE THAN THE ALTERNATE OPTICAL METHOD. IN ADDITION, IT CAN HANDLE LIQUIDS AT A FASTER RATE, FUNCTION AT HIGHER CONCENTRATIONS OF PARTICULATES, AND OPERATE IN REAL TIME. CONSIDERATION OF THIS TECHNIQUE FOR KSC APPLICATIONS IS BEING GIVEN IN VIEW OF THE MANY ADVANTAGES.

TRANSMISSION OSCILLATOR ULTRASONIC SPECTROMETER (TOUS)

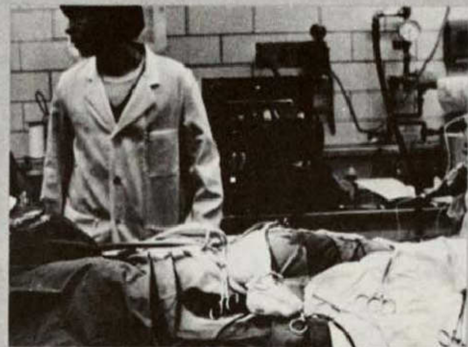
MICRO-PARTICLE DETECTOR

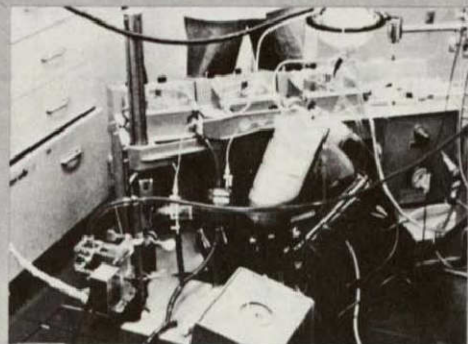


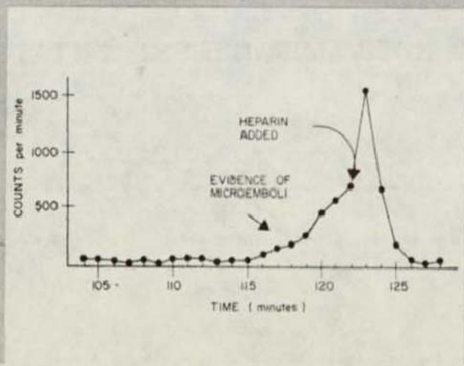




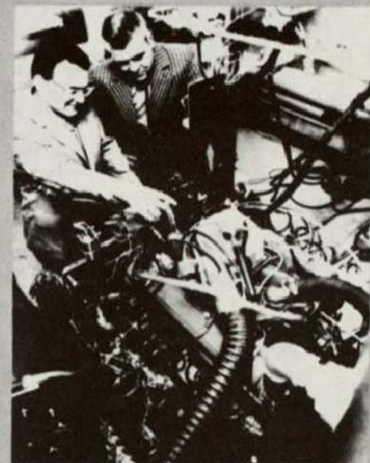
PRESENT APPLICATIONS



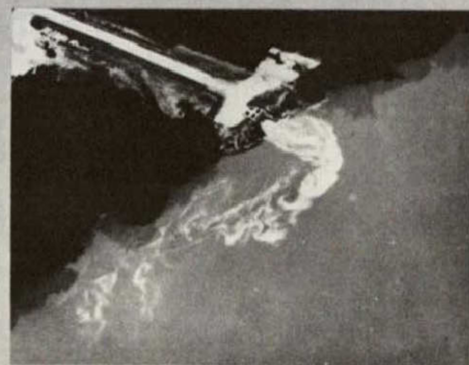




FUTURE APPLICATIONS



ENGINE LUBRICANT MONITOR



POLLUTION SENSOR

NASA HQ RE75-15260(3)
11-26-74

FUTURE TECHNOLOGY NEEDS DRIVING INSTRUMENTATION TECHNOLOGY GOALS AND MAJOR THRUSTS WERE DERIVED AT THE OAST WORKSHOP FROM THE OUTLOOK FOR SPACE (OFS) THEMES, REPRESENTATIVE SPACE SYSTEMS, AND SPECIFIC USER REQUIREMENTS. PERTINENT THEMES AND RELATED TECHNOLOGY THRUSTS CONCENTRATE ON IMPROVED COMMUNICATION SYSTEMS THROUGH INTEGRATION OF SENSING AND DATA PROCESSING INSTRUMENTATION AND MORE EFFICIENT RADIATION DETECTION USING MODULARIZED AND STANDARDIZED COMPONENTS.

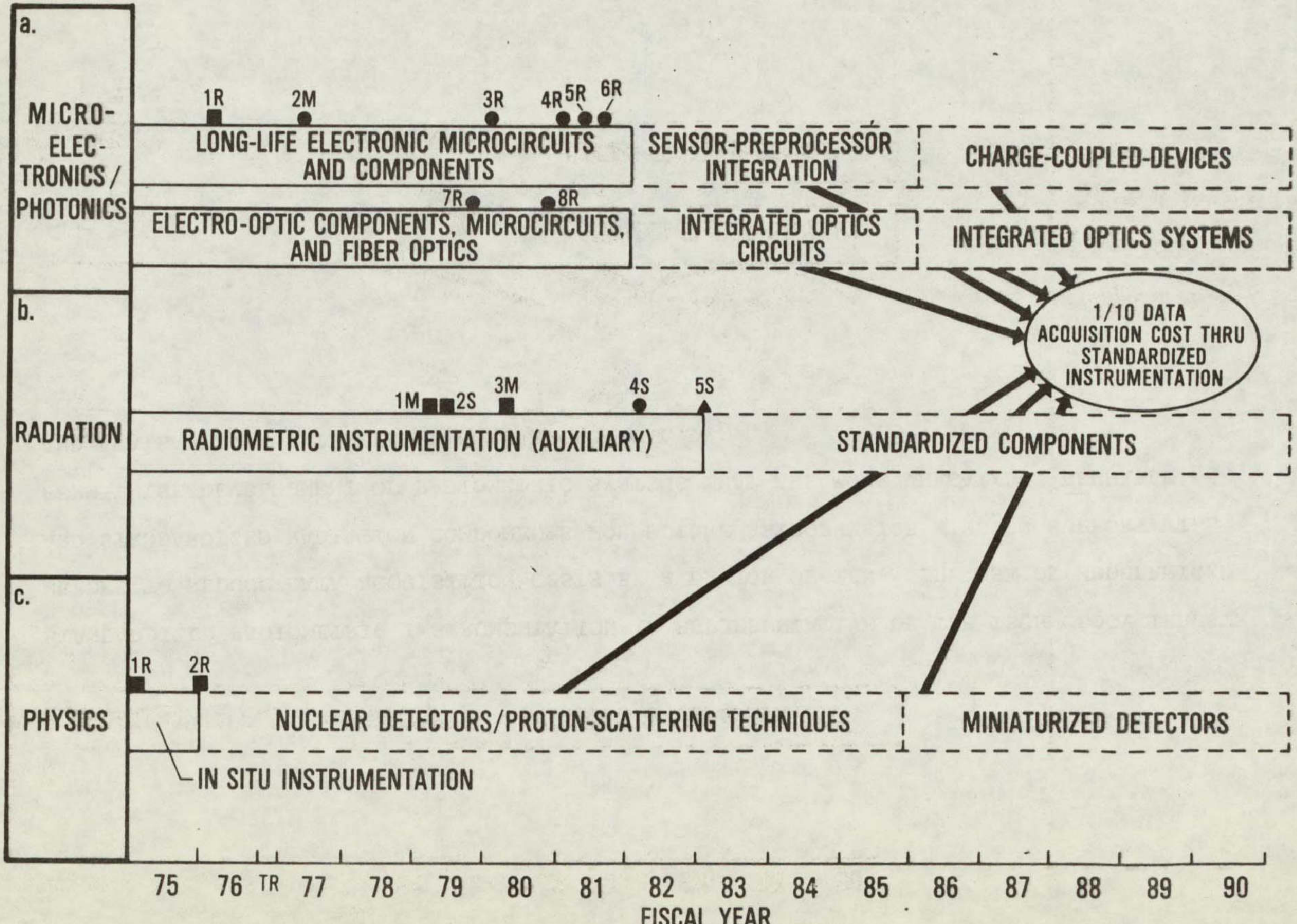
TECHNOLOGY THRUSTS

5. INSTRUMENTATION

Technical Area	Title	OFS Theme	
a. Microelectronics/Photonics	Sensor/Preprocessor Integration, CCD's, Integrated Optics	034	Communication/Navigation
		051	Domestic Communication
		140	New Automated Data Analysis Management Systems
b. Radiation	Standardized Components	094	Nature of Cosmic Rays
		103	Nature/Cause Solar Activity
		114	Origin/History Mag. Fields
c. Physics	Nuclear Detectors Miniaturized Detectors	061	Basic Physics/Chemistry
		062	Material Science
		130	Space Station

THE RESULTANT FUTURE TECHNOLOGY THRUSTS IN INSTRUMENTATION ARE SHOWN AS DASHED BARS ON THE ROADMAP. THE ASSOCIATED MAJOR GOAL IS A TEN-FOLD REDUCTION IN DATA ACQUISITION COSTS THROUGH THE USE OF STANDARDIZED INSTRUMENTATION IN SUCH AREAS AS SENSOR-PREPROCESSOR INTEGRATION AND RADIOMETRY.

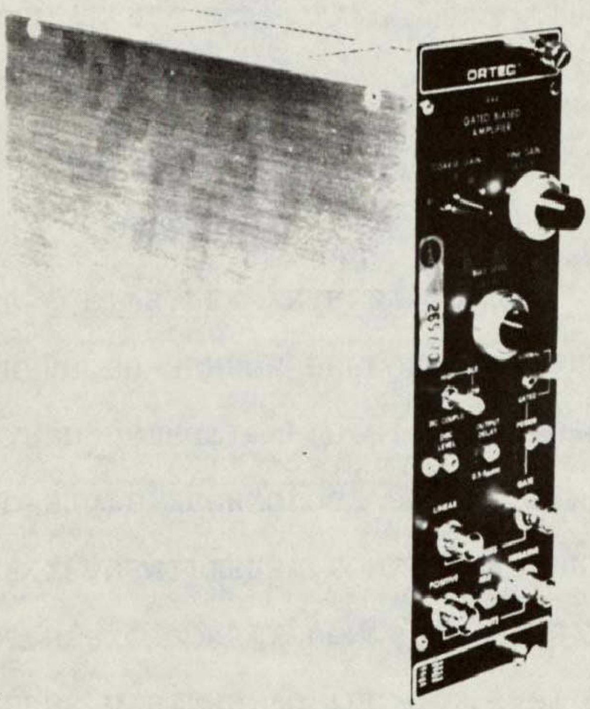
5. INSTRUMENTATION



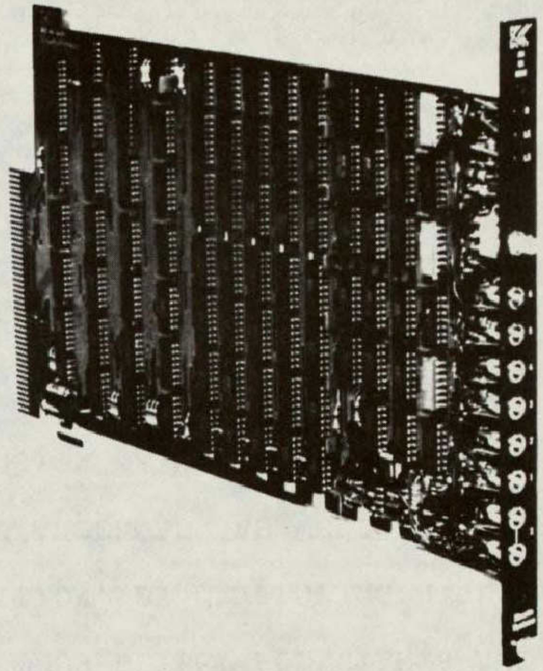
NASA HQ RE76-603 C (1)
2-17-76

STANDARDIZED RADIOMETRIC INSTRUMENTATION IS REPRESENTATIVE OF THE TECHNOLOGY THRUSTS NEEDED TO REDUCE DATA ACQUISITION COSTS BY A FACTOR OF TEN. THE USE OF MODULARIZED AND STANDARDIZED RADIATION COMPONENTS FOR FUTURE ASTROPHYSICS MISSION SUPPORT WILL PERMIT THE DEVELOPMENT OF RADIOMETRIC SYSTEMS THAT ARE MORE VERSATILE, REUSABLE, AND AVAILABLE, AND THEREFORE MORE ECONOMICAL.

STANDARD MODULAR COMPONENTS FOR ASTRONOMY/ASTROPHYSICS



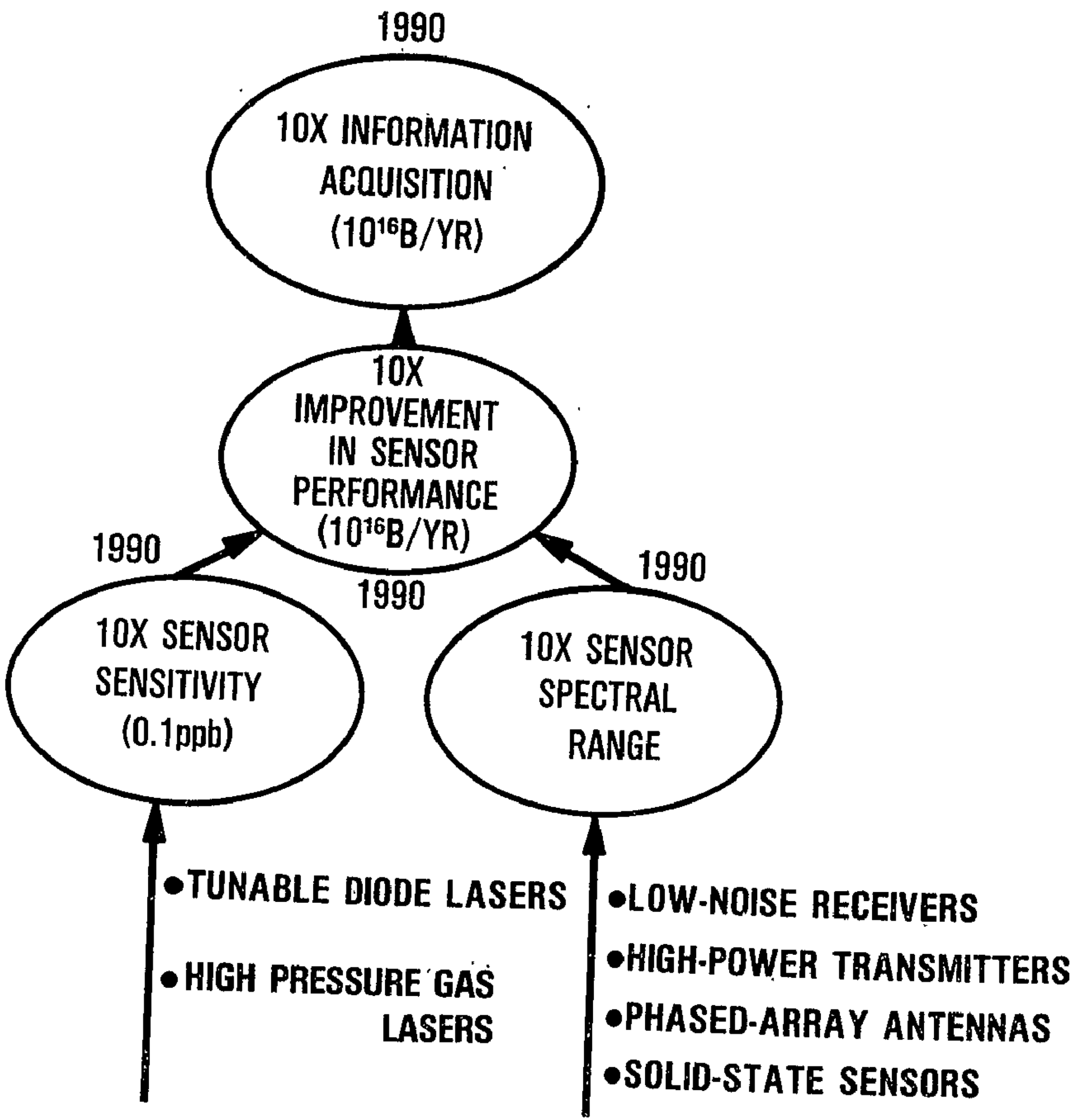
NIM MODULE



CAMAC MODULE

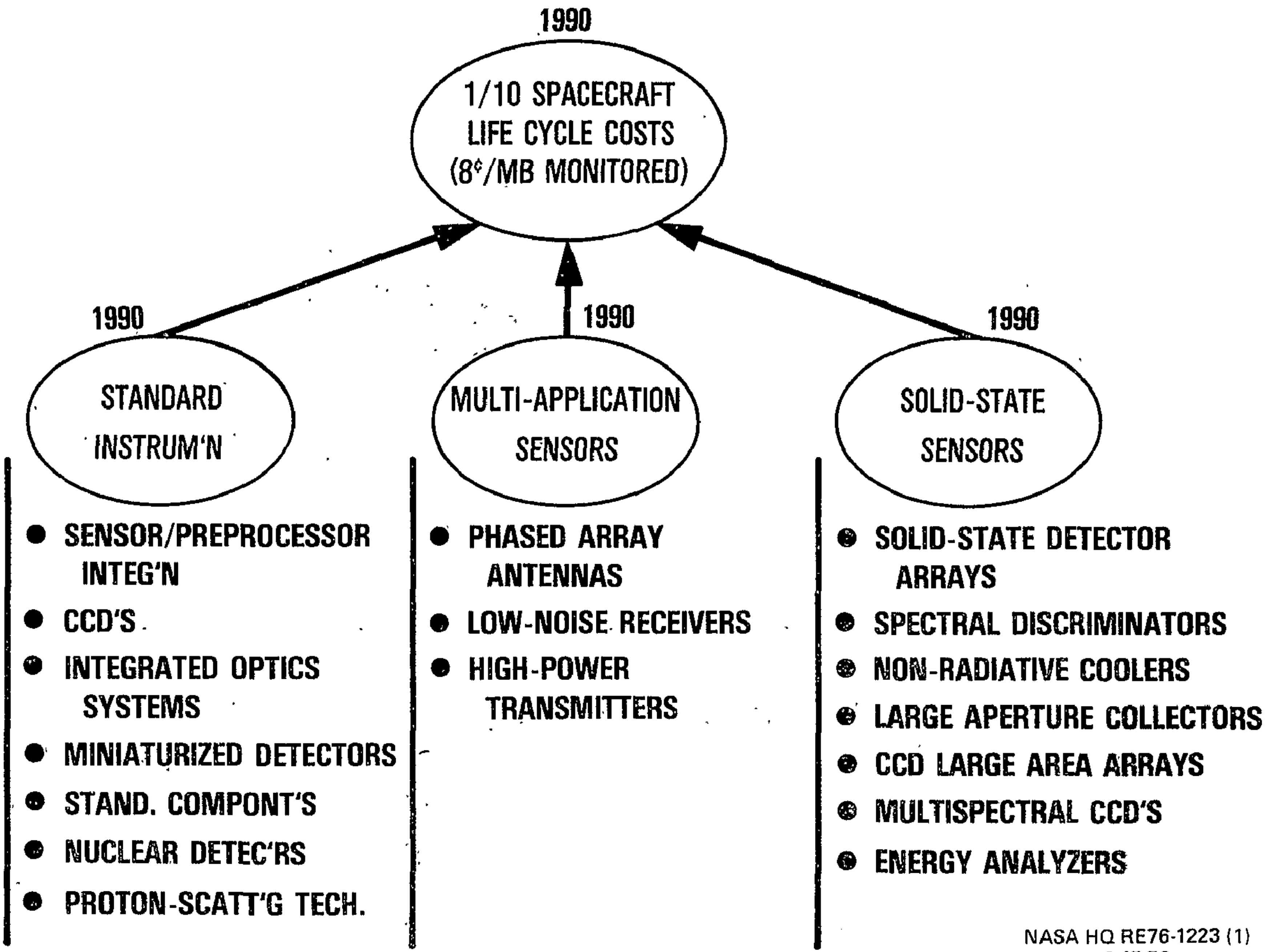
- LOW COST
- MODULARITY
- REUSABILITY
- VERSATILITY

THIS FIGURE RELATES THE FUTURE THRUSTS TO THE NASA GOAL OF INFORMATION ACQUISITION IMPROVEMENT BY A FACTOR OF TEN. BY DEVELOPING AND APPLYING TUNABLE DIODE LASERS AND HIGH ENERGY TUNABLE GAS LASERS, IT WILL BE POSSIBLE TO IMPROVE THE SENSITIVITY OF THESE SYSTEMS TO THE 0.1 PART PER BILLION RANGE AND THUS DETECT POLLUTANTS AND ATMOSPHERIC CONSTITUENTS AT EVEN LOWER LEVELS. IN ADDITION, BY DEVELOPING HIGHER POWER TRANSMITTERS, LOWER NOISE RECEIVERS, PHASED ARRAY ANTENNAS, AS WELL AS SOLID-STATE TECHNOLOGY, IT WILL MAKE POSSIBLE THE EXTENSION OF MICROWAVE AND INFRARED DETECTION TO HIGHER REGIONS OF THE SPECTRUM. THESE WILL ALL CONTRIBUTE TO ENHANCED SENSOR PERFORMANCE AND TO A NASA INFORMATION ACQUISITON CAPABILITY OF 10^{16} BITS PER YEAR BY 1990.



NASA HQ RE76-1244 (1)
2-17-76

THE FIGURE RELATES THE FUTURE THRUSTS TO THE NASA GOAL OF SPACECRAFT LIFE CYCLE COST REDUCTION BY A FACTOR OF TEN. BY DEVELOPING MINIATURIZED DETECTORS, STANDARDIZED COMPONENTS, BY THE INTEGRATION OF SENSORS AND PREPROCESSORS, BY APPLYING SOLID-STATE TECHNOLOGY TO DETECTOR ARRAYS, SPECTRAL DISCRIMINATORS AND ENERGY ANALYZERS, BY INTRODUCING MULTIAPPLICATION MICROWAVE SENSING, IT WILL BE POSSIBLE TO REDUCE THE COST OF MONITORING A MEGABIT OF INFORMATION TO EIGHT CENTS. THIS WILL BE EFFECTED BECAUSE OF THE LOWER POWER CONSUMPTION, SIZE, AND WEIGHT AS WELL AS THE IMPROVED PERFORMANCE OF THE NEW TECHNOLOGIES.



NASA HQ RE76-1223 (1)
2-17-76

IN SUMMARY, THE SENSING AND DATA ACQUISITION AREA AND THE INSTRUMENTATION AREA WERE FOUND TO BE GENERALLY WELL BALANCED AND COORDINATED. FUTURE THRUSTS ARE AIMED AT REDUCING COSTS AND IMPROVING DATA ACQUISITION CAPABILITY. TRENDS ARE TOWARD THE DEVELOPMENT AND GREATER USE OF SOLID-STATE SENSORS, MULTIAPPLICATION SENSORS AND STANDARDIZED INSTRUMENTATION. THE KEY DRIVERS ARE MICROWAVE, MULTI-SPECTRAL SCANNING AND INFRARED TECHNOLOGY.

SUMMARY

SENSING AND DATA ACQUISITION/INSTRUMENTATION

1. STRONG PROGRAM WITH OVER 300 SENSORS BEING DEVELOPED
2. STRONG SUPPORT INCLUDING 120 RTOPS OR ABOUT ONE-HALF OF THE TOTAL RTOP'S IN THE ELECTRONICS TECHNOLOGY PROGRAM IN NASA
3. GOOD COORDINATION AMONG CENTERS AND PROGRAM OFFICES
4. FUTURE THRUSTS:
   - REDUCE COSTS
   - INCREASE DATA ACQUISITION
   - INCREASE SENSOR PERFORMANCE
5. TRENDS ARE TOWARD:
   - INCREASED USE OF SOLID-STATE SENSORS
   - MULTIAPPLICATION SENSORS
   - STANDARDIZED INSTRUMENTATION
   - MINIATURIZED DETECTORS

DATA PROCESSING, STORAGE AND TRANSFER

DATA PROCESSING, STORAGE AND TRANSFER PROVIDES THAT VITAL LINK BETWEEN THE SENSING OR ACQUISITION OF DATA AND THE DELIVERY OF PRACTICAL INFORMATION TO THE USER. WITHIN THAT LINK, RAW DATA IS ACCUMULATED (ONBOARD STORAGE); CORRELATED WITH FLIGHT PARAMETERS, COMPRESSED, CODED AND SORTED (ONBOARD PROCESSING); COMMUNICATED TO A CENTRAL OR DISTRIBUTED RECEIVER ON THE GROUND EITHER DIRECTLY OR THROUGH RELAY POINTS (DATA TRANSFER); AGAIN ACCUMULATED AND MANIPULATED (GROUND STORAGE AND PROCESSING); AND FINALLY DISTRIBUTED TO THE USER COMMUNITY.

THE DISCIPLINE CATEGORIES COVERED IN THIS PRESENTATION ARE SIMPLY THOSE IN THE TITLE, e.g.

6. DATA PROCESSING
7. DATA STORAGE
8. DATA TRANSFER

SPECIFIC TECHNOLOGY AREAS FALLING IN THESE CATEGORIES ARE DISCUSSED IN THIS SECTION.

SPACE ELECTRONICS TECHNOLOGY

INTRODUCTION	PETER R. KURZHALS
APPROACH	ARTHUR HENDERSON
PROGRAM OUTLINE	CHARLES E. PONTIOUS
GUIDANCE, NAVIGATION & CONTROL	WILLIAM B. GEVARTER
SENSING & DATA ACQUISITION	BERNARD RUBIN
DATA PROCESSING, STORAGE & TRANSFER	HAROLD ALSBERG
PROGRAM GOALS	CHARLES E. PONTIOUS
CONCLUSION	PETER R. KURZHALS

NASA HQ RE76 1323 (1)
11-15-75

THE DATA PROCESSING ROADMAP DEPICTING THE ONGOING NASA ACTIVITIES, IS DIVIDED INTO FOUR TECHNICAL AREAS:

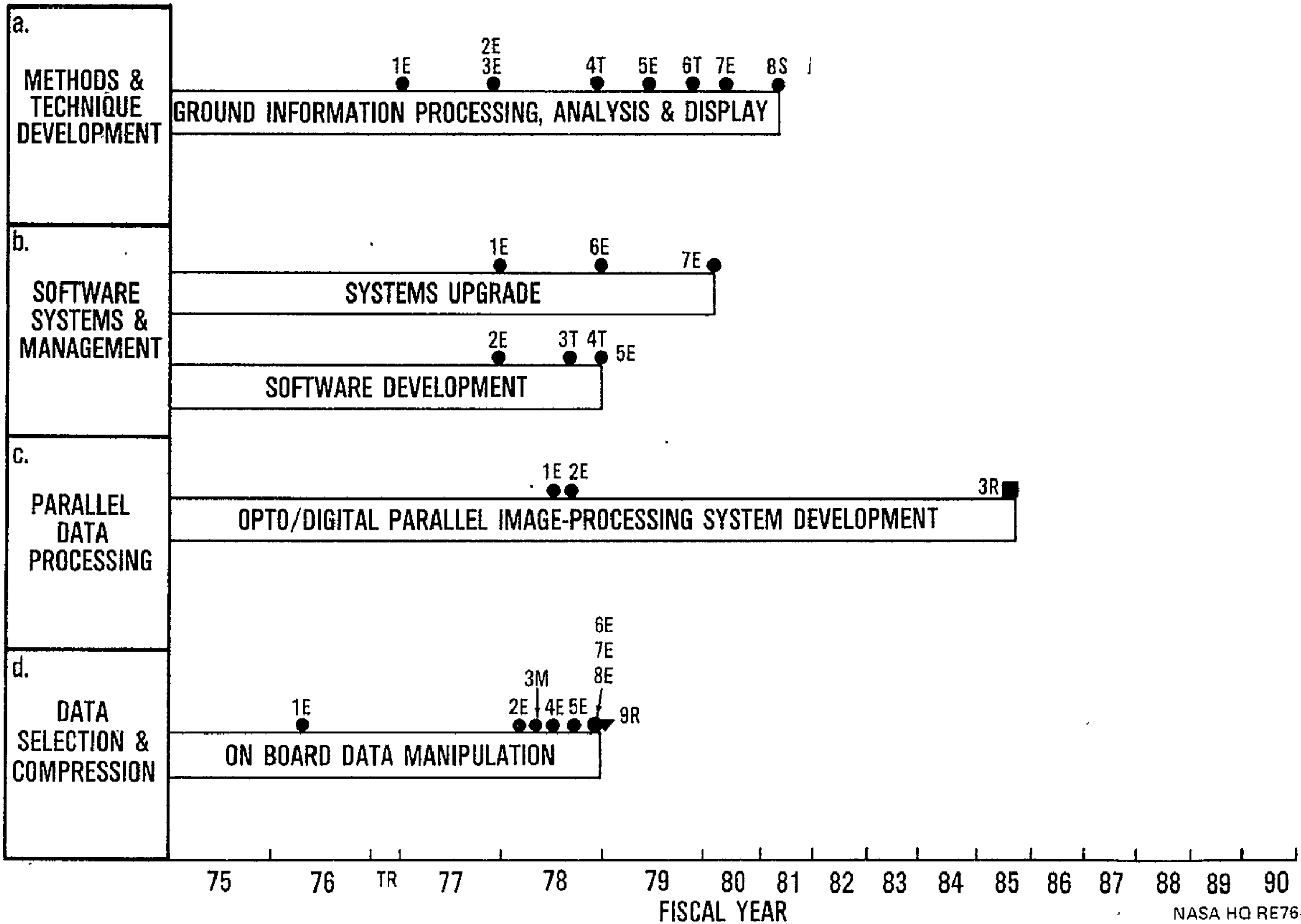
(a) THE METHODS & TECHNIQUE DEVELOPMENT DEALS WITH FINDING PROBLEM SOLVING SCHEMES FOR ANALYSIS AND DISPLAY OF "USEFUL" INFORMATION OUT OF EARTH RESOURCES DATA. PRIMARY SUPPORT FOR THIS WORK COMES FROM OA & OTDA.

(b) SOFTWARE SYSTEM & MANAGEMENT ADDRESSES THE IMPLEMENTATION AND INSTALLATION OF PROBLEM SOLVING ALGORITHMS THROUGH EFFICIENT MANAGEMENT PROCEDURES AND UPDATING OF AVAILABLE DATA PROCESSING SYSTEMS. THIS WORK IS SUPPORTED BY OA & OTDA.

(c) THE PARALLEL DATA PROCESSING TECHNIQUE DEVELOPMENT SEEKS TO INCREASE THE DATA REDUCTION CAPABILITIES BY PROVIDING SIMULTANEOUS ACCESS TO ALL IMAGE POINTS. THIS WORK IS SUPPORTED BY OAST & OA.

(d) THE DATA SELECTION AND COMPRESSION DEALS WITH THE MECHANIZATION OF ONBOARD PROCESSING TO REDUCE DATA RATES WITHOUT LOSS OF INFORMATION CONTENT BUT MAINTAIN NEAR-REAL-TIME INFORMATION DISPLAY CAPABILITY. THIS WORK IS SUPPORTED BY OA AND OAST.

6. DATA PROCESSING



NASA HQ RE76-712A (1)
2-17-76

THE ROADMAP GUIDE EXPLAINS THE ROADMAP AND INDICATES BY TECHNICAL AREA EACH OF THE MILESTONES DETAILING TITLES, STATUS, YEAR OF COMPLETION, THE COGNIZANT CENTER AND THE RTOP. ALL OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT AND LABORATORY VALIDATION OF DATA-TO-INFORMATION REDUCTION USING DIGITAL COMPUTATIONAL CAPABILITIES. 6c3R IS AN ENGINEERING TYPE BREADBOARD AND 6d7E AND 6d9R ARE SYSTEMS WHICH REQUIRE FLIGHT VALIDATION.

ROADMAP GUIDE

6. DATA PROCESSING

Technical Area	Mile-Stone #	Title	Status	FY	Center	RTOP #
a. Methods and Technique Development	1E	Earth Observation Data Management	O	77	GSFC	656-12-01
	2E	Conceptual Mathematical Models for Processing, Display and Management of Large Data Bases	O	78	MSFC	177-32-71
	3E	Research Leading to the Development of a Useful E-O Data Management System	O	78	MSFC	656-11-01
	4T	Computational Requirements Definition for Data Handling and Processing	O	79	GSFC	310-40-38
	5E	Sensor Requirement Definition	O	79	MSFC	656-21-01
	6T	Data Handling & Processing Tech.	O	80	GSFC	310-40-25
	7E	Transfer of Remote Sensing Analysis Technology via Time-Sharing Computers	O	80	JSC	177-32-82
	8S	Systems Performance and Technology Assessment for Unmanned Missions	O	81	LaRC	180-17-50
b. Software Systems & Data Management	1E	Data Management Systems Planning	O	78	MSFC	656-11-01
	2T	Image Processing Facility Performance Evaluation & Improvement Definition	O	78	GSFC	310-40-39
	3T	Project Operations Control Center Computational System of the 1980's	O	79	GSFC	310-40-40
	4T	Computer Operating Systems Study	O	79	GSFC	310-40-41
	5E	Procedures for Definition of Implementation of Data Systems Requirements	O	79	MSFC	656-31-01
	6E	Advanced Methods for Data Base Management	O	79	MSFC	656-31-01
	7E	Data Management	O	80	HQ	656-XX

6. DATA PROCESSING (Cont.)

Technical Area	Mile-Stone #	Title	Status	FY	Center	RTOP #
c. Parallel Data Processing	1E	Hybrid Digital/Optical Processing Technology	0	78	MSFC	656-23-01
	2E	Optical/Digital Processing of Multi-Spectral Data	0	78	JSC	177-32-81
	3R	Automated Data Handling Techniques and Components	□	84	GSFC	506-20-14
d. Data Selection & Compression	1E	IPL Upgrading	0	76	JPL	177-32-51
	2E	Data Compacting Technology	0	78	GSFC	175-31-42
	3M	Onboard Experiment Data Support Facility	0	78	JSC	975-50-01
	4E	Data Compression & Error Detection	0	79	GSFC	177-25-41
	5E	Data Compression for Graphic Trans.	0	79	GSFC	656-11-02
	6E	Conceptual Design of Compression/Reconstruction Hardware-Software Systems	0	79	GSFC	656-11-01
	7E	On-Board Radar Image Processor	▽	79	JPL	638-40-05
	8E	Video Compression Technology Development & Demonstration	0	79	ARC	650-60-10
	9R	Advanced Digital Data System for Deep Space	▽	80	JPL	506-20-11

A REPRESENTATIVE EXAMPLE, 6c3R, SHOWS THAT GSFC UNDER RTOP 506-20-14 IS INVESTIGATING METHODS FOR ONBOARD PROCESSING OF EARTH RESOURCES DATA. THIS ACTIVITY IS FOCUSSED ON INCREASING DATA REDUCTION SPEED BY PARALLEL IMAGE PROCESSING USING ELECTRO-OPTICAL COMPONENTS. ALL POINTS OF AN IMAGE ARE PROCESSED SIMULTANEOUSLY AT AN EFFECTIVE BIT RATE OF 10^{12} PER SECOND. THIS METHOD REPRESENTS A BOLD APPROACH TO OVERCOME THE SEVERE SPEED LIMITATIONS OF EXISTING SERIAL PROCESSORS.

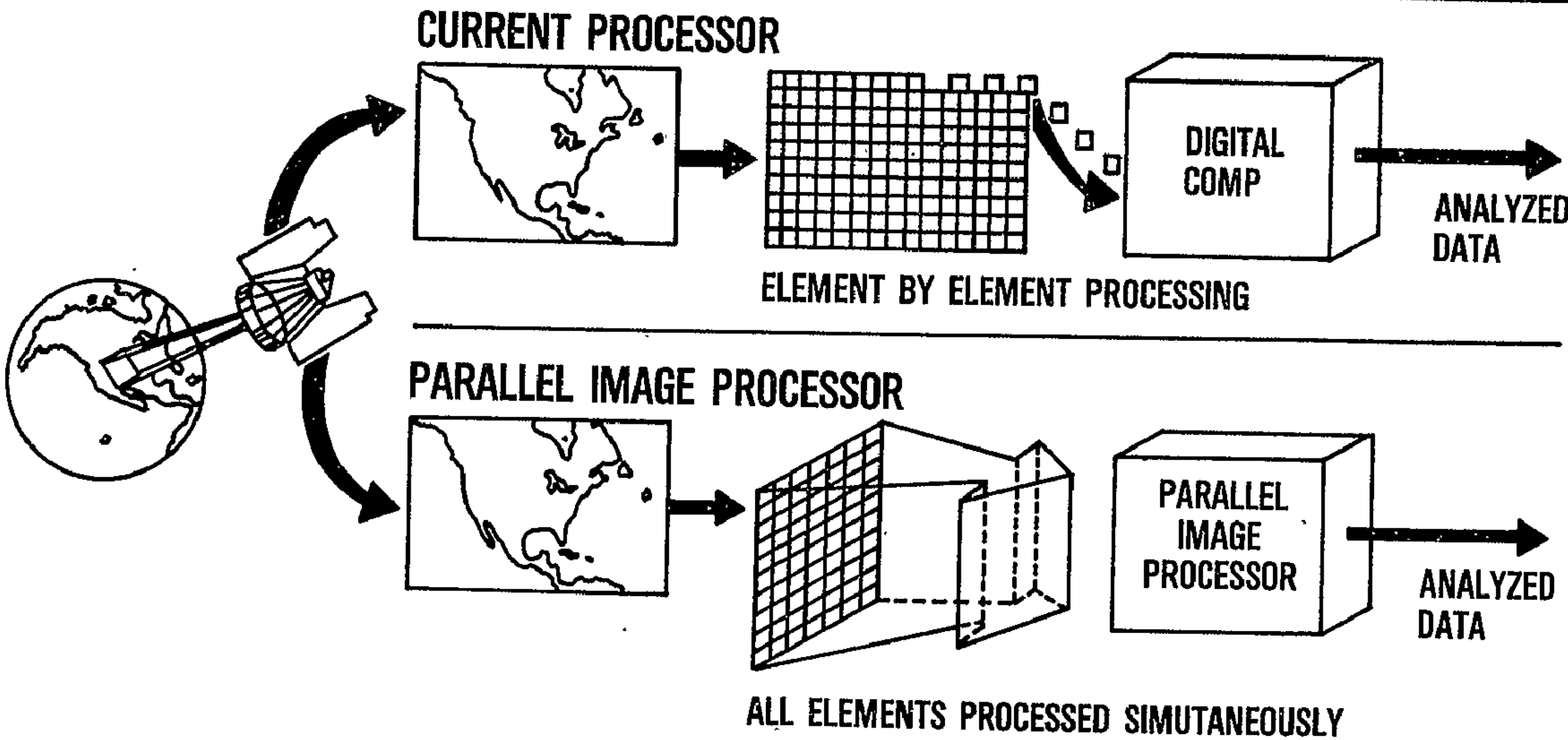
506-20-14	AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS

GSFC
8-1

GSFC
D.H. SCHAEFER
301-982-5184

OAST
D

HQ
H. ALSBERG
202-755-3266



- FASTER BY 10^4 TO 10^5
- ON BOARD PROCESSING TO REDUCE LOAD ON DATA LINK
- ANALYZE MASSIVE IMAGE DATA FROM SPACE ON THE GROUND

NASA HQ RE76-884(1)
10-23-75

ACTION ITEMS GENERATED BY THE JOINT ELECTRONIC PROGRAM REVIEWS RELATED TO THE FOUR TECHNICAL AREAS OF DATA PROCESSING ARE LISTED. THE TITLE OF THE ACTION, A DESCRIPTION, THE PARTICIPANTS AND THE APPLICABLE MILESTONES ARE CITED. THE EMPHASIS IS ON IMPROVED COORDINATION AND CROSS-FERTILIZATION AMONG ALL NASA CENTERS AND VARIOUS USAF ELEMENTS IN THE TECHNICAL AREAS OF REDUNDANT SYSTEMS, ONBOARD PROCESSING USING CCD'S, DATA COMPRESSION R&D, AND APPLICATIONS AND STANDARDIZATION OF DIGITAL INTERFACES.

ACTION ITEMS

6. DATA PROCESSING

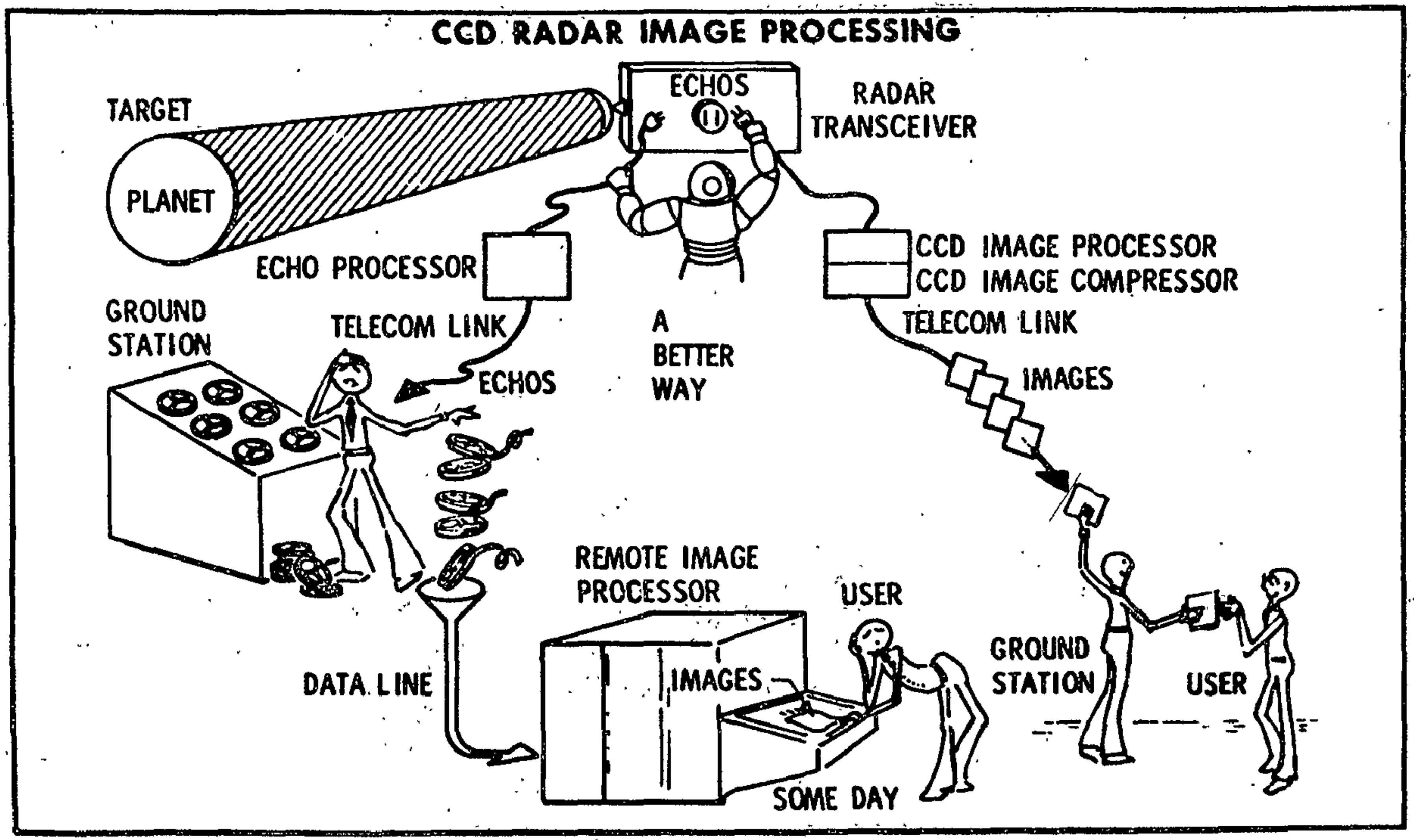
Title	Action	Participants	Associated Milestones
Redundant Systems Reliability	Provide briefing of MSFC & LaRC redundant system reliability assessment	MSFC/LaRC	6a8S
CCD Radar Image Processing	Develop a coordinated plan for CCD image processing R&D	JPL/LaRC	6d7E, 5a2R
Data Compression	Develop programmatic overview of NASA efforts in data compression R&D	JPL/ARC/MSFC/GSFC	6d1E, 6d2E 6d4E, 6d8E
Analog CCD Processing	Prepare first-cut estimate of potential payoffs of CCD processors in NASA applications	LaRC/JPL/ARC/JSC/ GSFC	5a2R, 6d7E
Standard Interfaces for Digital Data	Establish coordination between MSFC & USAF on Standard Avionics Module activities	MSFC/USAF	6d9R

AS AN EXAMPLE, TWO OF THE ACTION ITEMS CONCERN THE USE OF CCD'S FOR ONBOARD DATA PROCESSING. THE FIGURE ILLUSTRATES THE SIGNIFICANT IMPROVEMENTS WHICH ARE POSSIBLE IN DATA REDUCTION AND DISTRIBUTION THROUGH THE USE OF ONBOARD PROCESSORS. CCD TECHNOLOGY OFFERS THE POTENTIAL TO REALIZE THIS IMPROVEMENT AND SEVERAL INVESTIGATORS WITHIN NASA ARE WORKING ON THAT TECHNOLOGY. THE ACTION ITEMS REQUIRE COORDINATION AND, WHERE FEASIBLE, JOINT PLANNING OF THOSE CCD DEVELOPMENT PROGRAMS. JPL INVESTIGATORS, CONCERNED WITH THE APPLICATION OF CCD'S TO RADAR IMAGE PROCESSING, ARE WORKING DIRECTLY WITH THEIR COUNTERPARTS AT LARC TO APPLY THE COMPONENTS BEING DEVELOPED TO JPL'S MISSION NEEDS. A COORDINATED DEVELOPMENT PLAN IS BEING PREPARED FOR REVIEW IN MID-DECEMBER. THE FIRST CUT ESTIMATE OF POTENTIAL CCD PROCESSOR PAY-OFFS HAVE NOT YET BEEN FORMULATED.

ON BOARD RADAR IMAGE PROCESSOR

OA

B



NASA HQ RE76-1168 (1)
11-12-75

EARTH-ORIENTED APPLICATIONS, AS DEFINED BY THE OUTLOOK FOR SPACE THEMES, REPRESENT THE DRIVER FOR THE DATA PROCESSING AREA. MAJOR ADVANCES IN NASA'S ABILITY TO PROVIDE COST-EFFECTIVE MASS REDUCTION OF SPACE DATA ARE NEEDED TO ALLOW AUTOMATED ASSESSMENT OF EARTH LOOKING IMAGERY IN ORDER TO SUPPORT PRODUCTION AND MANAGEMENT OF FOOD AND FORESTRY RESOURCES, PREDICTION AND PROJECTION OF THE ENVIRONMENT, AND PROTECTION OF LIFE AND PROPERTY. KEY RELATED TECHNOLOGY THRUSTS ADDRESS THE DEVELOPMENT OF HIGH-SPEED AUTOMATED FEATURE RECOGNITION CAPABILITIES TO YIELD VASTLY IMPROVED ONBOARD AND GROUND DATA REDUCTION. SUCH ACTIVITIES ARE DIRECTED AT ATTAINING ORDERS-OF-MAGNITUDE COST SAVINGS IN DATA MANAGEMENT AND OPERATIONAL SOFTWARE GENERATION AND VERIFICATION FOR NASA'S MISSIONS. INCREASED PROCESSING SPEED AND AUTOMATION, TOGETHER WITH HEAVY EMPHASIS ON ONBOARD DATA REDUCTION, WILL ALLOW NEAR-REAL-TIME DELIVERY OF REDUCED DATA TO THE USER AT MUCH LOWER COST THAN IS CURRENTLY FEASIBLE, AND CAN OPEN THE DOOR TO PRACTICAL OPERATIONAL APPLICATION OF SPACE TO MAN'S NEEDS.

6. DATA PROCESSING

Technical Area	Title	OFS Theme
a. Methods and Technique Development	Recognition Processing of Image Data on the Ground and Onboard Spacecraft	013 Land Use and Environmental Assessment 031 Local Weather and Severe Storm 140 New Automated Data Analysis and Management
	Onboard Processing of Multispectral Scanner Data	011 Global Crop Production 025 Water Quality 150 More Efficient Low Cost Transfer of Systems to Space
b. Software Systems and Management	Modular Architecture for Data Processing & Transfer Systems	052 Intercontinental Communications 150 More Efficient Low Cost Transfer of Systems to Space
	Software Management & Standards	150 More Efficient Low Cost Transfer of Systems to Space 012 Water Availability 021 Large Scale Weather 033 Hazard Warning
	Software Generation and Human-Machine Interaction	013 Land Use and Environmental Assessment 066 Man Living and Working in Space

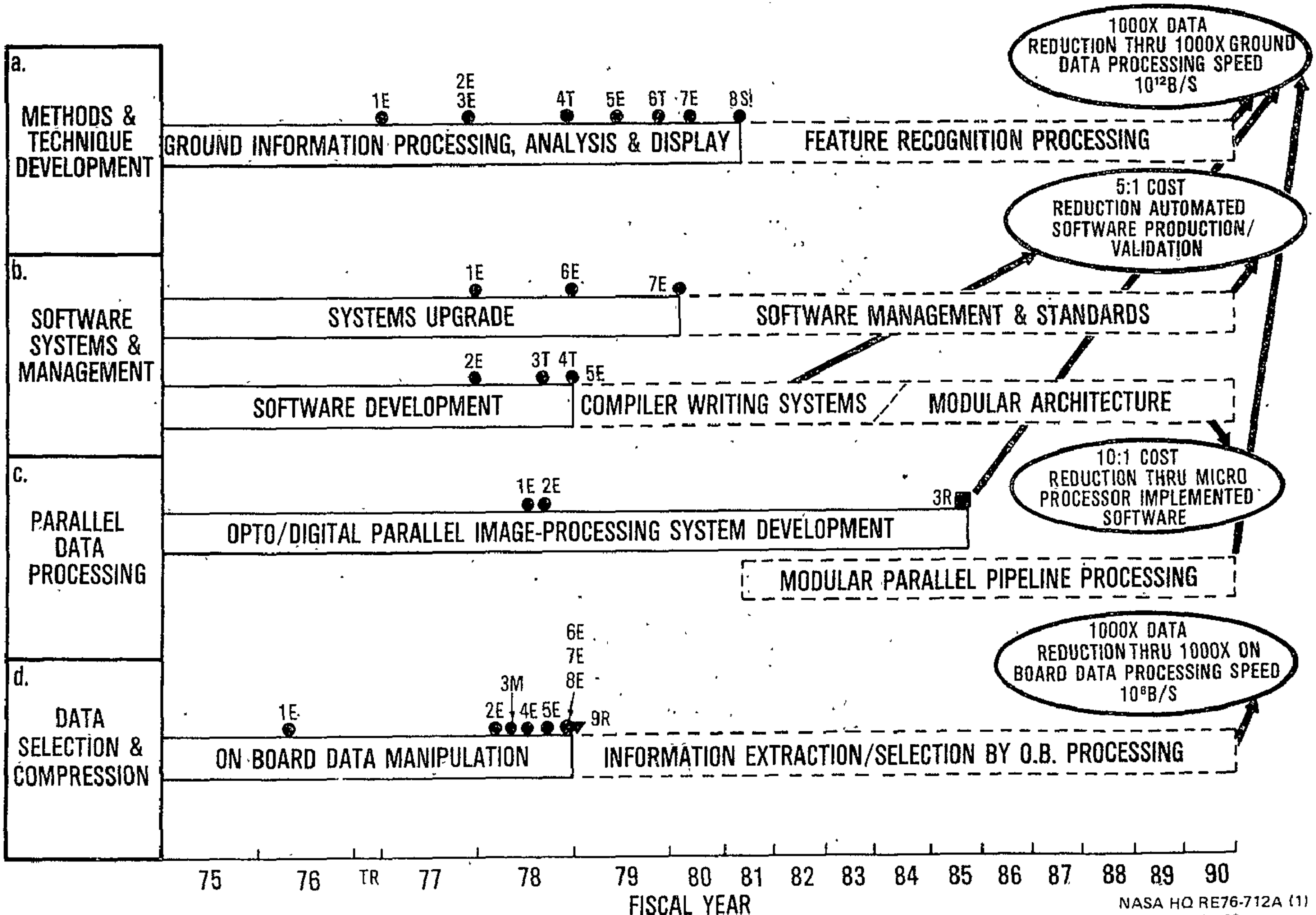
6. DATA PROCESSING (Cont.)

Technical Area	Title	OFS Theme
b. Software Systems and Management (Continued)	Vision Enhancement and Assistance for Teleoperator Control Systems	013 Land Use and Environmental Assessment 066 Man Living and Working in Space
c. Parallel Data Processing	Modular Parallel Pipe Line Processor	016 Range Land Assessment 021 Large Scale Weather 150 More Efficient Low Cost Transfer of Systems to Space
d. Data Selection and Compression	Information Extraction and Data Compression	140 New Automated Data Analysis and Management Systems 011 Global Crop Production 026 Global Marine Weather

THIS ROADMAP HAS BEEN EXTENDED TO INCLUDE THOSE TECHNOLOGIES WHICH MUST BE DEVELOPED TO MEET FUTURE NASA MISSION GOALS.

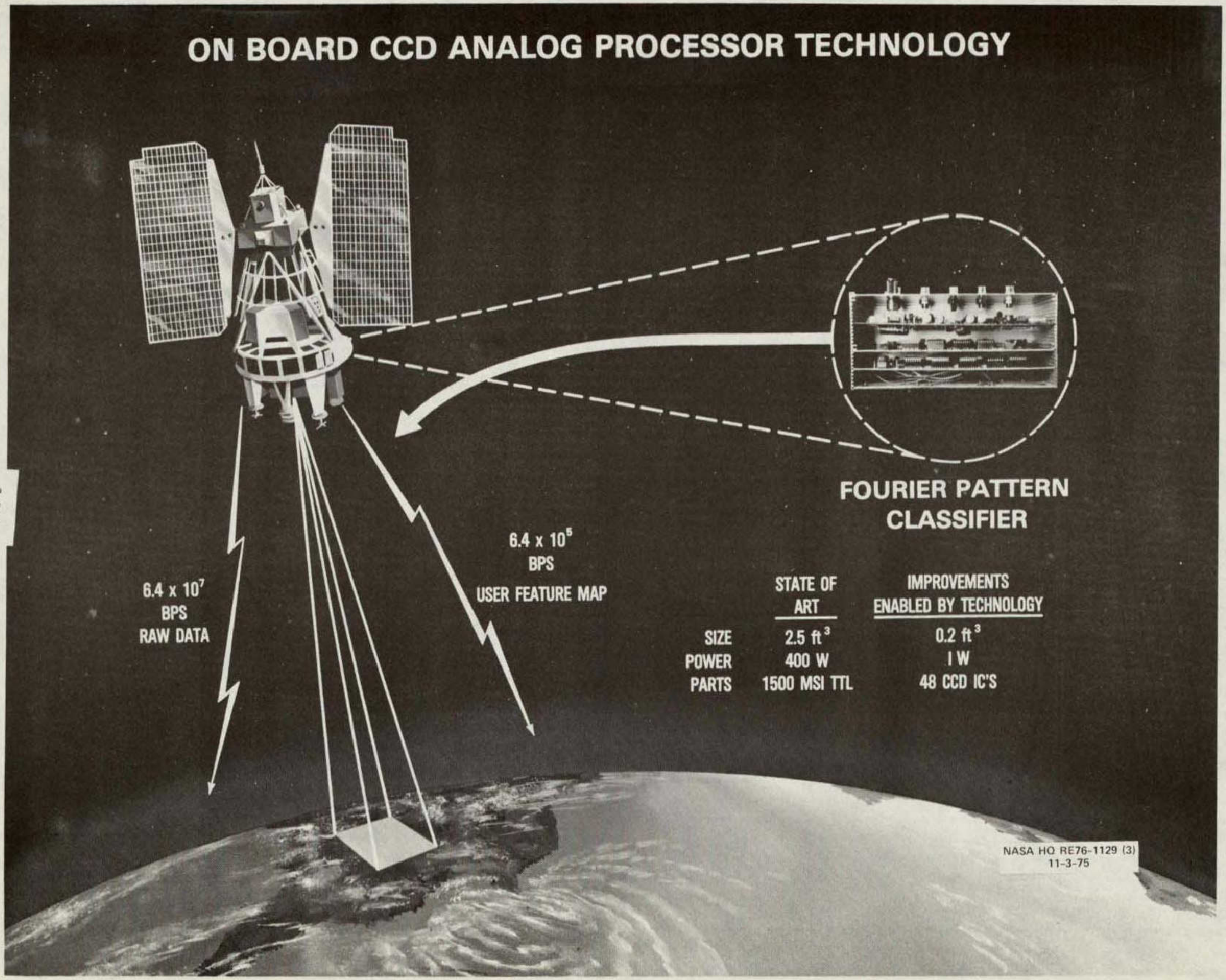
DATA PROCESSING IS THE KEY TO THE MAJOR BREAKTHROUGHS IN DATA REDUCTION NEEDED FOR FUTURE MISSIONS IN TERMS OF GROUND BASED AND ONBOARD FEATURE RECOGNITION PROCESSING, AND DATA SELECTION TECHNIQUES. NASA ANTICIPATED MISSION NEEDS ARE PROJECTED TO REQUIRE A 1000 X INCREASE IN DATA REDUCTION CAPABILITY WITHIN THE NEXT 15 YEARS. MAJOR ADVANCES IN BOTH ONBOARD DATA REDUCTION AND GROUND DATA HANDLING, WHICH INCREASE PROCESSING SPEED BY A FACTOR OF 1000, ARE NEEDED TO PROVIDE FUTURE USERS WITH NEAR-REAL-TIME INFORMATION AND TO ACCOMMODATE THE MASSIVE DATA FLOOD PROJECTED FOR THE SHUTTLE ERA. LOOKING AT THE OTHER MAJOR THRUSTS IN THE DATA PROCESSING AREA - TRANSFERABILITY OF SOFTWARE PROGRAMS CAN REDUCE SOFTWARE MISSION COST 5 TO 1 BY THE USE OF SOFTWARE STANDARDS, COMPILER WRITING SYSTEMS WHICH PROVIDE AUTOMATED SOFTWARE WRITING, AND VALIDATION AND THE USE OF STRUCTURED PROGRAMMING TECHNIQUES. COST REDUCTION BY A FACTOR OF 10 CAN BE ACCOMPLISHED BY GROUND BASED AND ONBOARD MICROPROCESSOR IMPLEMENTED SOFTWARE.

6. DATA PROCESSING



NASA HQ RE76-712A (1)
2-17-76

ONE KEY ELEMENT OF THE GOAL TO IMPROVE NASA'S DATA REDUCTION CAPABILITIES BY A FACTOR OF 1000 INVOLVES WORK ON IMPROVED ONBOARD PROCESSING SPEED THROUGH THE USE OF CCD ANALOG PROCESSOR TECHNOLOGY. THE FOURIER PATTERN CLASSIFIER SHOWN HERE, DEMONSTRATES HOW RAW DATA CAN BE MANIPULATED TO EXTRACT ONLY SPECIFIC SURFACE FEATURES FROM THE TOTAL DATA SET. EARLY EXPERIMENTS HAVE SHOWN THAT AN INPUT RATE OF 6.4×10^7 BPS CAN BE REDUCED BY A FACTOR OF 100 (TO 6.4×10^5 BPS) AND CAN DELIVER THE PROCESSED INFORMATION TO THE USER AS A FEATURE MAP IN NEAR REAL-TIME. TECHNOLOGIES LIKE THESE REPRESENT A MAJOR STEP TOWARDS QUANTUM JUMPS IN NASA DATA HANDLING CAPABILITIES.


ON BOARD CCD ANALOG PROCESSOR TECHNOLOGY
FOURIER PATTERN CLASSIFIER
6.4 x 10^5 BPS USER FEATURE MAP
6.4 x 10^7 BPS RAW DATA
STATE OF ART
IMPROVEMENTS ENABLED BY TECHNOLOGY
SIZE 2.5 ft^3 0.2 ft^3
POWER 400 W 1 W
PARTS 1500 MSI TTL 48 CCD IC'S
NASA HQ RE76-1129 (3) 11-3-75

THE DATA STORAGE ROADMAP DEPICTING THE ONGOING NASA ACTIVITIES IS DIVIDED INTO THREE TECHNICAL AREAS OF:

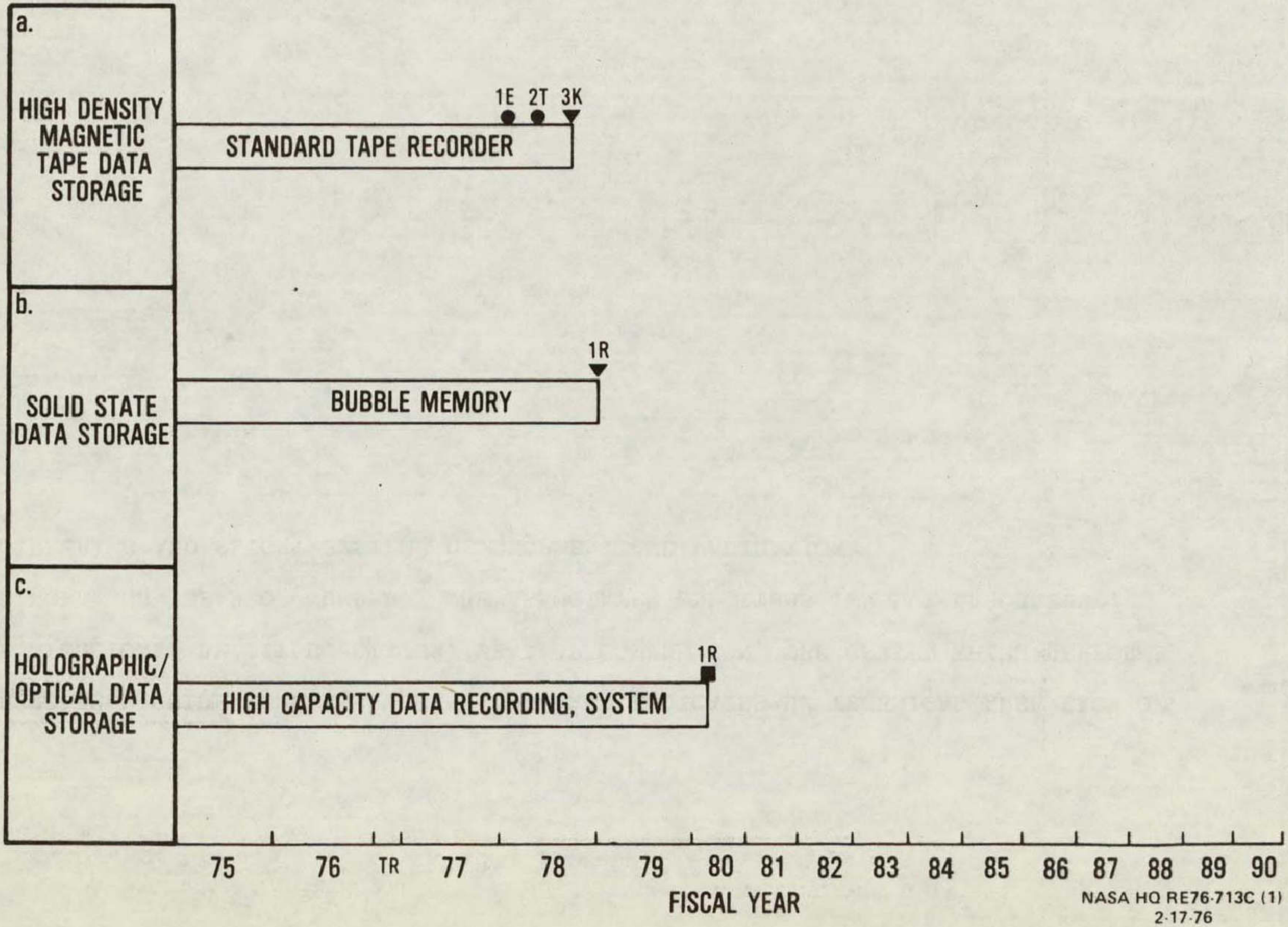
(a) HIGH DENSITY MAGNETIC TAPE DATA STORAGE WHICH INCLUDES THE NASA STANDARD TAPE RECORDER AND STORAGE SYSTEMS STUDIES.

(b) SOLID STATE DATA STORAGE IN WHICH THE BUBBLE DOMAIN MEMORIES OR STORAGE ELEMENTS ARE DEVELOPED.

(c) HOLOGRAPHIC/OPTICAL DATA STORAGE WHICH DEALS WITH A HIGH CAPACITY WRITE AND READ SYSTEM.

EXISTING EFFORTS ARE SUPPORTED BY OA, OAST, LCSO AND OTDA AND FOCUS ON GREATER DATA STORAGE CAPACITIES, HIGHER ACCESS SPEEDS, AND GREATER RELIABILITY.

7. DATA STORAGE



NASA HQ RE76-713C (1)
2-17-76

THE ROADMAP GUIDE EXPLAINS THE ROADMAP AND INDICATES BY TECHNICAL AREA EACH OF THE MILESTONES BY TITLE, STATUS, YEAR OF COMPLETION, THE CENTER WHICH PERFORMS THE WORK AND THE RTOP NUMBER. THE ASSOCIATED END ITEMS INVOLVE LABORATORY, ENGINEERING AND FLIGHT SYSTEMS DEVELOPMENT AND VALIDATION.

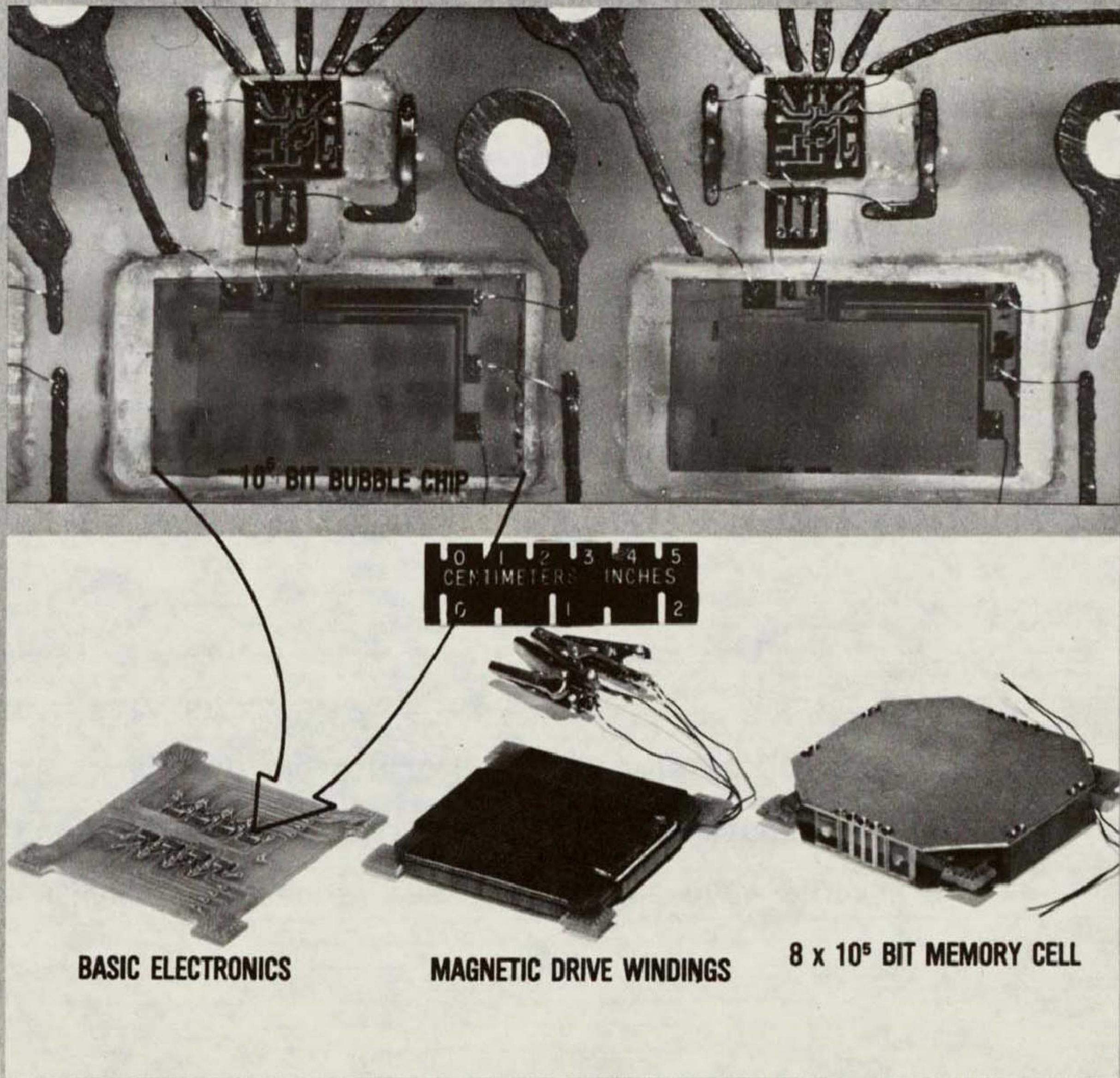
ROADMAP GUIDE

7. DATA STORAGE

Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
a. Magnetic Tape	1E	High Density Tape Recording Techniques	O	78	JSC	656-11-03
	2T	Storage Systems Studies	O	78	GSFC	310-40-44
	3K	Standard Tape Recorder	∇	78	GSFC	SE
b. Solid State Data Storage	1R	Solid State Data Recorder	∇	78	LaRC	520-71-01
c. Holographic/ Optical Data Storage	1R	High Capacity Systems	□	85	MSFC	506-20-13

IN THE TECHNICAL AREA OF SOLID STATE DATA STORAGE, LARC UNDER RTOP 520-21-01, IS DEVELOPING A SOLID STATE DATA STORAGE SYSTEM FOR SPACECRAFT APPLICATION. AS ILLUSTRATED IN THE FIGURE, THIS RECORDER IS BUILT AROUND BASIC ELECTRONIC BUILDING BLOCKS OF 10^5 BIT BUBBLE MEMORY CHIPS WHICH ARE ASSEMBLED INTO AT LEAST AN 8×10^5 BIT MEMORY CELL. WRITING AND READING OF DATA IS DIGITAL (ELECTRONIC) WHILE ACCESS TO THE MEMORY IS CONTROLLED MAGNETICALLY. THIS TECHNOLOGY PROVIDES A HIGHLY RELIABLE ONBOARD RECORDER AND PLAY-BACK STORAGE SYSTEM.

SOLID STATE DATA STORAGE



NASA HQ RE76-878(3)
10-23-75

ONLY ONE ACTION ITEM WAS DEVELOPED IN THE CATEGORY OF DATA STORAGE DURING THE JOINT PROGRAM REVIEW. THE ACTION IS LISTED ON THE FIGURE, RELATES TO MILESTONE 7c1R ON THE ROADMAP, AND CONCERNS THE STATUS OF RESEARCH ON MATERIALS FOR OPTICAL DATA STORAGE.

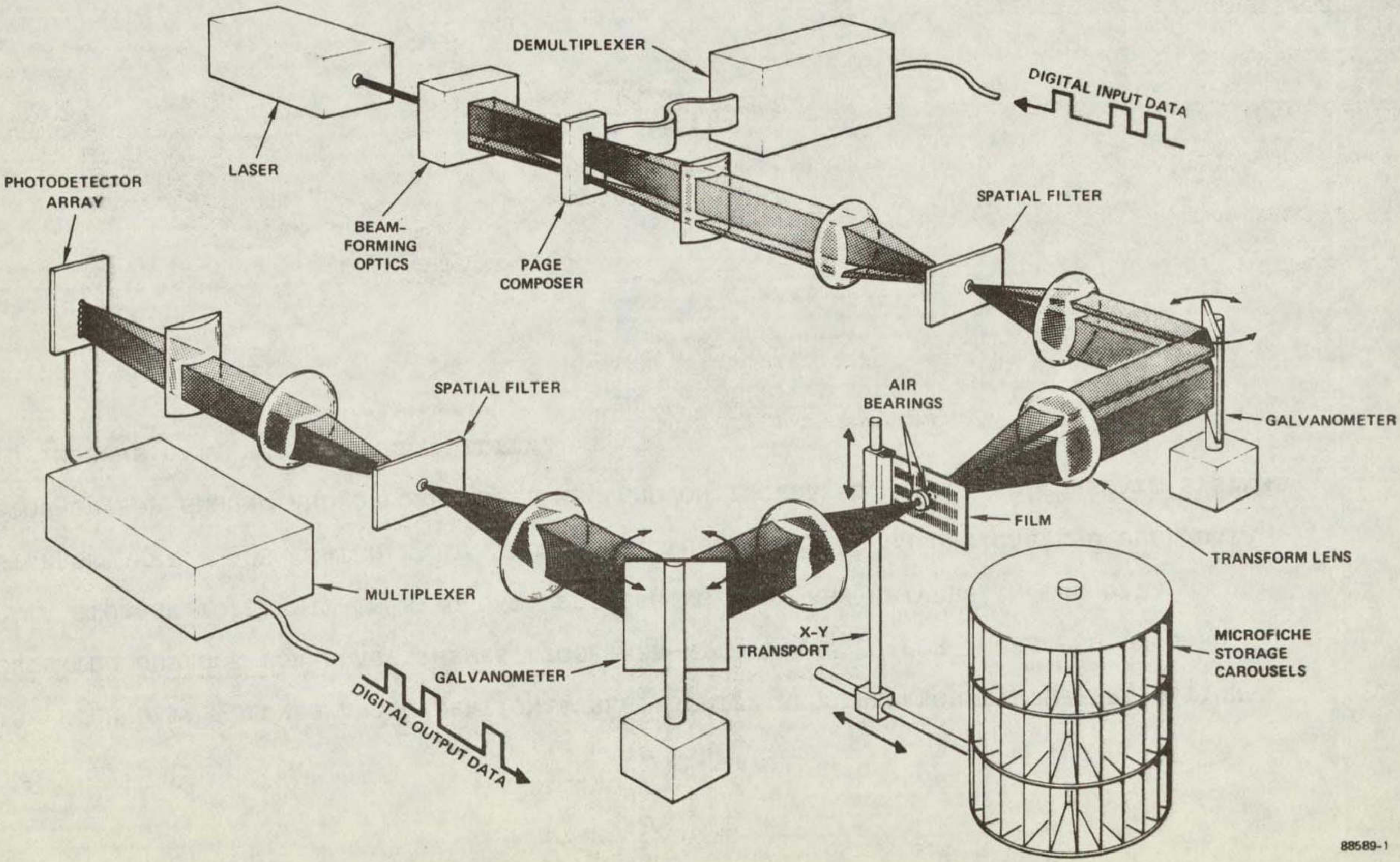
ACTION ITEMS

7. DATA STORAGE

Title	Action	Participants	Associated Milestones
Optical Mass Memory	Report status & nature of optical phase storage materials research at DoD-ARPA & LaRC	MSFC/DoD-ARPA/LaRC	7c1R

THE ACTION ITEM ON MATERIALS FOR OPTICAL DATA STORAGE DERIVES FROM A CURRENT LIMITING TECHNICAL PROBLEM IN THAT TECHNOLOGY. AS INDICATED IN THE ILLUSTRATION, OPTICAL SYSTEMS TECHNOLOGY NECESSARY TO READ AND WRITE DATA IN AN OPTICAL STORAGE SYSTEM HAS BEEN CONCEPTUALLY DEVELOPED AND DEMONSTRATED. REALIZATION OF THE FULL POTENTIAL OF OPTICAL DATA STORAGE IS INHIBITED, HOWEVER, BY LIMITATIONS ON THE STORAGE DENSITY OF AVAILABLE MATERIALS SO THAT MECHANICAL COMPONENTS MUST BE ADDED TO ACHIEVE TOTAL STORAGE CAPABILITIES COMMENSURATE WITH PROJECTED MISSION NEEDS. MATERIALS CAPABLE OF THREE DIMENSIONAL STORAGE COULD ALLEVIATE THIS PROBLEM AND ARE THEORETICALLY FEASIBLE. SEVERAL EFFORTS HAVE BEEN INITIATED TO DEVELOP SUCH MATERIALS. THE ACTION ITEM WAS TO PREPARE A STATUS REPORT ON THESE ACTIVITIES. THE REPORT, COMPLETED IN LATE SEPTEMBER, INDICATED NONE OF THE EFFORTS HAD BEEN COMPLETELY SUCCESSFUL AND THAT FUNDAMENTAL MATERIAL STUDIES WERE NEEDED TO OVERCOME THIS LIMITATION.

NASA HOLOGRAPHIC MEMORY SYSTEM



THE HIGH DATA VOLUMES AND OPERATIONAL RELIABILITY REQUIRED FOR EARTH-APPLICATION-ORIENTED OUTLOOK FOR SPACE THEMES, TOGETHER WITH THE NEED FOR INCREASED ONBOARD DATA STORAGE TO PERMIT IN SITU DATA PROCESSING, ARE KEY DRIVERS IN THE DATA STORAGE AREA. ASSOCIATED MAJOR TECHNOLOGY THRUSTS FOCUS ON OPTICAL AND BULK DATA STORAGE FOR GROUND AND ONBOARD SYSTEMS, AND ON INCREASED USE OF SOLID-STATE SYSTEMS TO IMPROVE DATA STORAGE RELIABILITY.

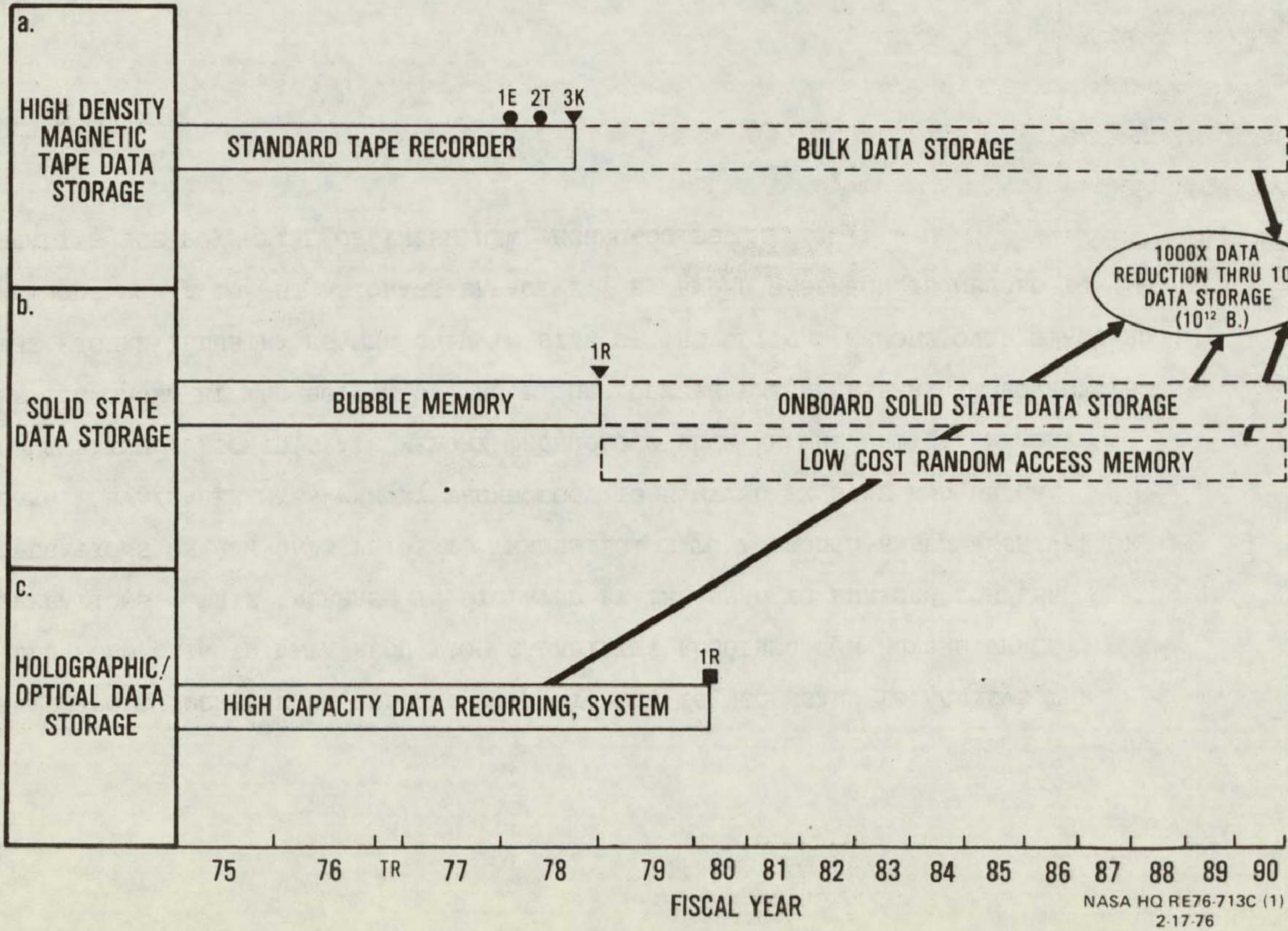
TECHNOLOGY THRUSTS

7. DATA STORAGE

Technical Area	Title	OFS Theme	
a. High Density Magnetic Tape Data Storage	Bulk Data Storage for Spacecraft (10^{12} or larger)	025	Global Marine Weather
		033	Hazard Warning
		073	Ocean Interior and Dynamics
b. Solid State Data Storage	On Board Solid State Data Storage Systems	011	Global Crop Production
		023	Climate
		034	Communication - Navigation
		052	Intercontinental Communications
		150	More Efficient Low-Cost Transfer of Systems to Space
	Low Cost Random Acess Memory	013	Land Use and Environmental Assessment
		053	Personal Communications Satellite
c. Holographic/Optical Data Storage	Mass Memory For Processing Acquired Data	140	New Automated Data Analysis and Management Systems
		011	Global Crop Production
		073	Ocean Interior & Dynamics
		034	Communication - Navigation

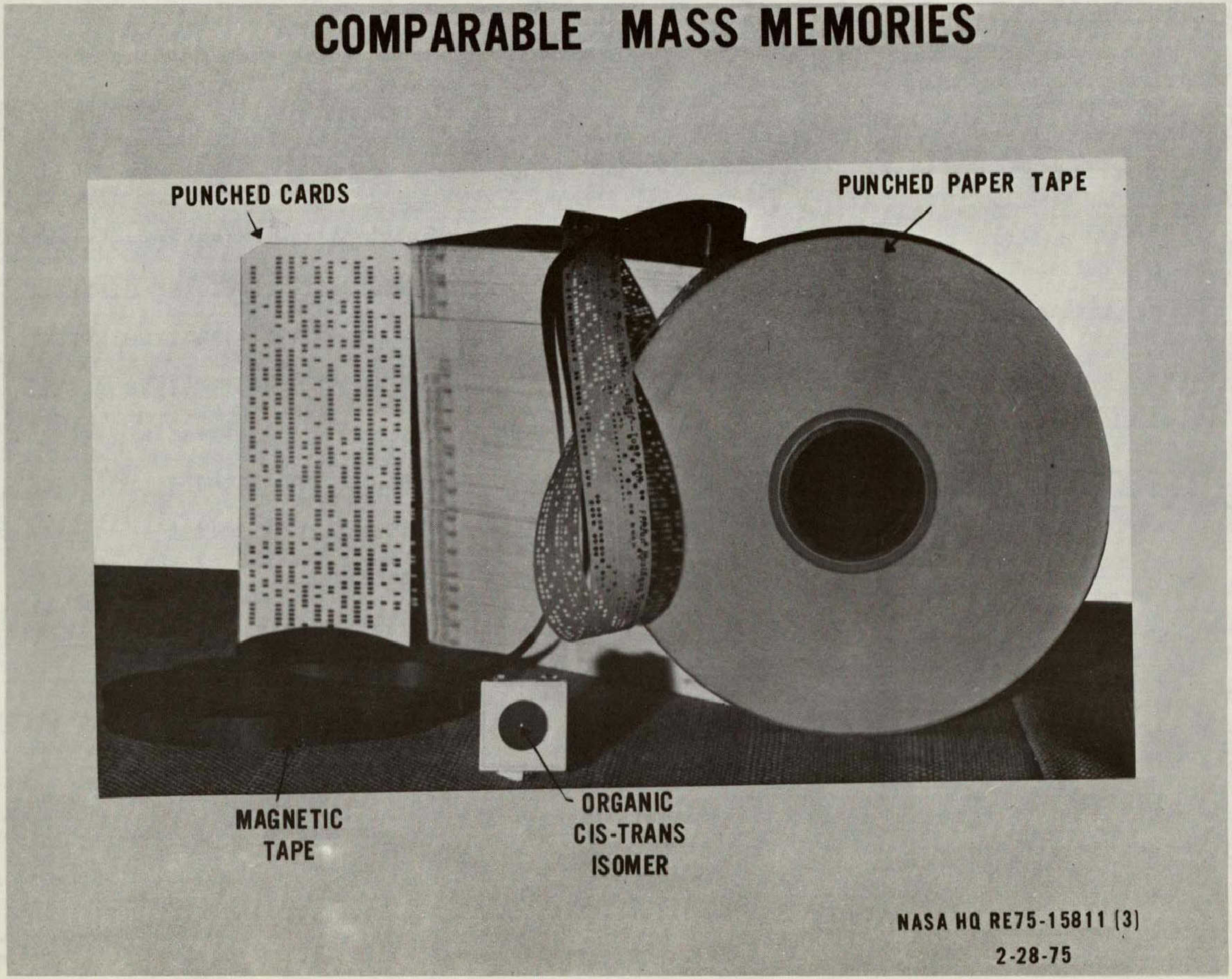
THIS ROADMAP HAS BEEN EXTENDED, TO SHOW WITHIN THE DASHED BARS, THOSE TECHNOLOGIES WHICH MUST BE DEVELOPED BY 1990 TO ADVANCE THE STATE-OF-THE-ART TO MEET NASA MISSION GOALS. A TEN-FOLD IMPROVEMENT IN DATA STORAGE CAPABILITY, COUPLED WITH SIGNIFICANT ADVANCES IN DATA STORAGE SYSTEM LIFETIME, ARE NEEDED TO PROVIDE AN OVERALL INCREASE IN DATA REDUCTION CAPABILITY BY A FACTOR OF 1000.

7. DATA STORAGE



NASA HQ RE76-713C (1)
2-17-76

A TEN-FOLD INCREASE IN ONBOARD DATA STORAGE IS NECESSARY TO ACHIEVE THE 1000-FOLD GAIN IN DATA REDUCTION CAPABILITY REQUIRED FOR FUTURE SPACE OPERATIONS. THIS INCREASE IS DICTATED BY THE NEED TO PERFORM COMPLEX OPERATIONS ON RAW DATA PRIOR TO TRANSMISSION TO A GROUND-BASED RECEIVER OR USER. AVAILABLE MASS MEMORY TECHNOLOGY IS LIMITED BY SIZE AND WEIGHT CONSTRAINTS. SOLID STATE MEMORY TECHNOLOGY SUCH AS THE OPTICAL MEMORY DEVICE SHOWN AT THE BOTTOM OF THE FIGURE OFFERS THE NECESSARY IMPROVEMENTS. THE FIGURE ILLUSTRATES THE GAIN IN SIZE OF THE OPTICAL MEMORY OVER STANDARD METHODS FOR A 10^5 BIT STORAGE CAPACITY. EXTENDED RESEARCH IS NEEDED TO REALIZE THE POTENTIAL OF THESE NEW TECHNOLOGIES.


COMPARABLE MASS MEMORIES
PUNCHED CARDS
PUNCHED PAPER TAPE
MAGNETIC TAPE
ORGANIC CIS-TRANS ISOMER
NASA HQ RE75-15811 (3)
2-28-75

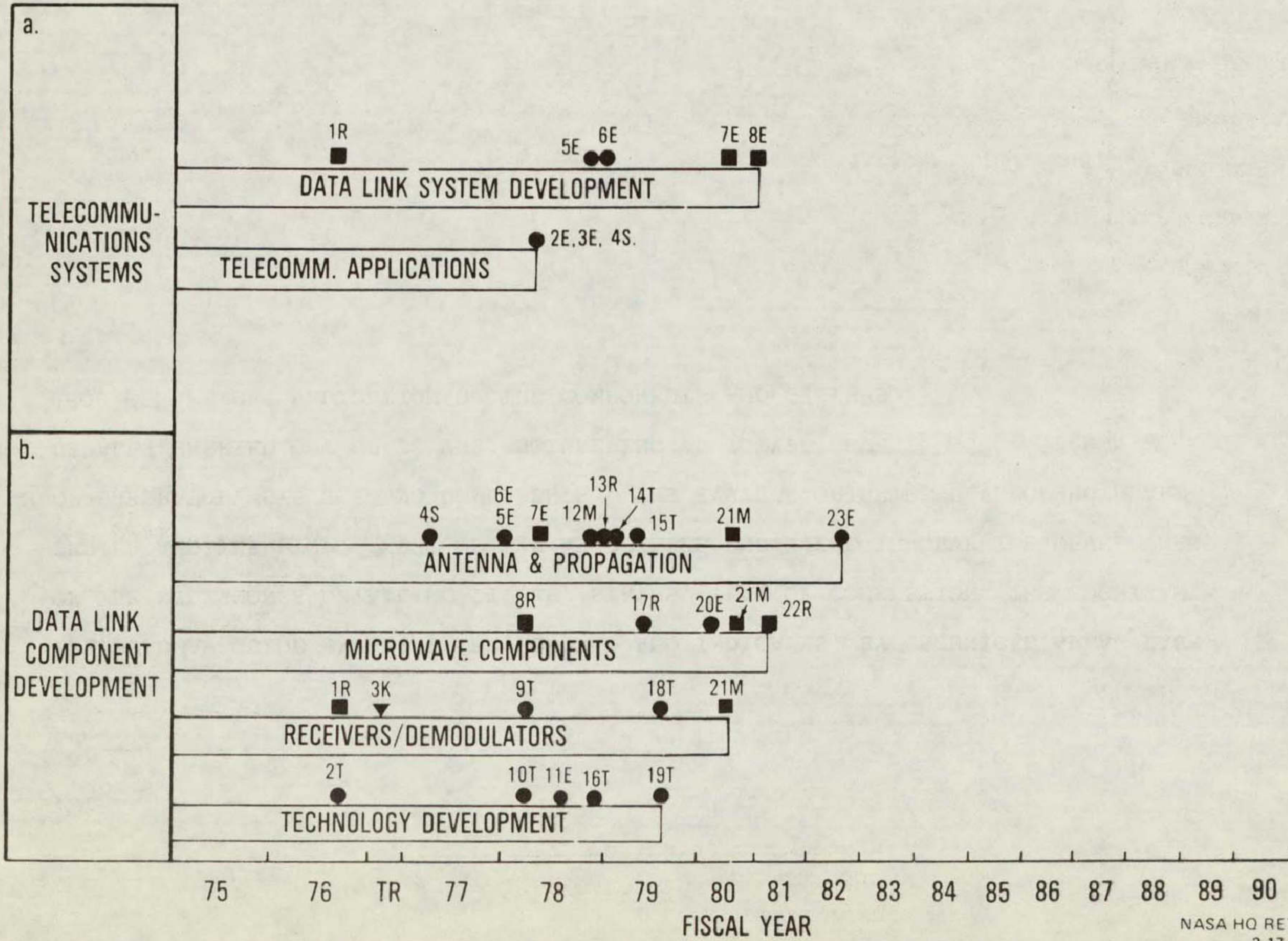
THE DATA TRANSFER ROADMAP LISTING THE ONGOING NASA ACTIVITIES, IS DIVIDED INTO TWO TECHNICAL AREAS:

(a) TELECOMMUNICATION SYSTEMS ADDRESSING THE DEVELOPMENT OF DATA LINKS AND THEIR APPLICATIONS.

(b) DATA LINK COMPONENT DEVELOPMENT DEALING WITH ANTENNAS, TRANSPONDERS, SOLID STATE AMPLIFIERS, RECEIVERS AND DIGITAL RADIO SYSTEMS IN SUPPORT OF HIGHER DATA TRANSMISSION RATES AND LOWER SYSTEM COSTS.

THIS WORK IS SPONSORED BY OA, OAST, LCSO, OTDA AND OSS AND IS FOCUSSED ON COMMUNICATIONS SYSTEMS FROM SPACE VEHICLE TO VEHICLE AND TO GROUND. EMPHASIS IS PLACED ON HIGHLY RELIABLE SYSTEMS AND COMPONENTS AND THE INCREASING NEED FOR HIGHER DATA RATES.

8. DATA TRANSFER



NASA HQ RE76-714C (1)
2-17-76

THE ROADMAP GUIDE EXPLAINS THE ROADMAP AND INDICATES, BY TECHNICAL AREA, EACH OF THE MILESTONES DETAILING TITLES, STATUS, YEAR OF COMPLETION, THE COGNIZANT CENTER AND THE RTOP. MOST OF THE ASSOCIATED END ITEMS INVOLVE THE DEVELOPMENT OF LABORATORY SYSTEMS AND COMPONENTS. THE SYSTEMS ORIENTED DEVELOPMENTS ARE USUALLY CARRIED OUT UP TO THE ENGINEERING PROTOTYPE LEVEL. SOME ANTENNA WORK REQUIRES FLIGHT VALIDATION OF THE COMPONENTS AND SYSTEMS.

ROADMAP GUIDE

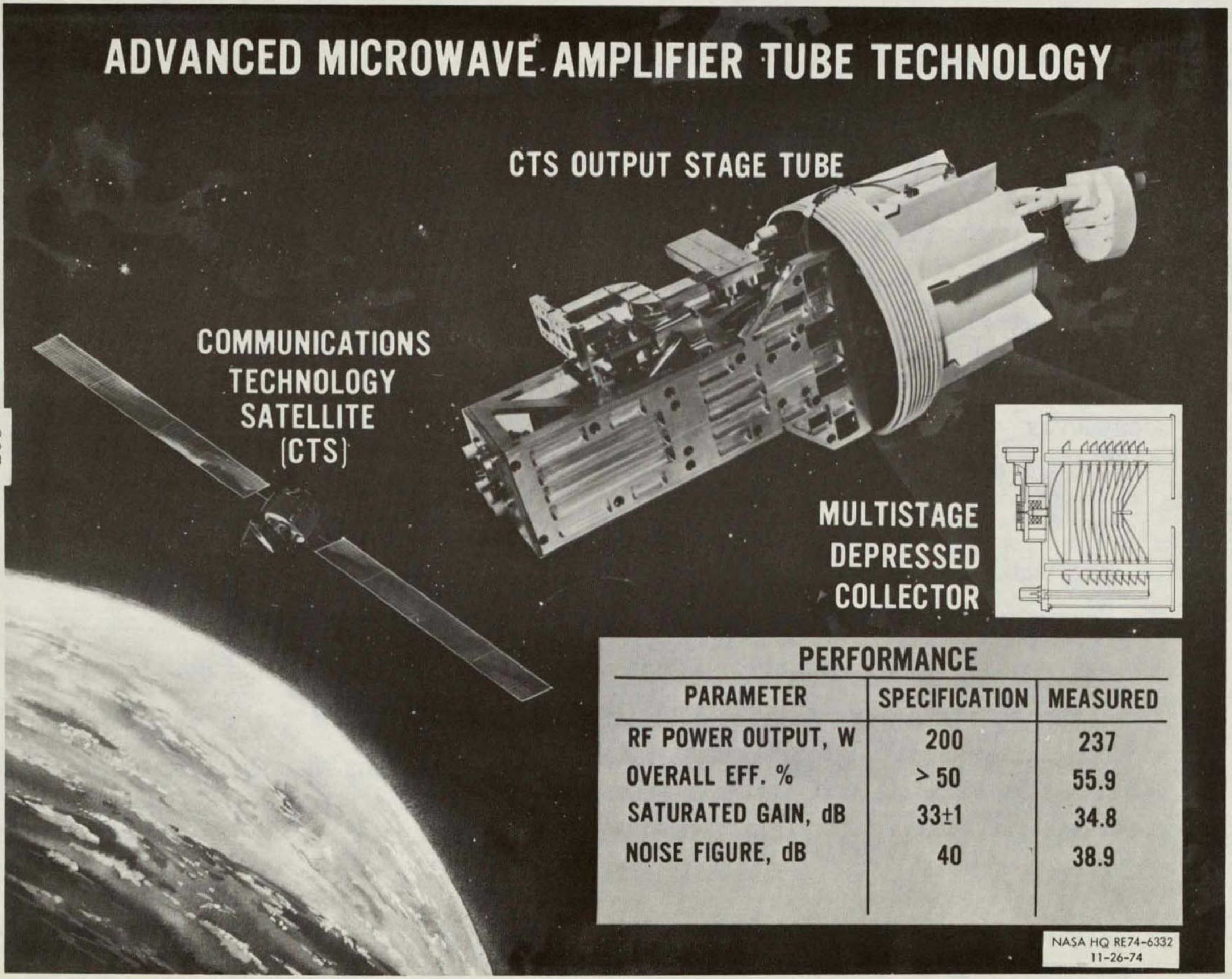
8. DATA TRANSFER

a. Technical Area	Mile-Stone #		Status	FY	Center	RTOP #
Telecommunication Systems	1R	High Data Rate Transfer and Tracking Technology	□	77	GSFC	506-20-32
	2E	Communications as a Substitute for Transportation	0	78	HQ	650-10-01
	3E	Remote Neighborhood Office Center Concept	0	78	HQ	650-10-02
	4S	Outer Planet Probe Telecommunications	0	78	ARC	186-68-75
	5E	Computer Based Management Information System	0	79	JPL	650-10-10
	6E	Advanced Communications Support	0	79	HQ	650-10-12
	7E	Bandwidth Experiment	□	79	JPL	645-23-03
	8E	Data Link Technology Development	▽	80	GSFC	650-60-11
b. Data Link Component Development	1R	Microminiature S/X Band Transponder Development	□	76	JPL	506-20-21
	2T	TDRSS Technology Development	0	76	GSFC	310-20-20
	3K	Standard Spacecraft Transponder	□	77	JPL	SE
	4S	Lightweight S-Band Antenna System	▽	77	GSFC	180-24-14
	5E	Antenna Research	0	78	JPL	650-10-11
	6E	Propagation Research	0	78	JPL	650-60-13
	7E	Large Erectable Antenna	▽	78	LaRC	638-10-00-01
	8R	Microwave Components & Techniques	□	78	JPL	506-20-22
	9T	High Data Rate Receiver/Demodulator for EOS, TDRSS and Shuttle	○	78	GSFC	310-30-24
	10T	Digital Systems Development	□	78	JPL	310-20-67
	11E	Modulation Techniques	0	78	JPL	650-10-10
	12M	Electronically Steerable Phased Array Antenna Systems	0	79	MSFC	909-54-07
	13R	Antenna Structures	0	79	JPL	506-17-15
	14T	Antenna Systems Development	0	79	JPL	310-20-65
	15T	Ground Antenna for Wideband Data Transmission System	0	79	GSFC	310-20-31
	16T	High Reliability Control System for Antennas	0	79	GSFC	310-20-32
	17R	Microwave Power Amplifier & Low Noise Preamplifier Development	0	79	GSFC	506-20-24

8. DATA TRANSFER (Cont.)

	Technical Area	Mile-Stone #	Title	Status/FY		Center	RTOP #
b.	Data Link Component Development (Continued)	18T	Development of S-Band and K-Band Spacecraft Antenna, Transponder, Transmitters and Receivers	0	79	GSFC	310-20-46
		19T	Radio Systems Development	0	79	JPL	310-20-66
		20E	Far IR Maser	0	79	GSFC	650-60-12
		21M	Space Systems Communications	□	79	JSC	909-44-07
		22R	Microwave Amplifier Technology	□	80	LeRC	506-20-23
		23E	Antenna Shuttle Experiment	0	82	JPL	645-25-02

THE MILESTONE 8b22R REPRESENTS RTOP 506-20-23 AND SHOWS THAT LERC IS ADVANCING STATE-OF-THE-ART MICROWAVE POWER AMPLIFICATION TASKS FOR SPACE AND TERRESTRIAL APPLICATIONS. PROGRAM EMPHASIS IS ON HIGH FREQUENCIES AND GREATER EFFICIENCY. A TRAVELLING WAVE TUBE OF THIS TYPE WILL BE FLOWN ON THE COMMUNICATIONS TECHNOLOGY SATELLITE IN FY 76. THE EMPHASIS OF THIS WORK IS ON HIGHER POWER LEVELS AT DECREASING WAVELENGTH, WHICH SIMPLIFIES ANTENNA DESIGN, AND PERMITS WIDEBAND/HIGH RATE DATA TRANSMISSION.



PARAMETER	SPECIFICATION	MEASURED
RF POWER OUTPUT, W	200	237
OVERALL EFF. %	> 50	55.9
SATURATED GAIN, dB	33±1	34.8
NOISE FIGURE, dB	40	38.9

ACTION ITEMS GENERATED BY THE JOINT ELECTRONICS PROGRAM REVIEW, RELATED TO THE TWO TECHNICAL AREAS OF DATA TRANSFER, ARE LISTED. THE TITLE OF THE ACTION, A DESCRIPTION, THE PARTICIPANTS AND THE APPLICABLE MILESTONES ARE CITED. THE EMPHASIS ON THE 1ST AND 7TH ITEMS IS ON IMPROVED COORDINATION BETWEEN CENTERS, AND BETWEEN CENTERS AND THE USAF, RESPECTIVELY. THE 2ND AND 5TH ACTION ITEMS DEAL WITH THE STANDARD TRANSPONDER DEVELOPMENT. THE DEVELOPMENT OF THE STANDARD TRANSPONDER IS TO BE REVIEWED NOT ONLY FROM A PROGRAMMATIC POINT OF VIEW, BUT ALSO TO ESTABLISH THE VIABILITY OF STANDARDS IN NETWORK OPERATION. THE 3RD ACTION ITEM HAS INITIATED THE PLANNING OF THE DEVELOPMENT OF A NASA STANDARD COMMAND DETECTOR. THE 4TH ACTION ITEM RESULTED IN IDENTIFICATION OF A POSSIBLE, LOW-COST SHUTTLE EXPERIMENT TO EVALUATE CRITICAL HIGH-DATA-RATE LASER COMMUNICATION LINK ELEMENTS.

ACTION ITEMS

8. DATA TRANSFER

Title	Action	Participants	Associated Milestones
Optical Transmission of TV Signals	Establish inter-Center coordination & liaison for fiber-optic data link technology development	JPL/JSC OAST, OSF	8b21M, 5a6R
Mission Operations Low Cost Study	Review and coordinate study effort to insure viability of standards in network operation	JPL LCSO, OTDA & OAST	8b3K, 8b1R, 8b10T
Standard Command Detector	Develop objectives, plan and schedule for development of a Standard Command Detector	JPL LCSO, OTDA, OAST	8b3K, 8b1R, 8b10T
Laser Communications	Define technology validation experiment of High Data Rate Laser Communication Link	GSFC OA, OAST, OTDA	8a1R, 8a8E
Standard Spacecraft Transponder	Define objectives & planned programs of the Standard Spacecraft Transponder	JPL/GSFC OSS, LCSO, OTDA & OAST	8b3K, 8b1R, 8b10T
Large Unfurlable Antenna Experiments	Provide experiment overview of Shuttle and AAFE planned activities	JPL/LaRC OA, OAST	8b7E
NASA/USAF TWT Program	Develop roadmap for NASA TWT work and USAF inputs and requirements	LeRC/USAF OAST	8b22R

THE STANDARD TRANSPONDER PROVIDES AN EXAMPLE OF THE ACTION ITEMS ARISING IN THE DATA TRANSFER DISCIPLINE CATEGORY. THE FIGURE ILLUSTRATES THE EVOLUTION OF THE STANDARD TRANSPONDER FROM A BASIC TECHNOLOGY DEVELOPMENT PROGRAM TO A MULTIAPPLICATION STANDARD FOR THE AGENCY. BECAUSE OF ITS MANY APPLICATIONS AND MULTIPLE SPONSORS, A JOINT PROGRAM PLAN WAS CONSIDERED ESSENTIAL. SEVERAL VERSIONS OF THE DESIRED PLAN HAVE BEEN DEVELOPED AND REVIEWED. CHANGES WERE NEEDED AS THE MISSION APPLICATIONS INCREASED. AT THIS TIME, THE STANDARD TRANSPONDER DEVELOPMENT PLAN IS BEING REVISED TO INCORPORATE TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS) REQUIREMENTS SO THAT IT CAN SERVE AS A STANDARD COMPONENT FOR SPACECRAFT INTERFACING WITH THE TDRSS.

323-40-02 506-20-21 186-68-53	NASA STANDARD TRANSPONDER (NST) PROGRAM

LCSO-OAST-OSS HQ

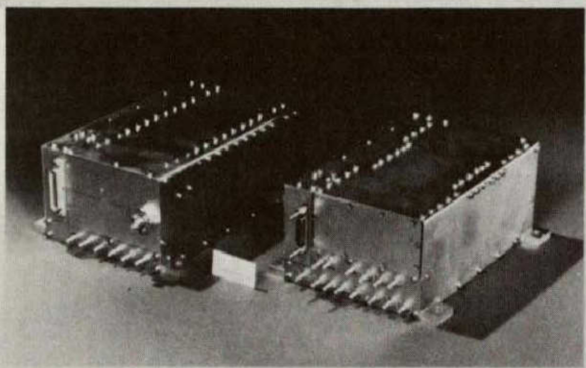
JPL
D. L. DAKAN
213/354-3835

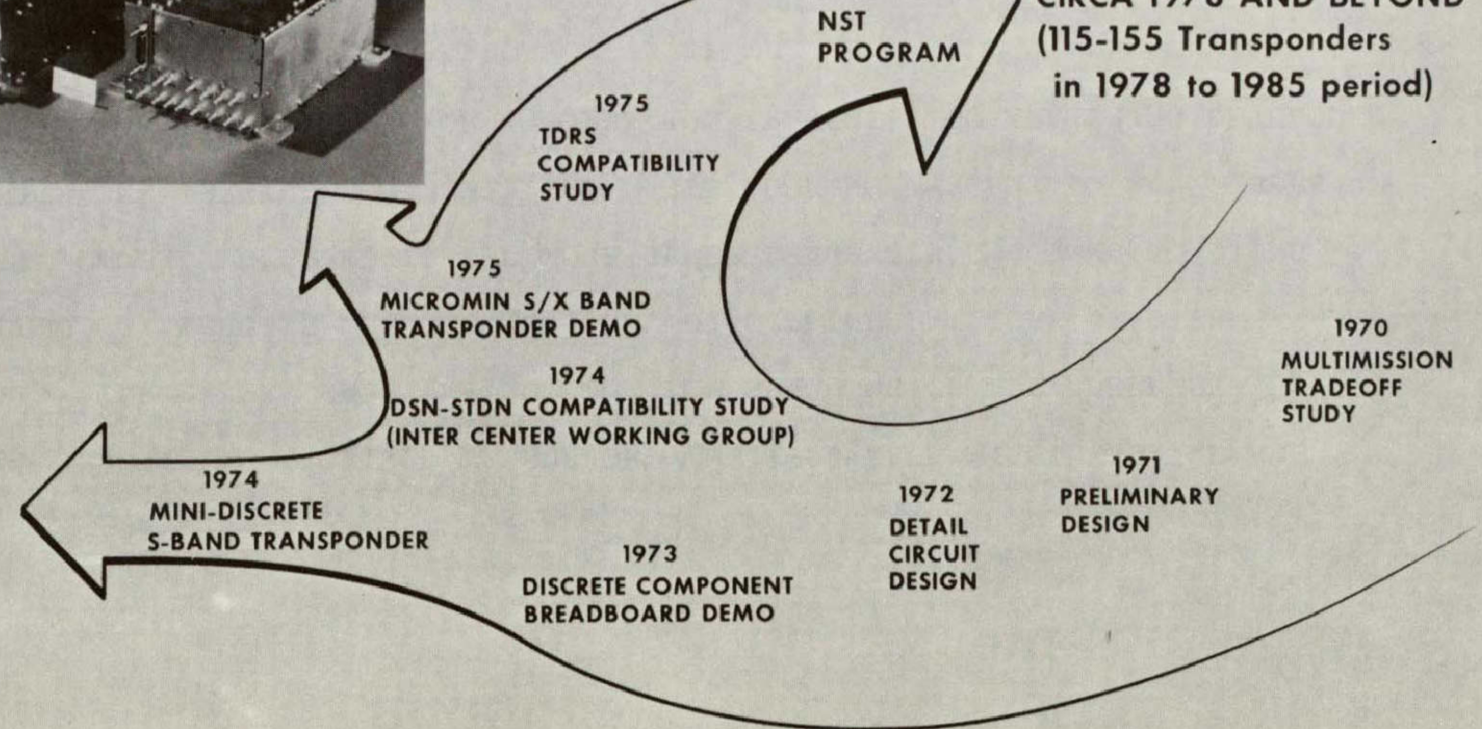
E

LCSO
L. RICHARDS
202/755-8323

OAST
H. ALSBERG
202/755-3227

OSS
P. TARVER
202/755-3770





TECHNOLOGY THRUSTS AS REQUIRED TO SUPPORT THE 1990 NASA MISSION GOALS ARE SHOWN HERE. THE THEMES FROM THE OUTLOOK FOR SPACE WHICH ARE ADDRESSED BY THESE TECHNOLOGY THRUSTS ARE LISTED. THE DISCIPLINE CATEGORY OF DATA TRANSFER IS CLOSELY RELATED TO THE MORE GENERAL ASPECTS OF COMMUNICATIONS SYSTEMS WITH ONE TERMINAL TRANSMITTING EARTH LOOKING IMAGERY TO MANY USERS ON THE GROUND. VARIOUS METHODS FOR INFORMATION TRANSMISSION ARE BEING DEVELOPED TO HELP SUPPORT PREDICTION AND PROJECTION OF THE ENVIRONMENT, PRODUCTION AND MANAGEMENT OF FOOD AND FORESTRY RESOURCES, AND PROTECTION OF LIFE AND PROPERTY. THE TECHNOLOGICAL THRUSTS OF DATA TRANSFER ARE FOCUSED ON VASTLY IMPROVED DATA DISTRIBUTION; INCREASED NEAR-REAL-TIME INFORMATION AVAILABILITY; END-TO-END SYSTEMS WHICH DELIVER MORE INFORMATION TO MORE USERS IN NEAR-REAL-TIME, AND GLOBAL SYSTEMS WHICH OPTIMIZE OVERALL DATA DISTRIBUTION COST AND ALLOW WIDE-SCALE APPLICATION OF LOW-COST USER TERMINALS.

TECHNOLOGY THRUSTS

8. DATA TRANSFER

Technical Area	Title	OFS Theme
a. Telecommunication Systems	Global Systems Architecture	150 More Efficient Low Cost Transfer Systems to Space
		011 Global Crop Production
		021 Large Scale Weather
		034 Communications - Navigation
		044 World Geologic Atlas
		052 Intercontinental Communications
	End to End Systems Integration	073 Ocean Interior & Dynamics
		012 Water Availability
		021 Stratospheric Changes & Effects
		031 Local Weather and Severe Storms
		053 Personal Communications Satellite
		150 More Efficient Low-Cost Transfer Systems to Space
	Communications	026 Global Marine Weather
		033 Hazard Warnings
		051 Domestic Communications
	Spectrum Monitoring Technology	125 Can We Detect Extraterrestrial Intelligent Life?
		140 New Automated Data Analysis and Management System

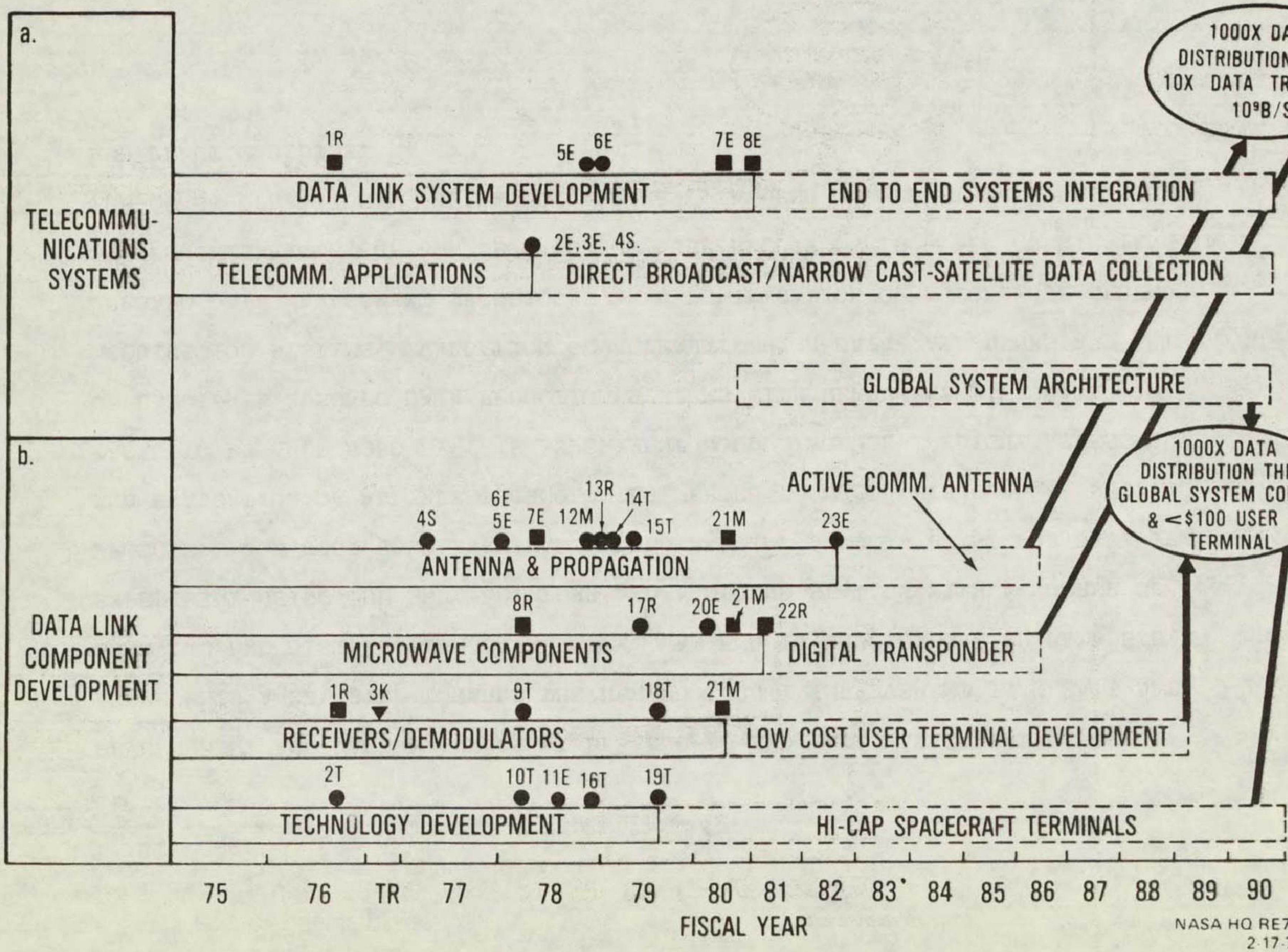
TECHNOLOGY THRUSTS

8. DATA TRANSFER (Cont)

Technical Area	Title	OFS Theme	
a. Telecommunication Systems (cont.)	Networking for NASA Computer Facility & Software Sharing	021	Large Scale Weather
		032	Trapospheric Pollutants
		051	Domestic Communications
		140	New Automated Analysis & Management Systems
b. Data Link Component Development	Modular Microwave Communications Active Antenna	150	More Efficient Low-Cost Data Transfer of Systems to Space
	Digital Transponders	050	Personal Communications Satellite
		034	Communication - Navigation
		150	More Efficient Low-Cost Transfer of Systems to Space
	Low Cost User Terminal Development	015	Timber Inventory
		021	Large Scale Weather
		033	Hazard Warning
		051	Domestic Communications
	High Capacity Spacecraft Terminals	013	Land Use and Environmental Assessment
		026	Global Marine Weather
		034	Communication - Navigation
		150	More Efficient Low Cost Transfer of Systems to Space
	Laser & Millimeter Wave Data Transfer	021	Large Scale Weather
		150	More Efficient Low-Cost Transfer of Systems to Space

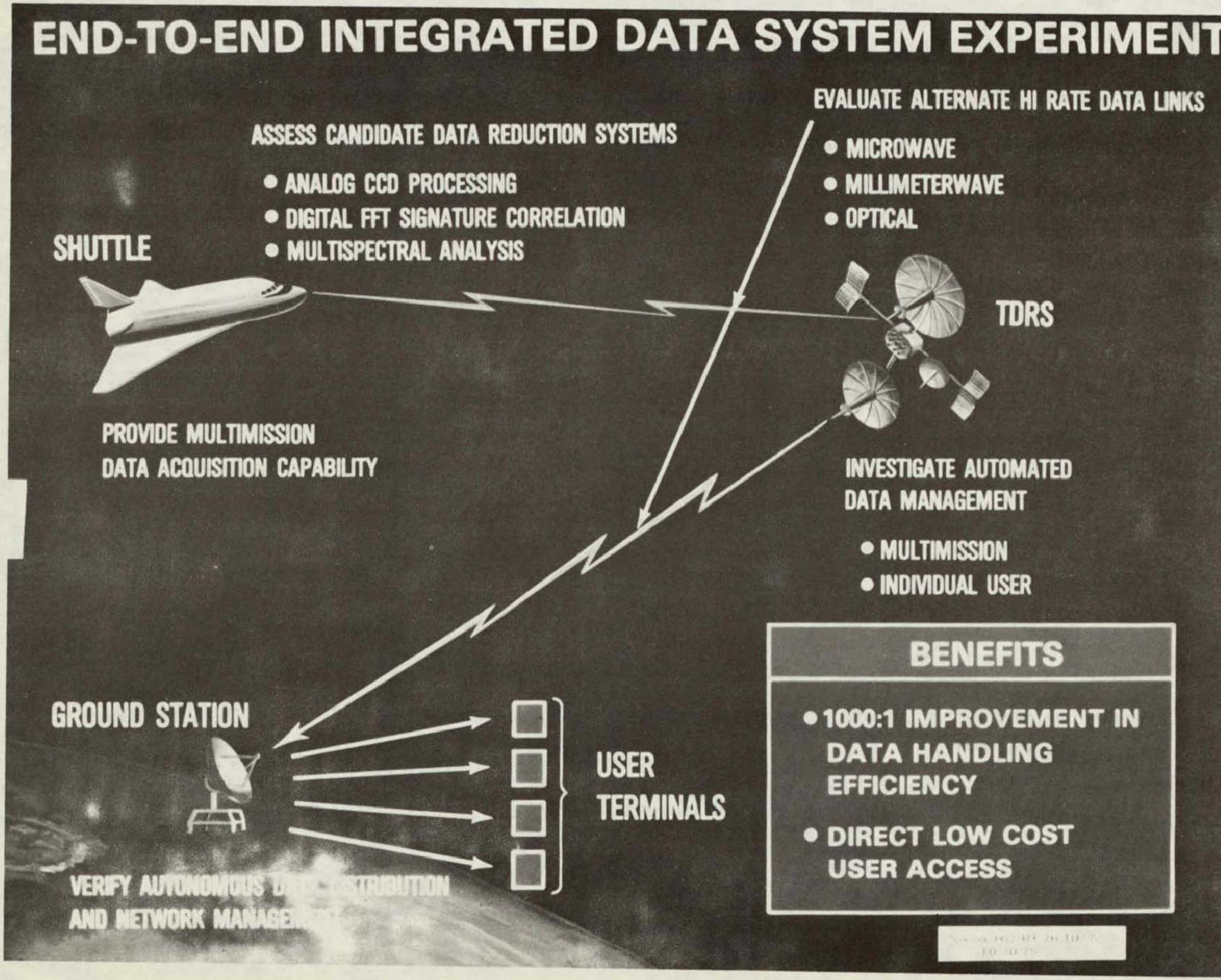
THIS ROADMAP HAS BEEN EXTENDED TO INCLUDE THOSE TECHNOLOGIES WHICH MUST BE DEVELOPED TO MEET FUTURE NASA MISSION GOALS. A QUANTUM JUMP IN THE ABILITY TO DISTRIBUTE DATA TO USERS THROUGH VASTLY IMPROVED DATA TRANSFER AND THE RIGHT KIND OF SYSTEMS CONFIGURATION IS NEEDED. ACHIEVEMENT OF THIS THOUSAND-FOLD DATA DISTRIBUTION CAPABILITY INVOLVES BOTH A LIMITED INCREASE (10X) IN DATA TRANSFER RATES TO HANDLE ANTICIPATED QUICK-LOOK AND HIGH-DATA-LOAD REQUIREMENTS AND A FUNDAMENTAL CHANGE IN THE WAY FUTURE DATA TRANSFER SYSTEMS ARE CONFIGURED. PRACTICAL MASS EVALUATION AND DISTRIBUTION OF NASA'S DATA APPEARS FEASIBLE BY PERFORMING HIGH-COST FUNCTIONS, SUCH AS DATA REDUCTION AND DISTRIBUTION, ON THE SPACECRAFT AND DEVELOPING VERY LOW-COST, SOLID-STATE USER TERMINALS (< $100 EACH) WHICH DIRECTLY INTERFACE WITH THESE FUNCTIONS.

8. DATA TRANSFER

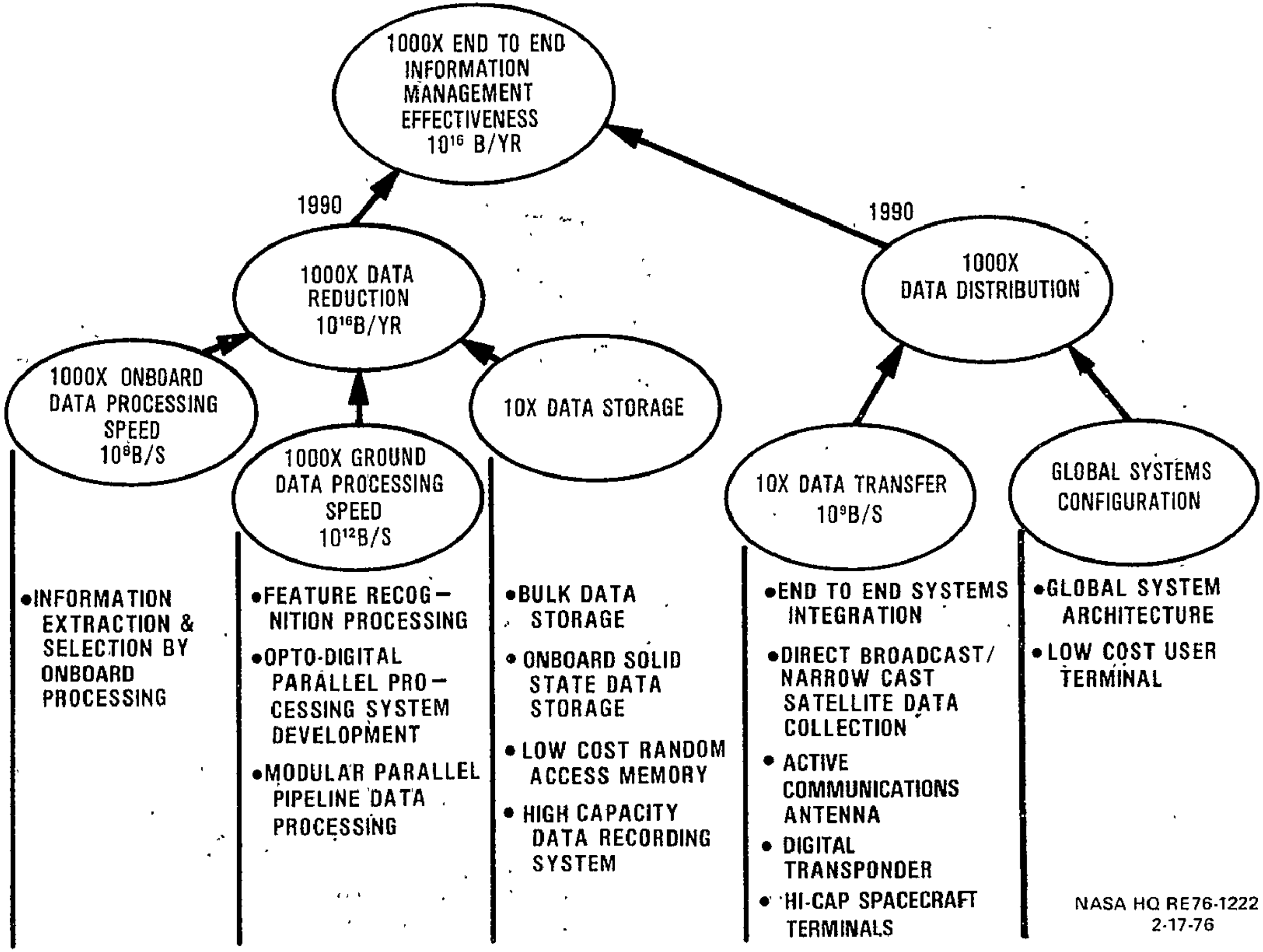


NASA HQ RE76-714C (1)
2-17-76

DEVELOPMENT AND VALIDATION OF VIABLE END-TO-END DATA MANAGEMENT CONCEPTS REPRESENTS A KEY STEP TOWARDS THE NEEDED 1000:1 IMPROVEMENT IN NASA'S DATA HANDLING AND DISTRIBUTION CAPABILITY. AN END-TO-END INTEGRATED DATA SYSTEM EXPERIMENT USING THE SHUTTLE, TDRS AND A GROUND STATION WITH A NUMBER OF PROTOTYPE LOW-COST USER TERMINALS WOULD PROVIDE A FOCAL POINT FOR DEVELOPMENT AND EVALUATION OF ALL KEY TECHNOLOGIES NEEDED TO MEET THIS GOAL. SPECIFIC TASKS TO BE ADDRESSED BY THIS EXPERIMENT WOULD INCLUDE INFLIGHT ASSESSMENT OF CANDIDATE ONBOARD DATA REDUCTION SYSTEMS WITH REPRESENTATIVE DATA ACQUISITION SYSTEMS, EVALUATION OF ALTERNATE HIGH-DATA-RATE LINKS AND AUTOMATED ONBOARD DATA MANAGEMENT TECHNIQUES, AND VERIFICATION OF AUTONOMOUS GROUND SYSTEM INTERFACES FOR A WIDE RANGE OF USER REQUIREMENTS - ALL CULMINATING IN THE QUASI-OPERATIONAL VALIDATION OF THE TOTAL END-TO-END SYSTEM FEASIBILITY AND PRACTICABILITY.


END-TO-END INTEGRATED DATA SYSTEM EXPERIMENT
ASSESS CANDIDATE DATA REDUCTION SYSTEMS
• ANALOG CCD PROCESSING
• DIGITAL FFT SIGNATURE CORRELATION
• MULTISPECTRAL ANALYSIS
EVALUATE ALTERNATE HI RATE DATA LINKS
• MICROWAVE
• MILLIMETERWAVE
• OPTICAL
SHUTTLE
TDRS
PROVIDE MULTIMISSION
DATA ACQUISITION CAPABILITY
INVESTIGATE AUTOMATED
DATA MANAGEMENT
• MULTIMISSION
• INDIVIDUAL USER
BENEFITS
• 1000:1 IMPROVEMENT IN DATA HANDLING EFFICIENCY
• DIRECT LOW COST USER ACCESS
GROUND STATION
USER
TERMINALS
VERIFY AUTONOMOUS
AND NETWORK

CURRENT ESTIMATES INDICATE NASA PROGRAMS AND MISSIONS ARE PRODUCING DATA AT A RATE OF ABOUT 10^{15} BITS PER YEAR AND THAT THIS PRODUCTION WILL INCREASE BY A FACTOR OF TEN OVER THE NEXT 10-15 YEARS. OTHER ESTIMATES INDICATE THAT ONLY ABOUT ONE PERCENT OF THAT DATA OR 10^{13} BITS PER YEAR IS CURRENTLY BEING REDUCED TO USEFUL INFORMATION. A MAJOR THRUST OF THE DATA PROCESSING, STORAGE AND TRANSFER DISCIPLINE IS TO ELIMINATE THIS BOTTLENECK IN THE FLOW OF DATA FROM THE SENSOR TO THE USER. MAJOR PROGRAM GOALS ARE TO ACHIEVE A 1000-FOLD INCREASE IN DATA REDUCTION CAPABILITY BY 1990 BY INCREASING ONBOARD DATA STORAGE CAPACITY AT LEAST 10 TIMES, BY INCREASING GROUND DATA PROCESSING SPEED 1000 TIMES THROUGH PARALLEL PROCESSING TECHNIQUES AND ADVANCED SCENE INTERPRETATION ALGORITHMS, AND BY INCREASING ONBOARD DATA PROCESSING SPEED 1000 TIMES THROUGH ADVANCED DATA EXTRACTION AND SELECTION TECHNIQUES. COMPLEMENTARY TO THE INCREASED DATA REDUCTION CAPABILITY IS THE GOAL OF INCREASING DATA DISTRIBUTION CAPABILITY A 1000-FOLD BY 1990 THROUGH THE USE OF GLOBAL SYSTEM CONFIGURATIONS AND A TEN-FOLD INCREASE IN DATA TRANSFER CAPABILITY USING HIGHER FREQUENCIES, ACTIVE ANTENNA SYSTEMS AND DIRECT BROADCAST TO USER TERMINALS. SUCCESS IN THESE ACTIVITIES SHOULD PERMIT A 1000-FOLD INCREASE IN END-TO-END INFORMATION MANAGEMENT EFFECTIVENESS BY 1990 AND MEET THE DEMANDS OF FUTURE MISSIONS.



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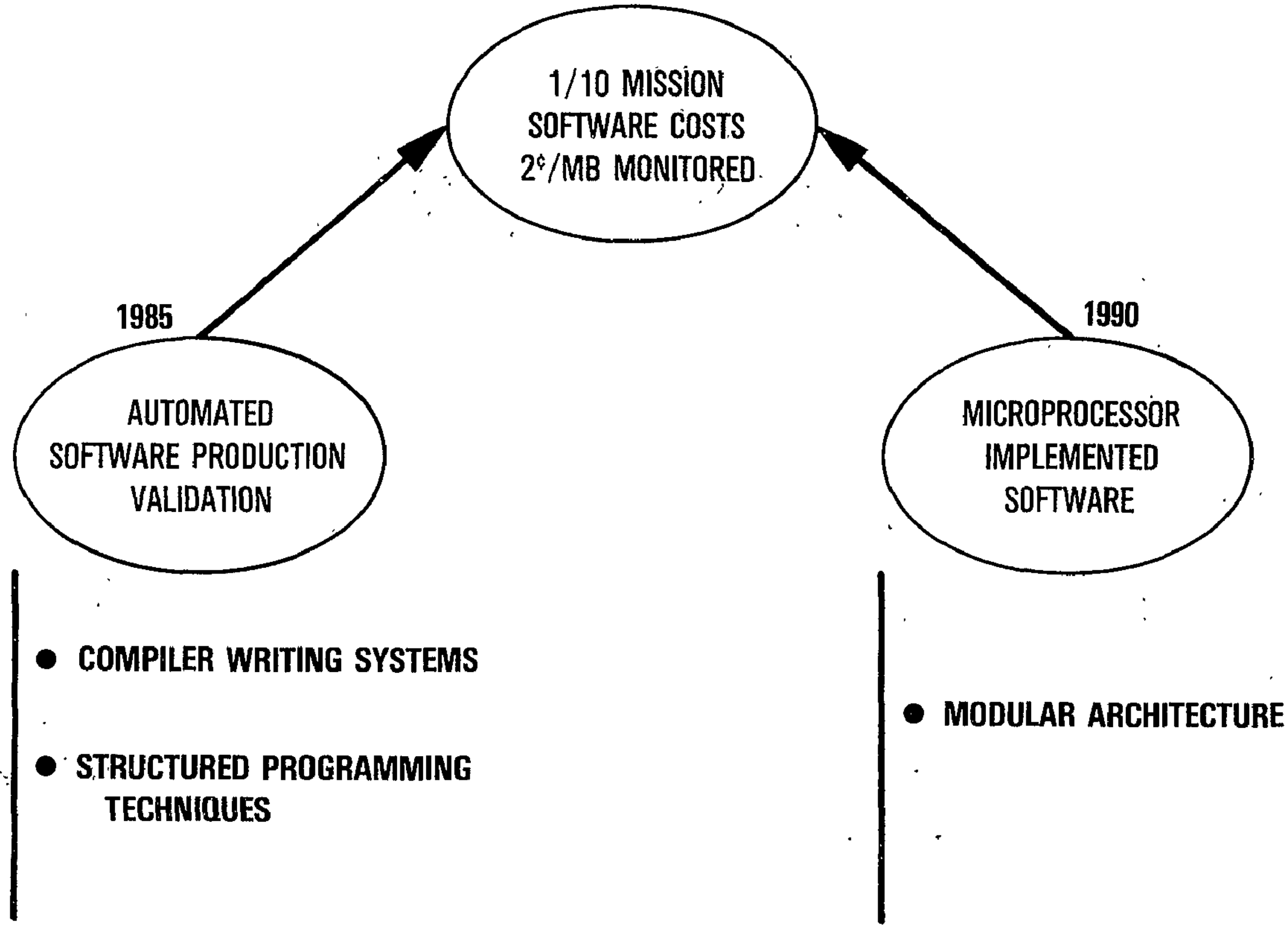
REDUCED MISSION COSTS CAN BE FACILITATED WITH APPROPRIATE EMPHASIS ON THE REDUCTION OF SOFTWARE COSTS. TWO OF THE PROGRAM GOALS IN THIS DISCIPLINE ARE AIMED TOWARD THAT OBJECTIVE. DEVELOPMENT OF STRUCTURED PROGRAMMING TECHNIQUES AND GENERALIZED COMPILER WRITING SYSTEMS TECHNOLOGY WILL LEAD TO AN AUTOMATED SOFTWARE PRODUCTION AND VALIDATION CAPABILITY BY 1985. MODULAR APPROACHES TO DATA SYSTEM ARCHITECTURE WILL INSURE THE USE OF MICROPROCESSOR IMPLEMENTED SOFTWARE BY 1990. SUCCESS IN ACHIEVING THESE GOALS SHOULD RESULT IN A REDUCTION IN MISSION SOFTWARE COSTS FROM THE CURRENT ESTIMATE OF ABOUT 20 CENTS PER MEGABIT OF INFORMATION TO 2 CENTS PER MEGABIT.



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REVIEW OF THE DATA PROCESSING, STORAGE AND TRANSFER DISCIPLINE INDICATED THIS TECHNICAL AREA IS REASONABLY WELL-BALANCED BETWEEN THE EXPLORATION OF NEW TECHNOLOGIES AND THE DEVELOPMENT OF SUPPORTING TECHNOLOGY FOR PLANNED OR PROPOSED MISSIONS. THE AREAS OF DATA PROCESSING, DATA DISTRIBUTION AND SOFTWARE RESEARCH WERE WEAK IN RELATION TO THEIR IMPORTANCE TO NASA CAPABILITIES AND SHOULD BE EMPHASIZED IN FUTURE ACTIVITIES. MORE EFFORT IN STANDARDS, BOTH HARDWARE AND SOFTWARE, TOGETHER WITH GLOBAL SYSTEM APPROACHES TO THE PROBLEM OF DATA MANAGEMENT ARE NEEDED TO ENHANCE NASA CAPABILITIES AND REDUCE MISSION COSTS.

MODULAR SYSTEMS, INCREASED USE OF LSI TECHNOLOGY, MORE EMPHASIS ON HARDWARE VERSUS SOFTWARE IN SYSTEM IMPLEMENTATIONS, AND A GREATER USE OF ONBOARD PROCESSING REPRESENT THE TRENDS IN THIS DISCIPLINE.

SUMMARY

DATA PROCESSING, STORAGE AND TRANSFER

1. BALANCED PROGRAM WITH LITTLE OVERLAP BETWEEN CENTERS
2. PROGRAM WEAKNESSES:
   - SOFTWARE SYSTEMS AND MANAGEMENT
   - ONBOARD DATA PROCESSING
   - DATA DISTRIBUTION
3. FUTURE THRUSTS:
   - REDUCTION OF MISSION SOFTWARE COSTS
   - INCREASED DATA REDUCTION CAPABILITIES
   - INCREASED NEAR-REAL-TIME DATA DISTRIBUTION
   - STANDARDIZATION OF SOFTWARE AND HARDWARE
   - GLOBAL SYSTEMS CONFIGURATION
4. TRENDS ARE TOWARD:
   - INCREASED UTILIZATION OF LARGE SCALE INTEGRATION (LSI)
   - HARDWARE RATHER THAN SOFTWARE IMPLEMENTATION
   - HIGH SPEED ONBOARD DATA PROCESSING
   - MODULAR SYSTEMS CONCEPTS

PROGRAM GOALS

THIS SECTION DESCRIBES THE INTERRELATION BETWEEN DISCIPLINARY TECHNOLOGY GOALS, ADVANCED SYSTEM CAPABILITIES, AND MAJOR PROGRAM THRUSTS NEEDED TO ENHANCE NASA's OVERALL MISSION CAPABILITY. IT CONCLUDES WITH A BRIEF SUMMARY OF BENEFITS DERIVED FROM THE JOINT PROGRAM REVIEW AND TECHNOLOGY PLANNING ACTIVITIES.

SPACE ELECTRONICS TECHNOLOGY

INTRODUCTION	PETER R. KURZHALS
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PROGRAM OUTLINE	CHARLES E. PONTIOUS
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SENSING & DATA ACQUISITION	BERNARD RUBIN
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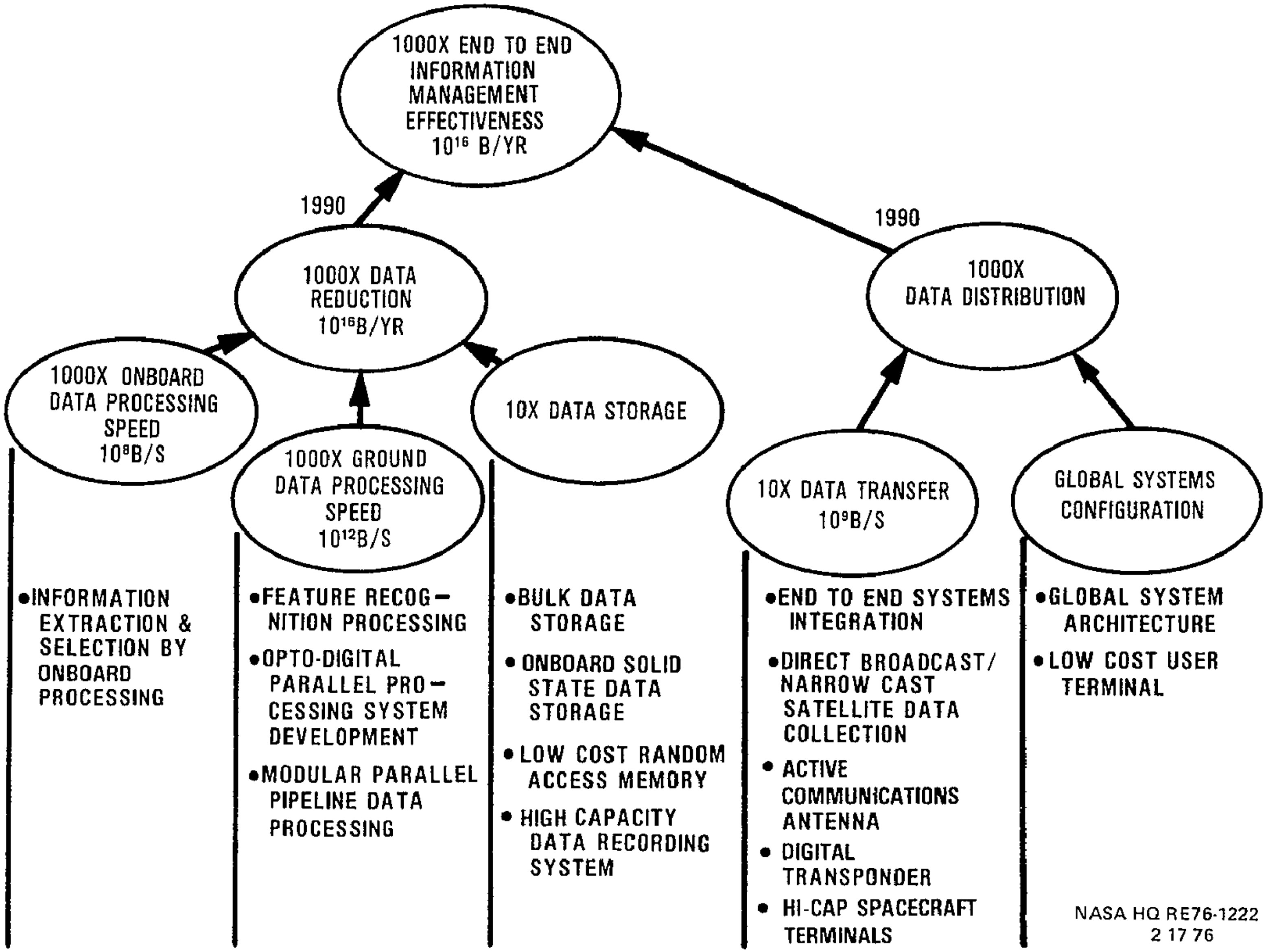
EACH DISCIPLINE PRESENTATION CONCLUDED ITS DISCUSSION OF THE TECHNICAL PROGRAM WITH SUMMARY CHARTS ILLUSTRATING THE INTERRELATION OF TECHNOLOGY THRUSTS, DISCIPLINE GOALS AND ADVANCED SYSTEM CAPABILITIES. THE FIGURE IS AN EXAMPLE FROM THE DATA PROCESSING, STORAGE AND TRANSFER DISCIPLINE. IT DEMONSTRATES THE RELATIONSHIP OF THAT DISCIPLINE'S PROGRAM GOALS TO AN ADVANCED SYSTEMS CAPABILITY OF A 1000-FOLD INCREASE IN END-TO-END INFORMATION MANAGEMENT EFFECTIVENESS BY 1990, I.E. A CAPABILITY TO CONVERT 1000 TIMES MORE BITS OF RAW DATA TO USEFUL INFORMATION WITH NO REAL INCREASE IN COST. SIMILAR FIGURES, SUMMARIZING PROGRAM GOALS AND THEIR CONTRIBUTIONS TO EITHER INCREASED MISSION CAPABILITY OR REDUCED MISSION COST, WERE INCLUDED IN EACH DISCIPLINE PRESENTATION.



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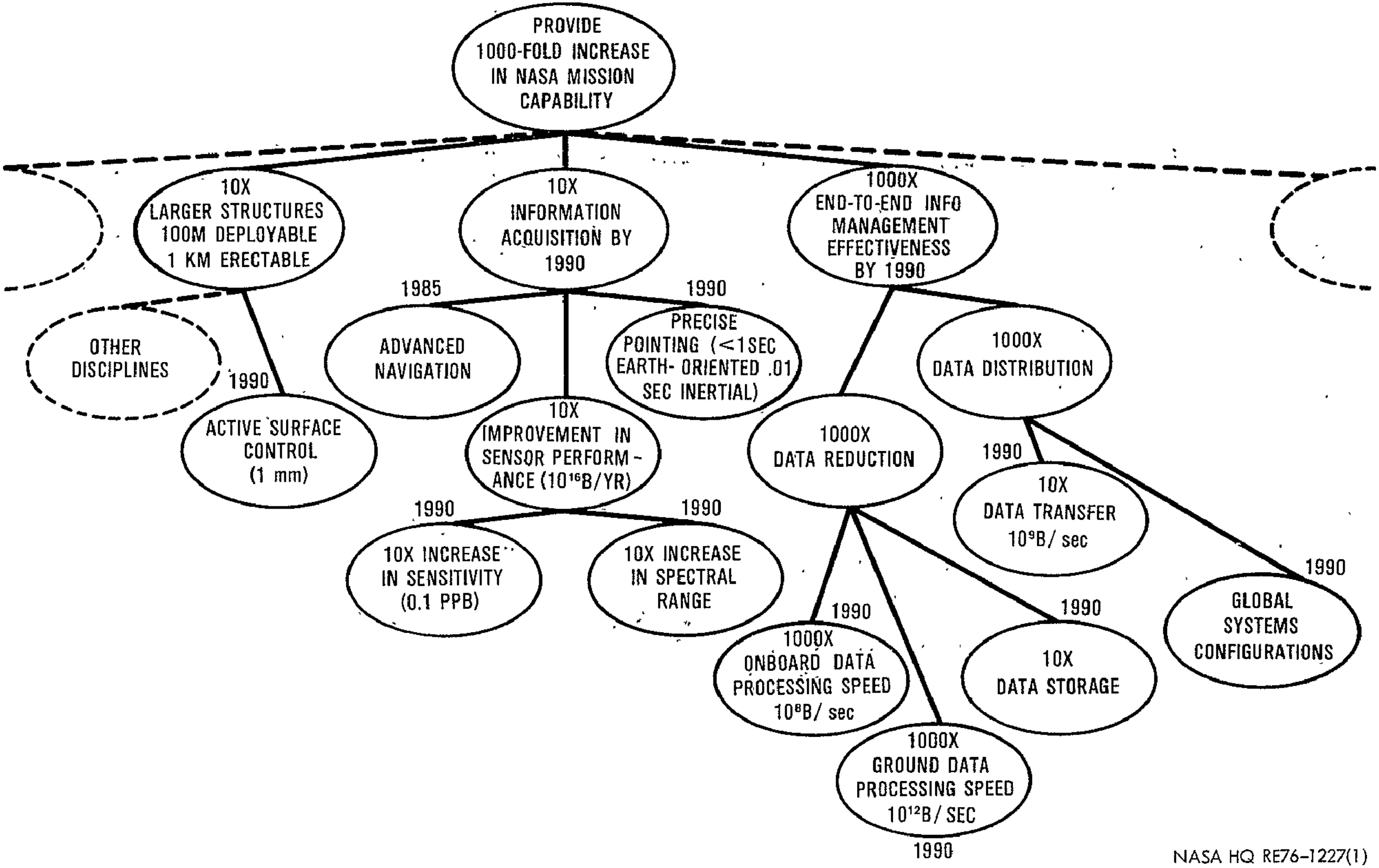
SIGNIFICANT INCREASES IN NASA MISSION CAPABILITY REQUIRE A BROAD BASE OF SUPPORTING TECHNOLOGY. CAREFUL, COORDINATED LONG RANGE PLANNING CAN PROVIDE THAT CAPABILITY. THE FIGURE ILLUSTRATES THE CONTRIBUTION OF PROGRAM GOALS FROM THE VARIOUS ELECTRONIC DISCIPLINES TO ADVANCED SYSTEM CAPABILITIES. THESE CAPABILITIES, INTEGRATED AND COMPLEMENTED BY SIMILAR ADVANCES IN OTHER TECHNICAL DISCIPLINES SUCH AS POWER, PROPULSION AND STRUCTURES PROVIDE THE TECHNOLOGY BASE NECESSARY TO ACHIEVE A THOUSAND-FOLD INCREASE IN NASA MISSION CAPABILITY, THROUGH THE ABILITY TO CONVERT 1000 TIMES MORE NEW DATA TO USEFUL INFORMATION THAN IS DONE TODAY.

SPACE ELECTRONICS TECHNOLOGY REVIEW

MAJOR THRUSTS



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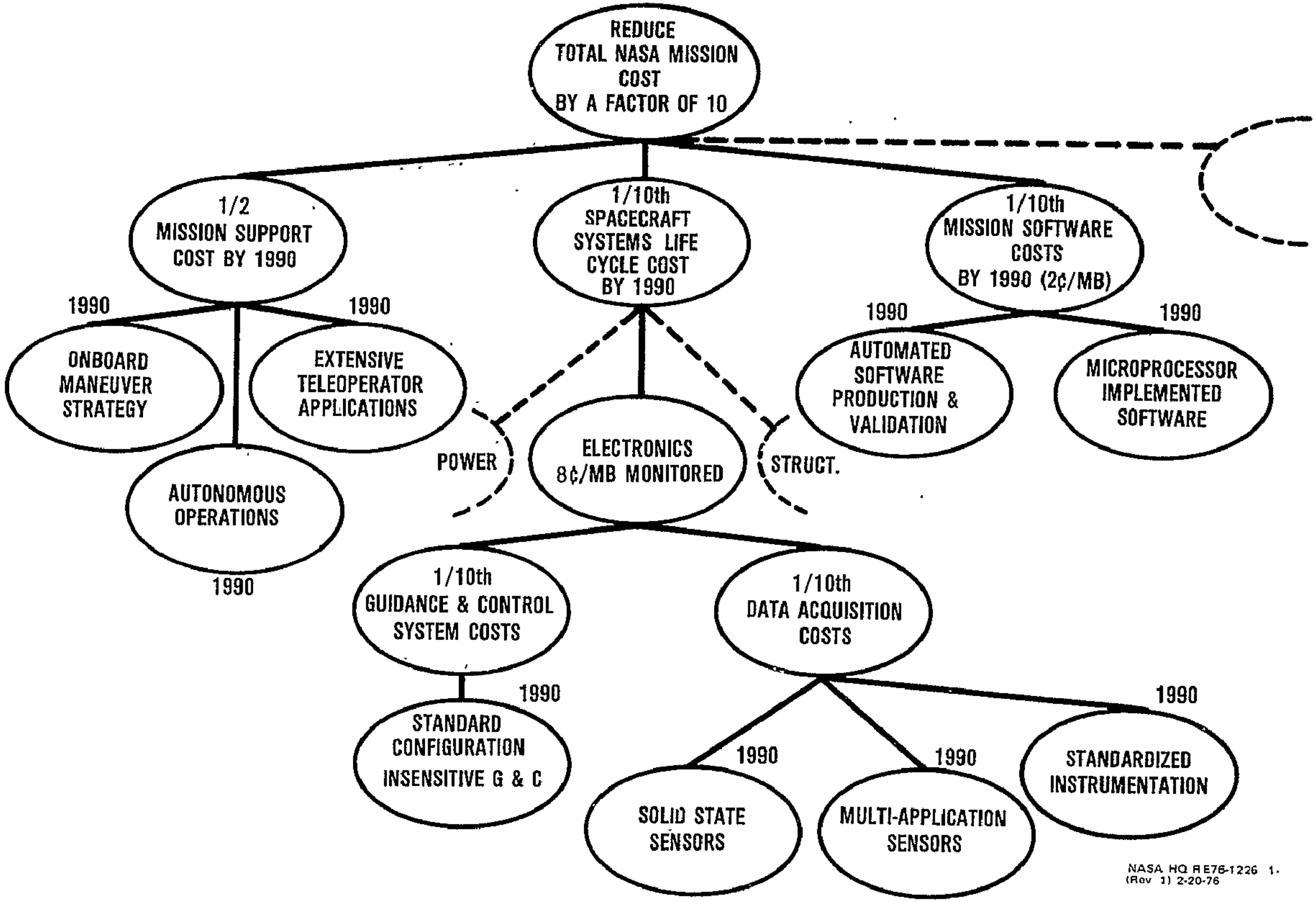
A CONCURRENT MAJOR THRUST FOR NASA'S TECHNICAL ACTIVITIES IS TO LOWER THE COST OF DOING BUSINESS IN SPACE WITHOUT SACRIFICING CAPABILITY. THE ELECTRONICS DISCIPLINES CONTRIBUTE TO THIS GOAL IN SEVERAL IMPORTANT AREAS, INCLUDING MISSION SUPPORT COSTS, SYSTEMS LIFE CYCLE COSTS AND MISSION SOFTWARE COSTS. THE FIGURE ILLUSTRATES THE POTENTIAL CONTRIBUTIONS TO THIS CAPABILITY OF THE PROGRAM GOALS ESTABLISHED IN EACH ELECTRONICS DISCIPLINE. AIDED BY SIMILAR ADVANCES IN OTHER TECHNICAL DISCIPLINES, AN ORDER OF MAGNITUDE REDUCTION IN MISSION COSTS PER BIT OF DATA MONITORED APPEARS FEASIBLE FOR THE 1990 ERA.

SPACE ELECTRONICS TECHNOLOGY REVIEW

MAJOR THRUSTS



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(Rev 1) 2-20-76

THE ELECTRONICS TECHNOLOGY REVIEW AND ASSOCIATED LONG RANGE PLANNING ACTIVITIES HAVE PROVIDED A COMPREHENSIVE LOOK AT NASA'S CURRENT CAPABILITIES AND PROJECTED NEEDS IN ELECTRONICS. THE REVIEW MATERIALLY STRENGTHENED THE AGENCY'S CURRENT TECHNICAL PROGRAM BY PROMOTING INTERCHANGE BETWEEN TECHNICAL EFFORTS AND ENCOURAGING JOINT PLANNING AND COORDINATION ACTIONS. THE LONG RANGE PLANNING ACTIVITIES HAVE IDENTIFIED MAJOR TECHNOLOGY NEEDS AND PROVIDED A BASE FOR FUTURE PROGRAM EMPHASES.

SPACE ELECTRONICS TECHNOLOGY REVIEW

SUMMARY

- SURVEYED THE TOTAL AGENCY R&D EFFORT IN ELECTRONICS TECHNOLOGY
  - PROVIDED A FORUM FOR MASS REVIEW OF ELECTRONICS R&D PROGRAMS
  - FORTIFIED THE INTERCHANGE OF TECHNICAL KNOWLEDGE AMONG NASA CENTERS AND TECHNICAL STAFFS
- INITIATED COORDINATION ACTIONS AND JOINT PLANNING ACTIVITIES TO STRENGTHEN AGENCY ELECTRONICS R&D POSTURE
- IDENTIFIED MAJOR TECHNOLOGY THRUSTS NEEDS AND OPPORTUNITIES
- PROVIDED A BASE FOR LONG RANGE PLANNING ACTIVITIES AND PROGRAM IMPLEMENTATION

CONCLUSION

THE CONCLUDING SECTION PROVIDES AN OVERALL ASSESSMENT OF NASA'S ELECTRONICS-RELATED TECHNOLOGY STATUS, ADDRESSES THE POTENTIAL BENEFITS OF A MORE FOCUSED FUTURE PROGRAM, AND INDICATES NEXT STEPS IN THE FORMULATION AND IMPLEMENTATION OF SUCH A PROGRAM.

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ASSESSMENT OF NASA'S OVERALL ELECTRONICS-RELATED TECHNOLOGY ACTIVITIES LEADS TO THREE MAIN CONCLUSIONS.

FIRST, MANY PRESSING NASA-WIDE ELECTRONICS PROBLEMS CONFRONT US TODAY. TO NAME JUST A FEW: OVER 300 DIFFERENT SENSORS ARE PRESENTLY UNDER NASA DEVELOPMENT AND THEIR NUMBER AND COST ARE GROWING; IMPROVED POINTING IS NEEDED TO ACCOMMODATE MOST EARTH APPLICATION MISSIONS ON SHUTTLE/SPACELAB; ONLY A FEW PERCENT OF THE TOTAL DATA MONITORED BY NASA CAN BE ADEQUATELY REDUCED AND DISTRIBUTED NOW; SEVERAL MONTHS ARE REQUIRED TO DELIVER REDUCED SPACE DATA TO A USER; NASA SOFTWARE EXPENDITURES ARE CONTINUING TO RISE; AND SO ON... ALL OF THESE PROBLEMS WILL BECOME MORE CRITICAL WITH THE ADVENT OF THE SHUTTLE ERA.

SECOND, NASA'S CURRENT SCATTERED TECHNOLOGY PROGRAMS PRIMARILY ADDRESS SHORT-TERM FIXES AND IMPROVEMENTS AND MAKE IT DIFFICULT TO ADDRESS NASA-WIDE PROBLEMS IN A MEANINGFUL WAY.

THIRD, EFFECTIVE SOLUTION OF CURRENT AND ANTICIPATED NASA PROBLEMS REQUIRES A LONGER RANGE PLAN FOR NASA'S TOTAL ELECTRONICS TECHNOLOGY, ALONG WITH A GOAL-ORIENTED IMPLEMENTATION APPROACH FOCUSED ON THE OVERALL CAPABILITY IMPROVEMENTS NEEDED TO SUPPORT OUR INCREASING MISSION DEMANDS AND TO MAINTAIN OUR OPTION FOR THE FUTURE.

SPACE ELECTRONICS TECHNOLOGY

ASSESSMENT

- NASA FACES MANY CRITICAL PROBLEMS IN ELECTRONICS-RELATED APPLICATIONS
  - SENSOR PROLIFERATION
  - POINTING ACCOMMODATION
  - DATA SATURATION
  - USER INTERACTION
  - SOFTWARE COSTS
  - ...

- MOST CURRENT ELECTRONICS-RELATED TECHNOLOGY ACTIVITIES HAVE SHORT-RANGE FOCUS
  - WIDELY SCATTED SPONSORSHIP AND IMPLEMENTATION
  - BITS AND PIECES
  - DIFFICULT TO ADDRESS NASA-WIDE PROBLEMS

- NASA NEEDS TO ADOPT A LONGER-RANGE, FOCUSED APPROACH TO TECHNOLOGY
  - JOINT PLANNING: GOAL ORIENTED
  - JOINT IMPLEMENTATION: CAPABILITY ORIENTED

  TO MEET CURRENT AND FUTURE NEEDS

THE BUILDING BLOCKS DERIVED FROM A LONG-RANGE TECHNOLOGY PROGRAM, STRUCTURED ALONG THE LINES OF THIS OVERVIEW, PROMISE MANIFOLD BENEFITS. SUCCESSFUL ACHIEVEMENT OF THE ASSOCIATED GOALS WILL PERMIT A THOUSAND-FOLD INCREASE IN NASA DATA RETURN BY 1990, ENOUGH TO ACCOMMODATE ALL CURRENTLY PROJECTED MISSION NEEDS. IN ADDITION, THE SAME TECHNOLOGY ADVANCES WILL ALLOW VASTLY EXPANDED MISSION CAPABILITIES SUCH AS OPERATIONAL GLOBAL EARTH APPLICATIONS WITH DIRECT, NEAR-REAL-TIME USER ACCESS; QUANTUM JUMPS IN OUR ABILITY TO EXPLORE AND EXPLOIT THE SOLAR SYSTEM; AND SIGNIFICANTLY REDUCED SPACE SYSTEMS IMPLEMENTATION AND OPERATION COSTS.

AND PERHAPS MOST IMPORTANT, THE INCREASED UNDERSTANDING OF NASA'S TECHNOLOGY CAPABILITIES CAN LET US TAKE FULL ADVANTAGE OF PROMISING NEW SPACE OPPORTUNITIES AS THEY ARISE. RESEARCH ON EFFICIENT LOW-COST DATA PROCESSING TECHNIQUES COULD YIELD THE KEY TO THE LARGE-SCALE SEARCH FOR EXTRA-TERRESTRIAL LIFE; AND THE CAPABILITY DEVELOPED FOR PRACTICAL OPERATIONAL SPACE APPLICATIONS COULD OPEN THE DOOR TO MANNED EXPLORATION AND EXPLOITATION OF SPACE.

SPACE ELECTRONICS TECHNOLOGY

POTENTIAL BENEFITS

FULL ACCOMMODATION OF PROJECTED MISSION NEEDS

- 1000 X DATA RETURN AT CURRENT NASA BUDGET LEVELS
  (10^{16} BITS MONITORED, REDUCED AND DISTRIBUTED ANNUALLY)

+

VASTLY EXPANDED MISSION CAPABILITIES

- PRACTICAL GLOBAL EARTH OBSERVATIONS
  (CROP PRODUCTION, CLIMATIC FORECASTING, POLLUTION MONITORING, ETC.)
- DIRECT, NEAR-REAL-TIME USER ACCESS
  (ORGANIZATION, MAN-IN-THE STREET)
- OUTER PLANET "APPLICATIONS"
- MINIMAL-COST SYSTEMS CONFIGURATION
  (AUTONOMOUS SPACECRAFT, INEXPENSIVE USER TERMINALS)
- EXTENSIVE IN-ORBIT ASSEMBLY AND MAINTENANCE

+

NEW SPACE OPPORTUNITIES

- EXTRA-TERRESTRIAL INTELLIGENCE
- SPACE COLONIZATION AND MANUFACTURING

THE FOLLOWING STEPS ARE PLANNED TO CONTINUE THE ACTIVITIES BEGUN WITH THE JOINT PROGRAM REVIEWS AND THE SPACE TECHNOLOGY WORKSHOP. COPIES OF THE INITIAL OVERVIEW REPORT HAVE BEEN DISTRIBUTED TO THE RTAC, ALL HEADQUARTERS PROGRAM OFFICES, AND TO COGNIZANT CENTER CONTACTS TO SOLICIT THEIR COMMENTS ON THE CURRENT PROGRAM SUMMARY, PROJECTED FUTURE THRUSTS, AND OVERALL GOALS. THIS REVISED VERSION OF THE REPORT WHICH INCORPORATES THESE FEEDBACKS WAS ISSUED IN LATE FEBRUARY 1976 AS A GUIDE TO FUTURE PLANNING.

ELEMENTS OF A CANDIDATE LONG-RANGE PLAN TO SUPPORT THE RESULTANT CAPABILITY GOALS AND INTERMEDIATE PROGRAM OFFICE NEEDS WILL THEN BE IDENTIFIED BY CENTER DISCIPLINE TECHNOLOGY WORKING GROUPS, UNDER GUIDANCE OF REPRESENTATIVES FROM ALL PROGRAM OFFICES. THE CANDIDATE PLAN IS EXPECTED TO BE AVAILABLE BY JUNE 1976 FOR HEADQUARTERS REVIEW AND DISCUSSION OF JOINT IMPLEMENTATION OF FUTURE PROGRAMS BY THE PROGRAM OFFICES.

SPACE ELECTRONICS TECHNOLOGY

NEXT STEPS

- DISTRIBUTE OVERVIEW REPORT — DECEMBER 1975
  - RTAC COMMITTEE
  - HEADQUARTERS & CENTER CONTACTS FOR JOINT PROGRAM REVIEWS
  - SPACE TECHNOLOGY WORKSHOP WORKING GROUP CHAIRMEN
- UPDATE OVERVIEW REPORT — FEBRUARY 1976
  - CURRENT PROGRAM
  - FUTURE TECHNOLOGY THRUSTS
  - GOALS
- DEVELOP INITIAL LONG-RANGE PLAN — MAY 1976
  - PROGRAM OFFICE INPUTS
  - TECHNOLOGY WORKING GROUPS
  - HEADQUARTERS REVIEW
- DISCUSS JOINT PROGRAM IMPLEMENTATION — JUNE 1976

National Aeronautics and
Space Administration