LIFE CYCLE COST BASED PROGRAM DECISIONS

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  - SPACE EXPLORATION INITIATIVE
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1983 - FACILITY ASSESSMENT TEAM

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- CONCENTRATE ON FACILITIES AT GOVERNMENT SITES
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ASSESSMENT TEAM CHARTER

ASSESS STATUS OF NATION'S LIQUID CHEMICAL SPACE PROPULSION TEST FACILITIES AND THEIR ADEQUACY TO SUPPORT CURRENT, NEAR-TERM, AND LONG-RANGE NATIONAL PROGRAM REQUIREMENTS.

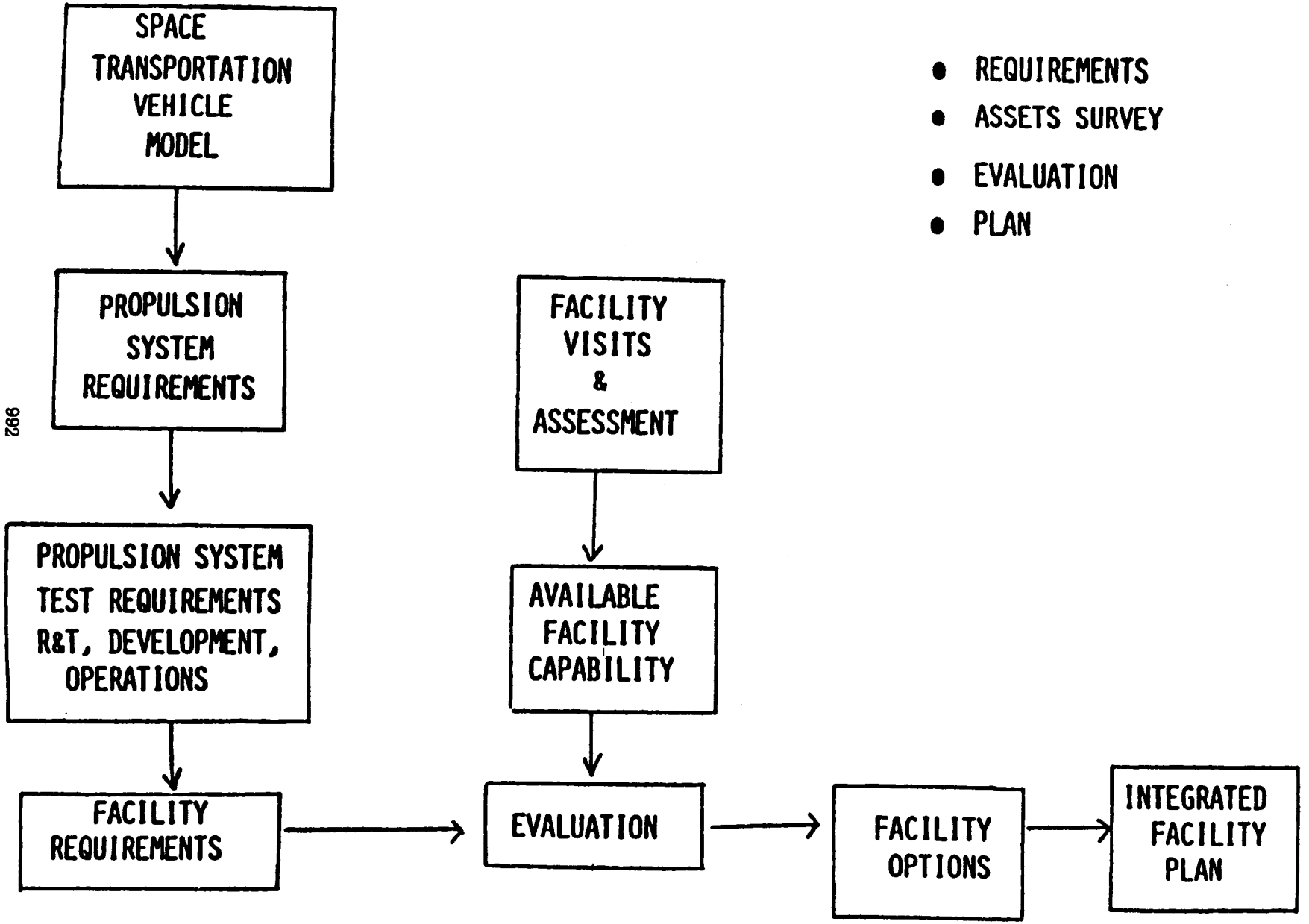
KEY ISSUES

- WHAT FACILITIES ARE REQUIRED?
- WHAT FACILITIES ARE AVAILABLE?
- WHAT ARE THE FACILITY DEFICIENCIES?
- HOW CAN THE DEFICIENCIES BE ACCOMMODATED?
- WHAT IS THE PROPER BALANCE BETWEEN GOVERNMENT AND CONTRACTOR FACILITIES?
- WHY SIMILAR FACILITIES?

LIQUID CHEMICAL SPACE PROPULSION TEST FACILITY VARIABLES

VARIABLES	RANGE/SCOPE
THRUST (LBS.)	MINI (10^1) (RCS) LOW (10^3) (ALTITUDE ADJ.) MODERATE (10^4) (OTV) LARGE (10^6) (SSME)
PROPELLANTS	CRYOGENIC STORABLES (MONOPROPELLANT, BIPROPELLANT)
RUN TANKAGE	MEDIA VOLUME PRESSURE
PRESSURANT	MEDIA CAPACITY PRESSURE
TEST PRESSURE	SEA LEVEL ALTITUDE
DATA ACQUISITION	NO. CHANNELS ANALOG/DIGITAL FREQUENCY/SAMPLE RATE OBSOLESCENCE MODERNIZATION PLANS
SYSTEM LEVEL	COMPONENTS ENGINES PROPULSION SYSTEMS STAGES
DUTY CYCLE	MIN./MAX. BURN DURATION THRUST RANGE MISSION DURATION

SCOPE


SPACE TRANSPORTATION VEHICLE MODEL
PROPULSION SYSTEM REQUIREMENTS
PROPULSION SYSTEM TEST REQUIREMENTS R&T, DEVELOPMENT, OPERATIONS
FACILITY REQUIREMENTS
FACILITY VISITS & ASSESSMENT
AVAILABLE FACILITY CAPABILITY
EVALUATION
FACILITY OPTIONS
INTEGRATED FACILITY PLAN
• REQUIREMENTS
• ASSETS SURVEY
• EVALUATION
• PLAN
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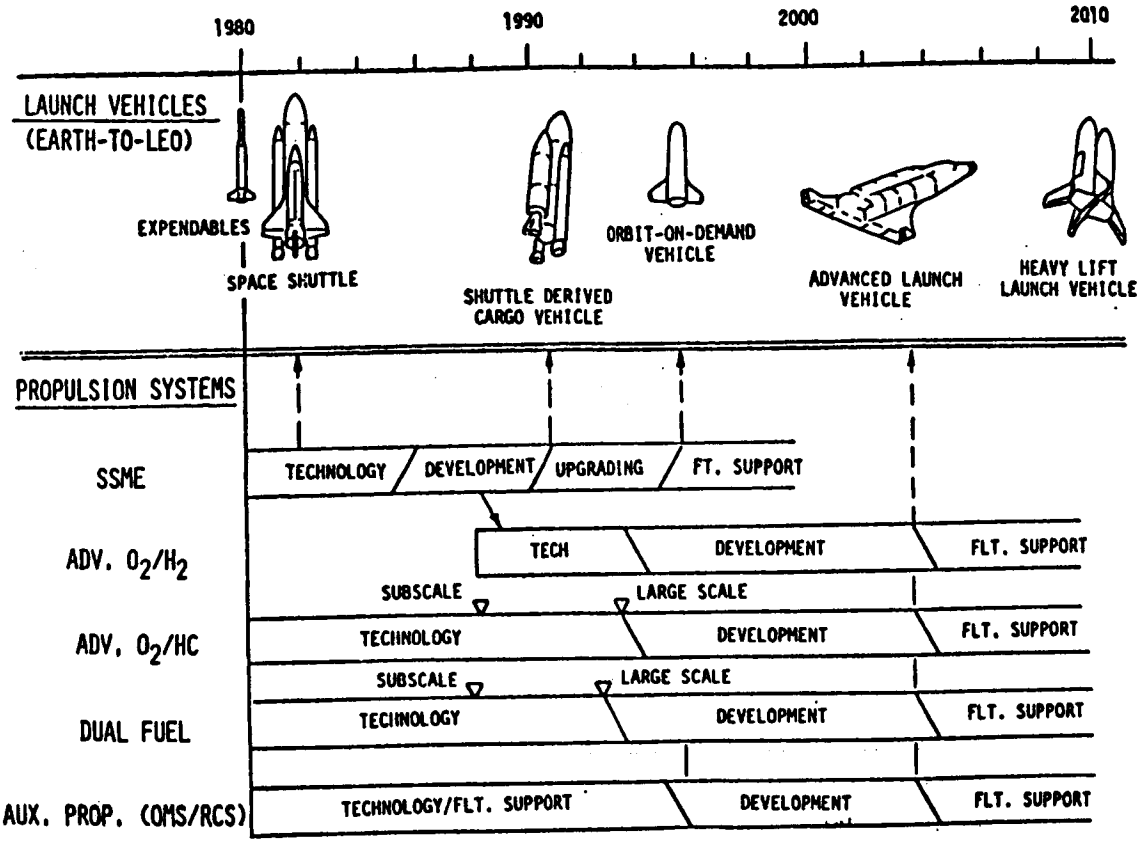
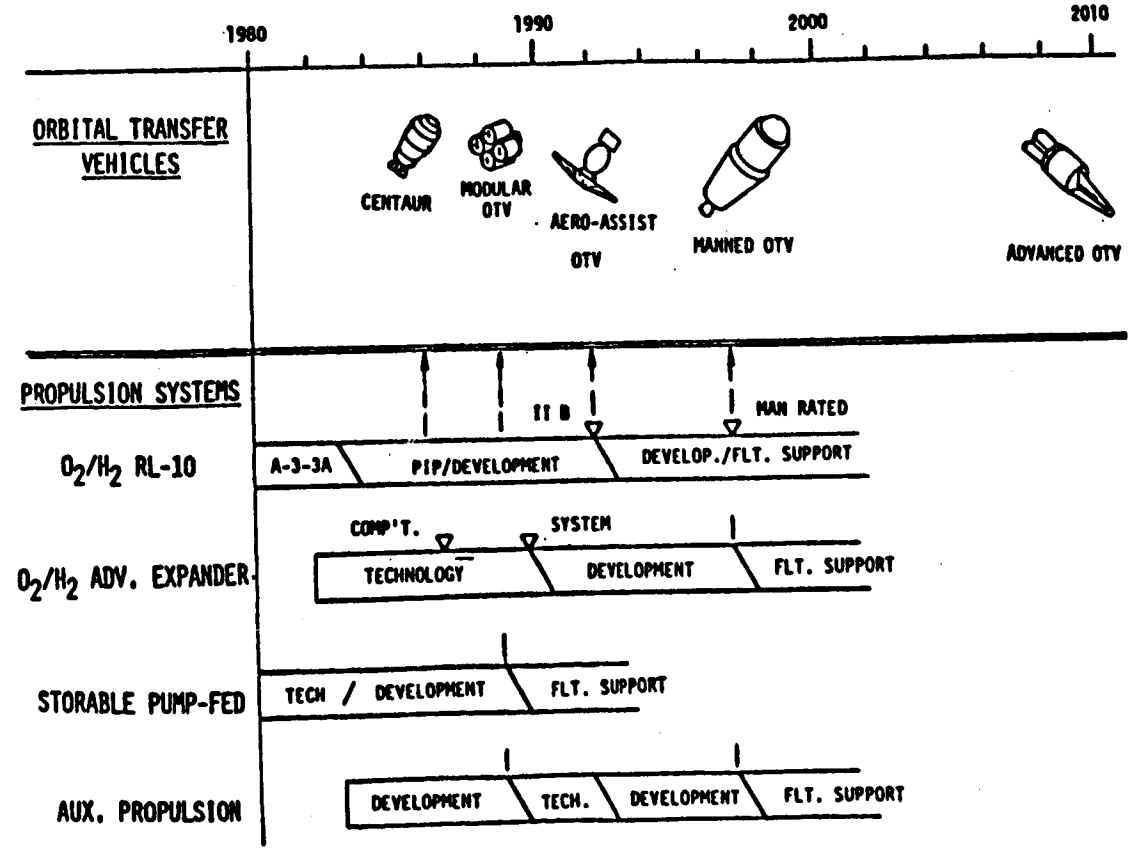
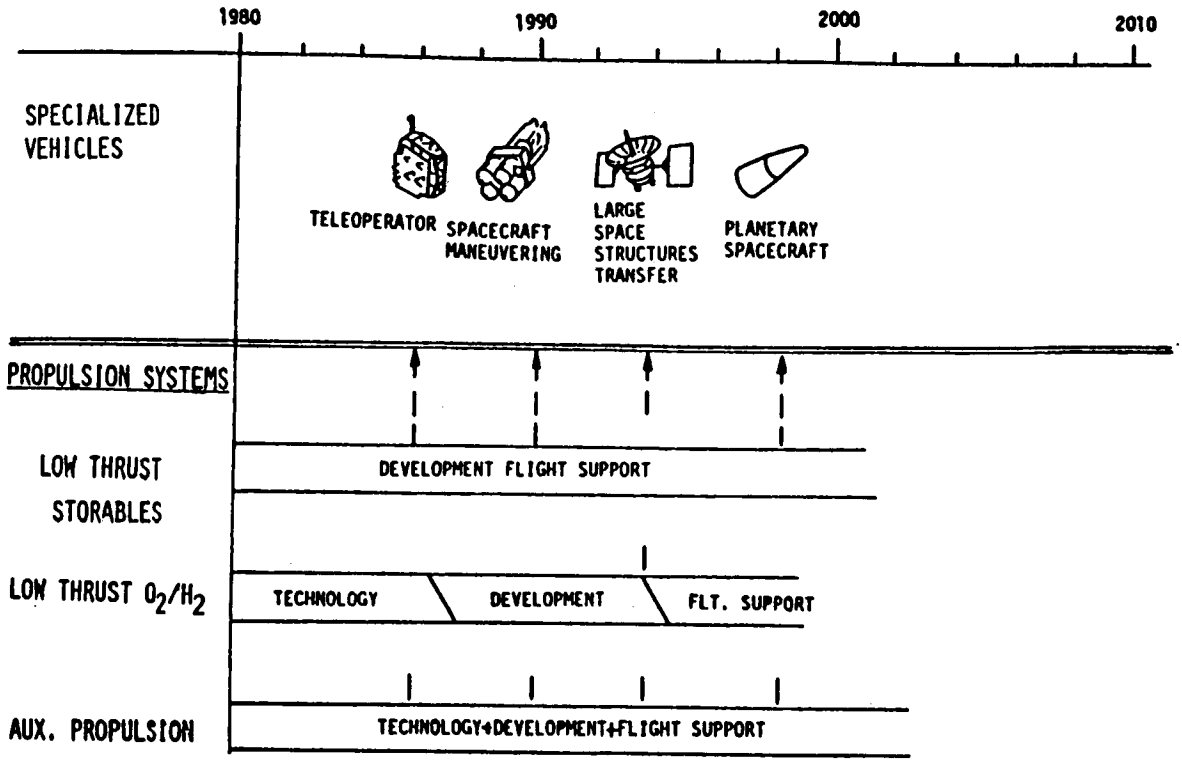
LAUNCH VEHICLE PROPULSION PROGRAMS



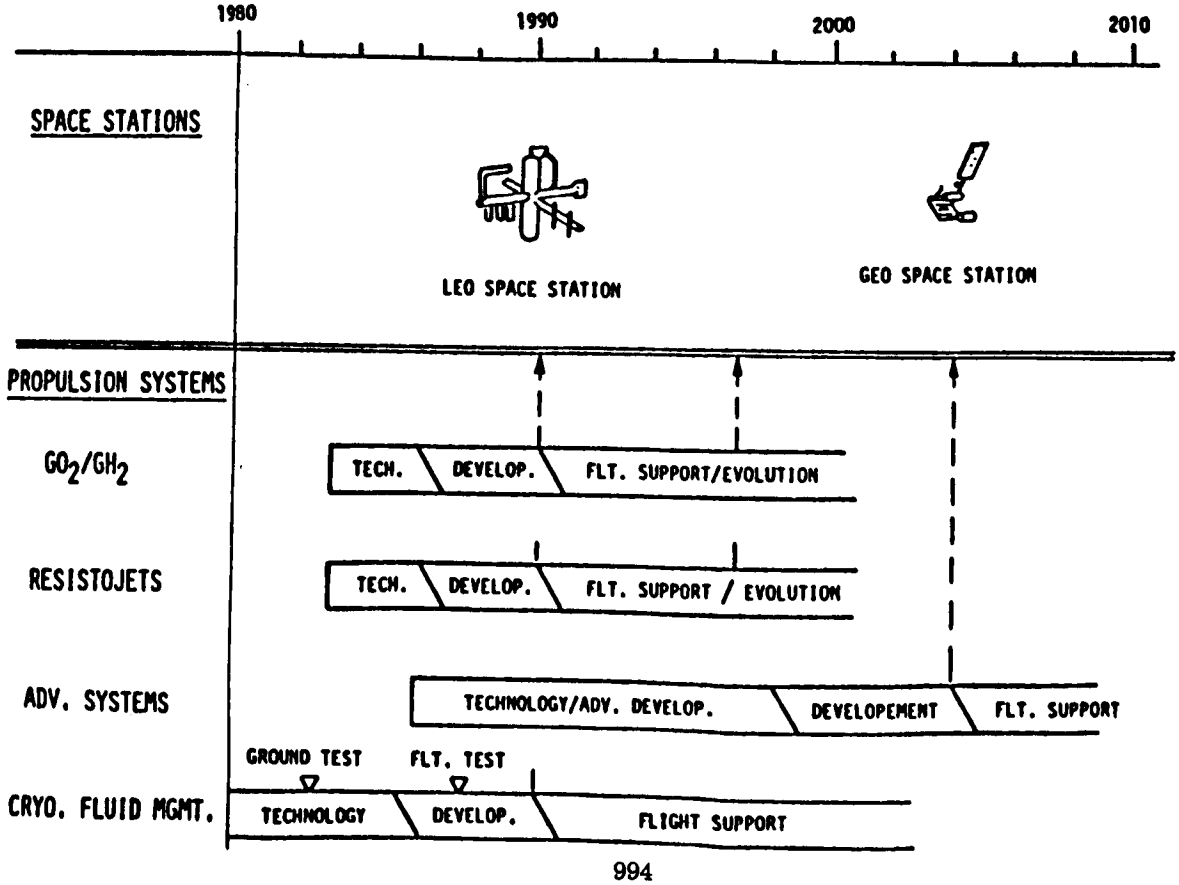
ORBITAL TRANSFER PROPULSION PROGRAMS



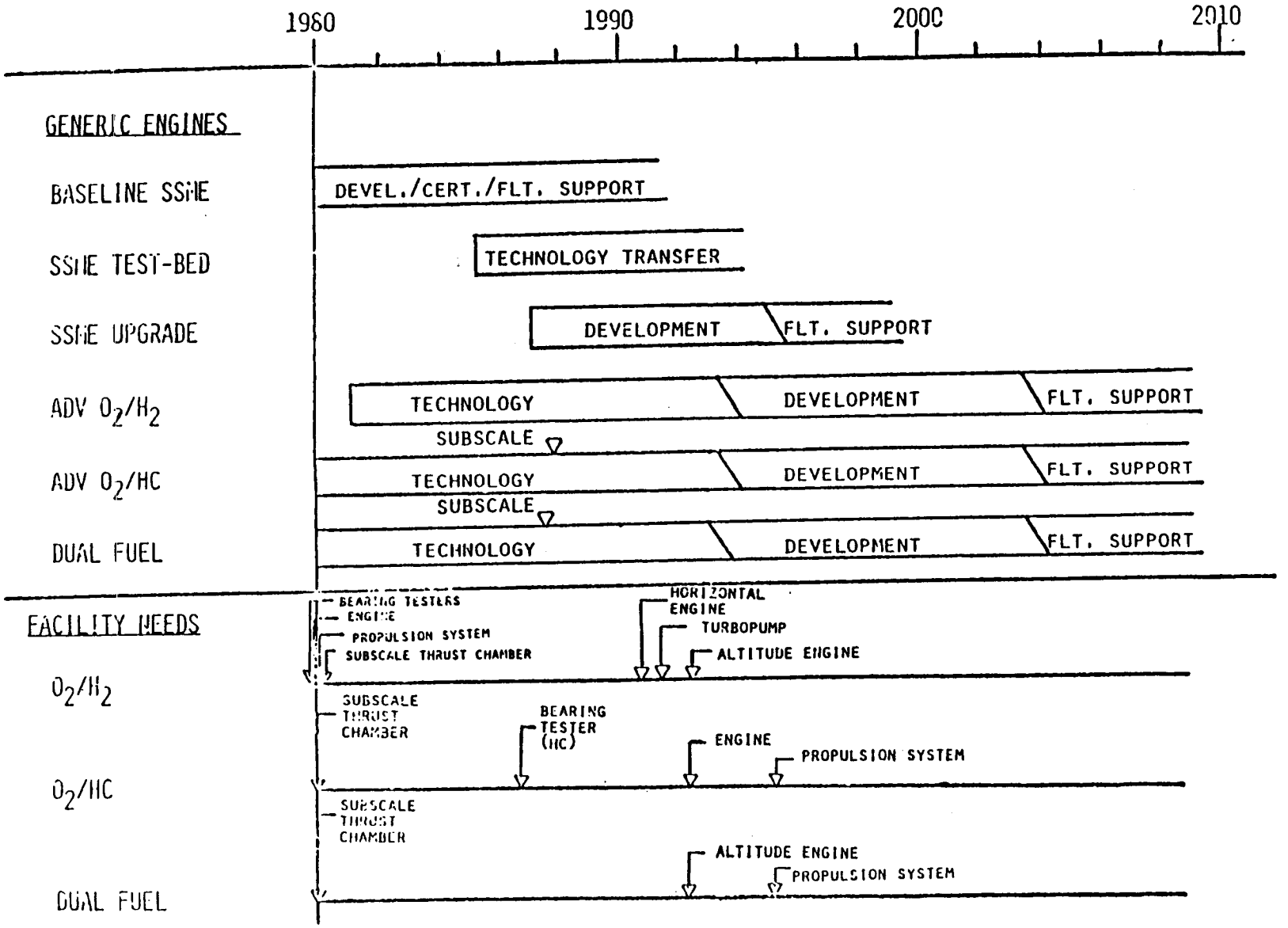
SPECIALIZED VEHICLE PROPULSION PROGRAMS



SPACE STATION AUXILIARY PROPULSION PROGRAMS



LARGE ENGINE THRUST LEVEL - PROGRAMS AND FACILITY NEEDS



LARGE ENGINE THRUST LEVEL

SYSTEM LEVEL SUMMARY

GENERIC ENGINES	LOCATION		
	AFRPL	MSFC	NSTL
SSME CURRENT BASELINE	N/A	N/A	B-2
TECHNOLOGY TEST BED	←	NONE REQUIRED	→
HORIZONTAL TEST	TS1-56 ***	S-1C**	B-1** B-2*
ADVANCED O_2/H_2	N/A	S-1C**	B-1** B-2
ADVANCED O_2/HC	N/A	S-1B* S-1C*	B-1* B-2*
DUAL FUEL	N/A	S-1C**	B-1** B-2*

* MINOR DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM)

** MODERATE DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM PLUS UPGRADE FUEL SYSTEM)

*** MAJOR DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM PLUS LACKS FUEL CAPABILITY)

LARGE ENGINE THRUST LEVEL
ENGINE LEVEL SUMMARY

GENERIC ENGINE	LOCATIONS				
	ROCKETDYNE	MSFC	NSTL	AEDC	AFRPL
SSME BASELINE	A-3	N/A	A-1 A-2	N/A	N/A
SSME TECHNOLOGY TEST BED	A-3	S-1C **	A-1 A-2 B-1 ** B-2 *	J-4 **	N/A
SSME UPGRADING					
• ALTITUDE TEST	A-3 ***	S-1C ***	A-1 *** A-2 *** B-1 *** B-2 ***	J-4 *	N/A
• SEA LEVEL TEST (VERT)	A-3	S-1C **	A-1 A-2 B-1 ** B-2 *	J-4 **	N/A
• SEA LEVEL TEST (HORIZ.)	A-3 *	S-1C **	A-1 * A-2 * B-1 ** B-2 *	N/A	TS 1-56***
ADVANCED O_2/H_2	A-3	S-1C **	A-1 A-2 B-1 ** B-2 *	J-4 **	N/A
ADVANCED O_2/Hc	A-3 ***	S-1C * F-1 * S-1B **	A-1 ** A-2 ** B-1 * B-2 *	J-4 **	N/A
DUAL FUEL	A-3 ***	S-1C *	A-1 ** A-2 ** B-1 * B-2 *	J-4 **	N/A

LARGE ENGINE THRUST LEVEL
COMPONENT LEVEL SUMMARY

GENERIC ENGINES	COMBUSTION DEVICES (GAS GENERATORS, PRE-BURNERS, TURBINE BLADES, HEAT EXCHANGERS, THRUST CHAMBERS, NOZZLES)	BEARINGS	TURBOPUMPS
O_2/H_2	MSFC * ROCKETDYNE	MSFC ROCKETDYNE	ROCKETDYNE * NO GOV'T TEST SITE
O_2/HC	MSFC * ROCKETDYNE	MSFC ROCKETDYNE	(Hi Pc 3000 psi) ROCKETDYNE * NO GOV'T TEST SITE

* MINOR DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM)

** MODERATE DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM PLUS UPGRADE FUEL SYSTEM)

*** MAJOR DEFICIENCIES (STRUCTURAL, PIPING OR SYSTEM PLUS LACKS FUEL CAPABILITY)

LARGE ENGINE THRUST LEVEL

DEFICIENCY #1 - SSME TEST STANDS

REQUIREMENT: SSME TEST OPERATIONS REQUIRE MAINTAINING MORE THAN TWO ACTIVE TEST STANDS TO SUPPORT (1) THE PRODUCTION PROGRAM (INCLUDING ENGINE REBUILDS), (2) SOLVING CURRENT ENGINE PROBLEMS, (3) THE ENGINE PRODUCT IMPROVEMENT PROGRAM, (4) AN SSME TECHNOLOGY TEST BED, AND (5) THE NEED TO MAINTAIN SUFFICIENT TEST POSITIONS TO PROTECT THE ON-GOING STS OPERATIONAL PROGRAM.

FACILITY DEFICIENCY: PLANNED CLOSING OF ROCKETDYNE'S (RKD'S) A-3 TEST POSITION, LEAVES ONLY NSTL A-1 AND A-2.

OPTIONS FOR ADDITIONAL TEST STANDS:

	PRO	CON
• RETAIN RKD A-3.	• EXISTING OPERATION.	• OPERATING COST.
• ACTIVATE NSTL B-2 OR B-1 FOR SINGLE ENGINE TESTING.	• ACTIVE LOX/LH_2 TEST SITE. • LOW OPERATING COST (COST SHARED WITH A-1/A-2).	• INITIAL FACILITY INVESTMENT COST (LOW).
• ACTIVATE MSFC S-IC FOR SINGLE ENGINE TESTING.	• DEVELOP & MAINTAIN IN-HOUSE ENGINEERING EXPERTISE & CAPABILITY. • LOW OPERATIONAL COST.	• INITIAL FACILITY INVESTMENT COST (MODERATE).

LARGE ENGINE THRUST LEVEL

DEFICIENCY #1 (CONT'D.)

RECOMMENDATION:

- A COMPARATIVE STUDY BE MADE IMMEDIATELY OF THE ABOVE OPTIONS TO DETERMINE THE NUMBER AND LOCATION OF TEST STANDS CONSIDERING THE PROPOSED PHASE-OUT OF RKD'S A-3 TEST STAND AND THE REQUIREMENT TO IMPLEMENT AN SSME TECHNOLOGY TEST BED. (A JOINT OSF/OAST STUDY).
- PRESERVE NSTL B-2 TEST POSITION IN CURRENT CONFIGURATION UNTIL COMPARATIVE STUDY IS COMPLETE AND FINAL DECISION IS MADE.

LARGE ENGINE THRUST LEVEL

DEFICIENCY #2 - HORIZONTAL SSME TESTING

REQUIREMENT: HORIZONTAL ORBIT-ON-DEMAND CONCEPTS REQUIRE RAPID ENGINE START-UP AND OPERATION IN HORIZONTAL POSITION.

FACILITY DEFICIENCY: HORIZONTAL TEST POSITION FOR SSME/SSME DERIVATIVE ENGINE ≈ 1990.

OPTIONS:	PRO	CON
• RKD A-3	• DEVELOPMENT ENGR. SUPPORT	• INVESTMENT COST FOR MODS.
• MSFC S-IC	• DEVELOPMENT ENGR. SUPPORT	• INVESTMENT COST FOR MODS. AND REACTIVATION.
• NSTL A-1/A-2 B-1/B-2	• LOW OPERATING COST (SHARED FACILITY)	• INVESTMENT COST FOR MODS.
• RPL 1-56	• EXISTING HORIZONTAL TEST SITE	• INVESTMENT COST TO ADD LH_2 CAPABILITY AND REACTIVATION.

RECOMMENDATION:

- CONTINUAL REVIEW OF ORBIT-ON-DEMAND REQUIREMENTS, INITIATE A FACILITY STUDY TRADE ≈ 1985/6.

DEFICIENCY #3 - MSFC "BACKYARD CAPABILITY"

REQUIREMENT: ADEQUATE SPECIALIZED "BACKYARD" FACILITIES ARE REQUIRED TO ENABLE MSFC TO ACCOMPLISH LEAD ROLE IN COMPONENT LEVEL TESTING FOR SSME AND ADVANCED ENGINE TECHNOLOGY DEVELOPMENT. SPECIFICALLY: (1) LH_2 TESTING OF LARGE BEARINGS 50 MM, WITH RADIAL AND AXIAL LOAD AT SPEEDS 40,000 RPM AND (2) HIGH PRESSURE 3500 PSI O_2/H_2 TESTING OF TURBINE DRIVE COMBUSTION TECHNOLOGY, ADVANCED CHAMBER COMBUSTION TECH, EXHAUST PLUME ANALYSIS.

FACILITY DEFICIENCY: 1) NO H_2 TEST OPERATION PERMITTED AT MSFC's BEARING TEST STAND, TP-500, UNTIL A PRESSURIZED TERMINAL ROOM IS CONSTRUCTED. (SAFETY ISSUE) 2) CURRENT IDENTIFIED WORK LOAD FOR HI PRESS O_2/H_2 TESTING REQUIRES TWO TEST POSITIONS - ONLY ONE AVAILABLE (TP 116). THEREFORE, TECHNOLOGY TEST PROGRAMS ARE DELAYED AND/OR DEFERRED TO ACCOMODATE SPECIFIC ON-GOING PROGRAM DEVELOPMENT ACTIVITIES (SSME TURBINE BLADE TEST) OR UNSCHEDULED ANOMALY RESOLUTIONS (STS OVERPRESSURE PROBLEM).

OPTIONS:	PRO	CON
• MSFC TP 500 & 115	• DEVELOP & MAINTAIN IN-HOUSE TECHNICAL EXPERTISE CONSISTENT WITH ETO ENGINE DEV. ROLE. • IMPROVED CAPABILITY FOR ANOMALY RESOLUTION. • EXISTING SUPPORTING FACILITIES ARE AVAILABLE. • LOW OPERATIONAL COST.	• NONE

LARGE ENGINE THRUST LEVEL

DEFICIENCY #3 (CONT'D.)

OPTIONS (CONT'D):

	PRO	CON
• OTHER GOVERNMENT SITES.	• NONE.	• BASIC TEST CAPABILITY DOES NOT EXIST.
• CONTRACTOR SITES.	• EXPAND INDUSTRY BASE AT ONE CONTRACTOR (PROBABLY RKD.)	• INVESTMENT COST SIGNIFICANT. • OPERATING COST.

RECOMMENDATION:

IMPLEMENT FY 1985 CoF MODIFICATION FOR MSFC'S TP 500 & 115.

LARGE ENGINE THRUST LEVEL

ISSUE #4 - ENVIRONMENTALLY COMPLIANT TEST SITES

REQUIREMENT: ADEQUATE ETO ENGINE AND SYSTEM LEVEL TEST SITES ARE REQUIRED TO MEET NATIONAL NEEDS. THEY MUST COMPLY WITH ENVIRONMENTAL REQUIREMENTS.

FACILITY CONCERN: ENVIRONMENTAL CONSTRAINTS LIKELY TO INCREASE FOR TEST SITES LOCATED ADJACENT TO POPULATED AREAS CURRENTLY EXPERIENCING ENVIRONMENTAL CONSTRAINTS ON ENGINE LEVEL TEST AT SEVERAL TEST SITES, E.G. ROCKETDYNE AT SANTA SUZANNA RESTRICTED TO TEST OPERATIONS DURING DAY LIGHT HOURS.

OPTIONS:

	PRO	CON
• RELOCATE RKD A-3 TEST OPERATIONS.	• ELIMINATES ENVIRONMENTAL PROBLEMS.	• REQUIRES ALTERNATE SITE.
• PROTECT BUFFER ZONE AT ISOLATED TEST SITES.	• PROTECTS CRITICAL NATIONAL ASSET.	• LOCAL PRESSURE FOR LAND USE.

RECOMMENDATION:

PROTECT NSTL BUFFER ZONE AND PRESERVE OTHER EXISTING GOVERNMENT REMOTE TEST SITES (MSFC).

LARGE ENGINE THRUST LEVEL
DEFICIENCY #5 - LOX/HYDROCARBON TEST SITE

REQUIREMENT: ADVANCED EARTH TO ORBIT TRANSPORTATION SYSTEMS WILL REQUIRE THE DEVELOPMENT OF LARGE HYDROCARBON AND/OR DUAL FUEL ENGINES @ Hi Pc. TEST AT ALTITUDE CONDITION MAY BE REQUIRED.

FACILITY DEFICIENCY: NO FACILITY HAS CAPABILITY TO MEET BOTH PROPELLANT AND ALTITUDE REQUIREMENTS.

OPTIONS:

	PRO	CON
• GOV'T. TEST SITES AEDC, MSFC, NSTL, RPL.	• BUILDS ON EXISTING OPERATIONAL BASE.	• INVESTMENT COST.
• CONTRACTOR TEST SITES. AEROJET, PRATT, RKD.	• MAINTAIN INDUSTRY CAPABILITY.	• INVESTMENT COST. • COST OF OPERATION.

RECOMMENDATION:

INITIATE A TECHNICAL FEASIBILITY/FACILITY TRADE STUDY IN 1984 TO ESTABLISH A TEST PHILOSOPHY, i.e., ENGINE/COMPONENT TEST BED VIS-A-VIS COMPONENT LEVEL TESTING, TO SUPPORT A CoF PER IN FY 1987.

LARGE ENGINE THRUST LEVEL
DEFICIENCY #6 - ADVANCED ENGINE TURBOPUMP TESTING

REQUIREMENT: ADVANCED O_2H_2, O_2/HC AND/OR DUAL FUEL EARTH TO ORBIT ENGINES REQUIRE TURBOPUMP TESTING.

FACILITY DEFICIENCY: EXISTING CONTRACTOR FACILITY HAS NOT SATISFACTORILY DEMONSTRATED THIS CAPABILITY. TEST POSITION IS PROJECTED TO BE CLOSED BY 1986 AND CRITICAL HIGH PRESSURE TANKAGE LIKELY TO BE MOVED TO OTHER LOCATIONS. NO ALTERNATE GOV'T. TEST POSITION EXISTS.

OPTIONS:

	PRO	CON
• RKD A-3	• CURRENTLY EXISTING FACILITY.	• FACILITY LIKELY TO BE CLOSED IN SPITE OF THIS REQUIREMENT. • OPERATIONS COST.
• MSFC	• SUPPORTS ETO DEVELOPMENT RESPONSIBILITY. • BUILDS ON EXISTING CAPABILITY BASE.	• INITIAL INVESTMENT COST.
• NSTL	• UTILIZES EXISTING PROPELLANT SUPPLY FACILITIES.	• INITIAL INVESTMENT COST.
• TEST BED ENGINE	• MAY BE ONLY PRACTICAL SOLUTION AT REASONABLE COST.	• TURBOPUMP TESTS MUST BE ACCOMPLISHED IN CONJUNCTION WITH ENGINE SYSTEM TESTS.

LARGE ENGINE THRUST LEVEL DEFICIENCY #6 (CONT'D.)

RECOMMENDATION:

CONDUCT TRADE STUDY TO ESTABLISH TECHNICAL FEASIBILITY AND COST ESTIMATES FOR TURBOPUMP TEST METHOD TO SUPPORT AN FY 1987 CoF PROJECT. THIS STUDY SHOULD BE INITIATED AS AN INTEGRAL PART OF THE PRIOR ENGINE ISSUE.

CATEGORIZATION OF GOVERNMENT FACILITIES

I. ACTIVE - IN CURRENT USE.

II. RETAIN IN CURRENT STATUS FOR POTENTIAL FUTURE USE
- NOT UNIQUELY REQUIRED BY VEHICLE MODEL.
- ASSET OF POTENTIAL VALUE TO FUTURE PROGRAM.
- COSTLY TO DUPLICATE, CONTAIN EXPENSIVE, LONG-LEAD HARDWARE.

- STANDBY - MAINTAIN TO PERMIT RAPID ACTIVATION.
- DOWNMODE - MAINTAIN AT MINIMUM LEVEL TO ARREST DETERIORATION.

III. RETAIN AS A SOURCE OF HARDWARE
- NOT REQUIRED BY VEHICLE MODEL.
- CONTAIN EXPENSIVE, LONG-LEAD HARDWARE.

IV. INDICATE TO CONTROLLING GOVERNMENT ORGANIZATION THAT FACILITY RETENTION FOR PROPULSION PURPOSES CANNOT BE JUSTIFIED
- NOT REQUIRED BY VEHICLE MODEL.
- INCLUDE FACILITIES AT NASA, DOD, AND DOE LOCATIONS AND GOVERNMENT FACILITIES AT CONTRACTOR LOCATIONS.

MEDIUM ENGINE THRUST LEVEL - ENGINE CHARACTERISTICS

	THRUST FULL/LOW(LBS.)	Pc (PSIA)	EXPANSION RATIO	DURATION CLASS (SEC.)
O_2H_2				
RL-10 IIB	15,000/1500	400	205	1,400
ADV EXPANDERS	15,000/500	2,000	1,000	1,800
	3,000/500	2,000	1,000	1,800
ADV OMS	6,000	500	300	600
N_2O_4/MMH				
ADV PUMP-FED	3,750	1,500	400	1,000
CURRENT OMS	6,000	125	55	600
ADV OMS	6,000	1,500	400	600
O_2/HC				
ADV OMS	6,000	600	300	600

MEDIUM ENGINE THRUST LEVEL - ENGINE LEVEL TEST CAPABILITY

PROPULSION SYSTEM \ FACILITY		AEDC	RPL	GSFC	JAF	JPL	JSC	LeRC	LeRC P.B.	MSFC	NSTL	WSTF	ALRC	BELL	BOE.	HAM. STD.	TMC	PWA	RKD	RR	TRW
O_2/H_2	RL-10 IIB	A	A					P	SP	P	P	A	P					P	P		A
	ADV EXPANDER	A	A					P	SP	P	P	A	P					P	P		A
	OMS	A	A					P	SP	P	P	A	*	A				P	P		A
N_2O_4/MMH	OMS	*	*					P				*	*	A				A	*		*
	ADV PUMP-FED	*	*			*		P				*	*	*				A	*		*
O_2/HC	OMS	*	*					P				*	*	A				A	*		*

* FULL EXISTING CAPABILITY

A EXIST. ALTITUDE CAPABILITY

P EXIST. PROPELLANT SYSTEM

S TEST STAND IN PLACE

ENGINE CLASS	FEED SYSTEM		BEARING TESTERS	TURBO-PUMPS	THRUST CHAMBERS	NOZZLES	ENGINE TEST		STAGE TEST	
							S.L.	ALTITUDE	S.L.	ALTITUDE
O_2H_2	PUMP FED	GOV'T	LeRC		LeRC MSFC		LeRC MSFC NSTL	AEDC J-4	AFRPL MSFC WSTF NSTL	AEDC AFRPL WSTF
		CONTR.	R/D	BELL R/D	R/D		ALRC R/D BELL		ALRC R/D BELL	
N_2O_4/MMH	PUMP FED	GOV'T			AFRPL LeRC		AFRPL LeRC WSTF	AEDC J-3 AFRPL JPL WSTF	AFRPL WSTF	AEDC AFRPL WSTF
		CONTR.	R/D	BELL R/D	BELL R/D	ALRC BELL R/D	ALRC BELL R/D TRW	ALRC BELL R/D TRW	ALRC BELL R/D TRW	
	PRESS. FED	GOV'T	N/A	N/A	RPL LeRC WSTF	AEDC AFRPL WSTF	AFRPL LeRC WSTF	AEDC J-3 AFRPL WSTF	AFRPL WSTF	AEDC AFRPL WSTF
		CONTR.	N/A	N/A	ALRC R/D BELL TRW	ALRC TRW R/D	ALRC BELL R/D TRW	ALRC R/D TRW	ALRC R/D BELL TRW	
O_2/HC	PUMP FED	GOV'T	LeRC		LeRC MSFC		LeRC MSFC NSTL	AEDC J-3	AFRPL MSFC WSTF NSTL	AEDC AFRPL NSTL
		CONTR.	ALRC R/D	ALRC BELL R/D	ALRC R/D	ALRC	ALRC BELL R/D	ALRC	ALRC BELL R/D	

MEDIUM ENGINE THRUST LEVEL

DEFICIENCY #1 - ENGINE ALTITUDE TESTING

REQUIREMENT:

VERY HIGH EXPANSION RATIO (E) ENGINES ARE REQUIRED FOR FUTURE HIGH PERFORMANCE OTV'S (MID-1990'S) AND FOR ETO VEHICLES ORBIT MANEUVERING SYSTEMS (OMS) (POST 2000)

- RL-10B (PRODUCT IMPROVEMENT PROGRAM (PIP)) NEED DATE: 1986
- ADV EXPANDER NEED DATE: 1989

DEFICIENCY:

CAPABILITY TO TEST HIGH ϵ DUAL THRUST ENGINES THROUGH FULL MISSION DUTY CYCLES CURRENTLY EXISTS ONLY AT AEDC J-4.

OPTIONS:	PRO	CON
• MODIFY P&W TEST STAND E-6	ACCOMMODATES CURRENT SCHEDULE	• NOT AVAILABLE TO OTHER CONTRACTORS • DOES NOT SATISFY MISSION DURATION REQUIREMENTS
• USE AEDC J-4 FOR ALL HIGH ϵ TESTING	• NO CoFF FUNDING REQUIRED	• VERY HIGH OPERATING COSTS (CHARGES) • PRIORITIES/SCHEDULING PROBLEMS • SINGLE POINT FAILURE
• MODIFY OTHER GOVERNMENT FACILITY (AEDC J-3, WSTF, LeRC, MSFC, NSTL.	COST EFFECTIVE LONG-TERM SOLUTION	REQUIRES NEAR TERM CoFF FUNDING (FY 1985)

MEDIUM ENGINE THRUST LEVEL
DEFICIENCY #1 (CONT'D.)

RECOMMENDATION:

- ACCOMMODATE NEAR TERM TEST REQUIREMENTS (RL-10 IIB PIP) AT AEDC J-4.
- CONDUCT TRADE STUDY TO DETERMINE MOST COST/SCHEDULE EFFECTIVE LOCATION FOR PERMANENT HIGH ALTITUDE TEST FACILITY(S), WHICH CAN ALSO ACCOMMODATE HIGH ϵ NOZZLE TESTING
- COMPLETE STUDY IN TIME TO IMPACT FY 86 CoFF (COULD MEET RL-10 IIB PIP REQUIREMENTS, IF DELAYED)

MEDIUM ENGINE THRUST LEVEL
ISSUE #1 - ENGINE TESTING

CONSIDERATION OF POTENTIAL FACILITIES

MINOR MODS	MODERATE MODS	MAJOR
	AEDC (J-3)	MSFC
	LeRC (PSL)	NSTL
	WSTF	
	P&W	ALRC
		BELL
		RKD
		TRW

MEDIUM ENGINE THRUST LEVEL

DEFICIENCY #2 - NOZZLE TESTING

REQUIREMENT:

HIGH EXPANSION RATIO (ε) ENGINES REQUIRED FOR FUTURE HIGH PERFORMANCE OTV'S (MID-1990'S) AND ETO VEHICLE ORBIT MANEUVERING SYSTEMS (OMS) (POST 2000)

DEFICIENCY:

CAPABILITY TO TEST HIGH ε NOZZLES AT ALTITUDE WITH PRESSURE FED THRUST CHAMBERS DOES NOT EXIST AT ANY TEST FACILITY - INITIAL NEED DATE (R&T): 1988

OPTIONS:	PRO	CON
• PROVIDE HIGH PRESSURE TANKAGE TO AEDC (J-3) OR WSTF	PROVIDES REQUIRED CAPABILITY	COST OF HIGH PRESSURE TANKS
• TEST AT ENGINE LEVEL AT GOVERNMENT FACILITY.	LOW PRESSURE TANKS IN PLACE OR AVAILABLE	PUMP LIFE/MAINT./CONTROL
• TEST SUBSCALE HARDWARE AT LeRC, ALRC,, RKD	IN-PLACE CAPABILITIES	EXTRAPOLATION OF RESULTS TO FULL SCALE NOZZLES

RECOMMENDATION:

CONDUCT STUDY IN CONJUNCTION WITH ENGINE SYSTEM TEST FACILITY OPTIONS TO DEVELOP MOST COST EFFECTIVE SOLUTION

MEDIUM ENGINE THRUST LEVEL
ISSUE #2 - NOZZLE TESTING

CONSIDERATION OF POTENTIAL FACILITIES

MINOR MODS	MODERATE MODS E.G., PROPELLANT SYS	MAJOR MODS E.G., ALTITUDE SYSTEM
	AEDC J-4	MSFC
	AEDC J-3	NSTL
	AFRPL	
	LeRC PSL	
	WSTF	
	ALRC	BELL
	P&W	RKD

MEDIUM ENGINE THRUST LEVEL

DEFICIENCY #3 - TURBOMACHINERY TESTING

REQUIREMENT: DEVELOP TECHNOLOGY FOR HIGH PRESSURE, HIGH SPEED TURBOPUMPS REQUIRED FOR HIGH PERFORMANCE OTV ENGINES (MID-1990'S) AND ORBIT MANEUVERING SYSTEM ENGINES (POST 2000).

DEFICIENCY:
- NO GOVERNMENT CAPABILITY EXISTS AT REQUIRED PRESSURES AND SPEEDS
- CONTRACTOR CAPABILITY EXISTS ONLY AT ROCKETDYNE

OPTIONS:	PRO	CON
• RELY ON RKD FOR TECHNOLOGY AND DEVELOPMENT	• MINIMUM INVESTMENT	• LIMITED GOVERNMENT EXPERTISE • NO CONTRACTOR COMPETITION
• PROVIDE CAPABILITY WITHIN GOVERNMENT	• PROVIDES EXPERTISE THRU "BACKYARD" CAPABILITY • MINOR MOD • AVAILABLE TO ALL CONTRACTORS • SUPPORTS PROGRAM REQUIREMENT WITH TECHNOLOGY	o NONE

RECOMMENDATION: FUND FY 85 LeRC CoFF SUBMISSION TO SUPPORT LeRC'S R&T RESPONSIBILITY.

MEDIUM ENGINE THRUST LEVEL

ISSUE #3 - TURBOMACHINERY TESTING

CONSIDERATION OF POTENTIAL FACILITIES

MINOR MODS	MODERATE MODS	MAJOR MODS
AFRPL		
JPL-ETS		
JSC-TTA		
LeRC		
MSFC		
WSTF		
ALRC		
P&W		
RKD		

MEDIUM ENGINE THRUST LEVEL

DEFICIENCY #4 - BEARING TESTER

ISSUE

REQUIREMENTS:

ADV HIGH PRESSURE PUMP-FED N_2O_4/MMH ENGINES REQUIRED FOR FUTURE HIGH PERFORMANCE OTV'S AND FOR ETO VEHICLE ORBIT MANEUVERING SYSTEMS (OMS) BY MID-1990'S

DEFICIENCY:

CAPABILITY TO TEST SMALL, HIGH SPEED N_2O_4 AND MMH BEARINGS DOES NOT EXIST AT ANY GOVERNMENT FACILITY--ONLY AT ROCKETDYNE

OPTIONS:	PRO	CON
PROVIDE CAPABILITY AT LeRC OR RPL	AVAILABLE TO TEST ALL CONTRACTOR DESIGNS. MINIMUM EXPENSE TO INSTALL	NONE

RECOMMENDATION:

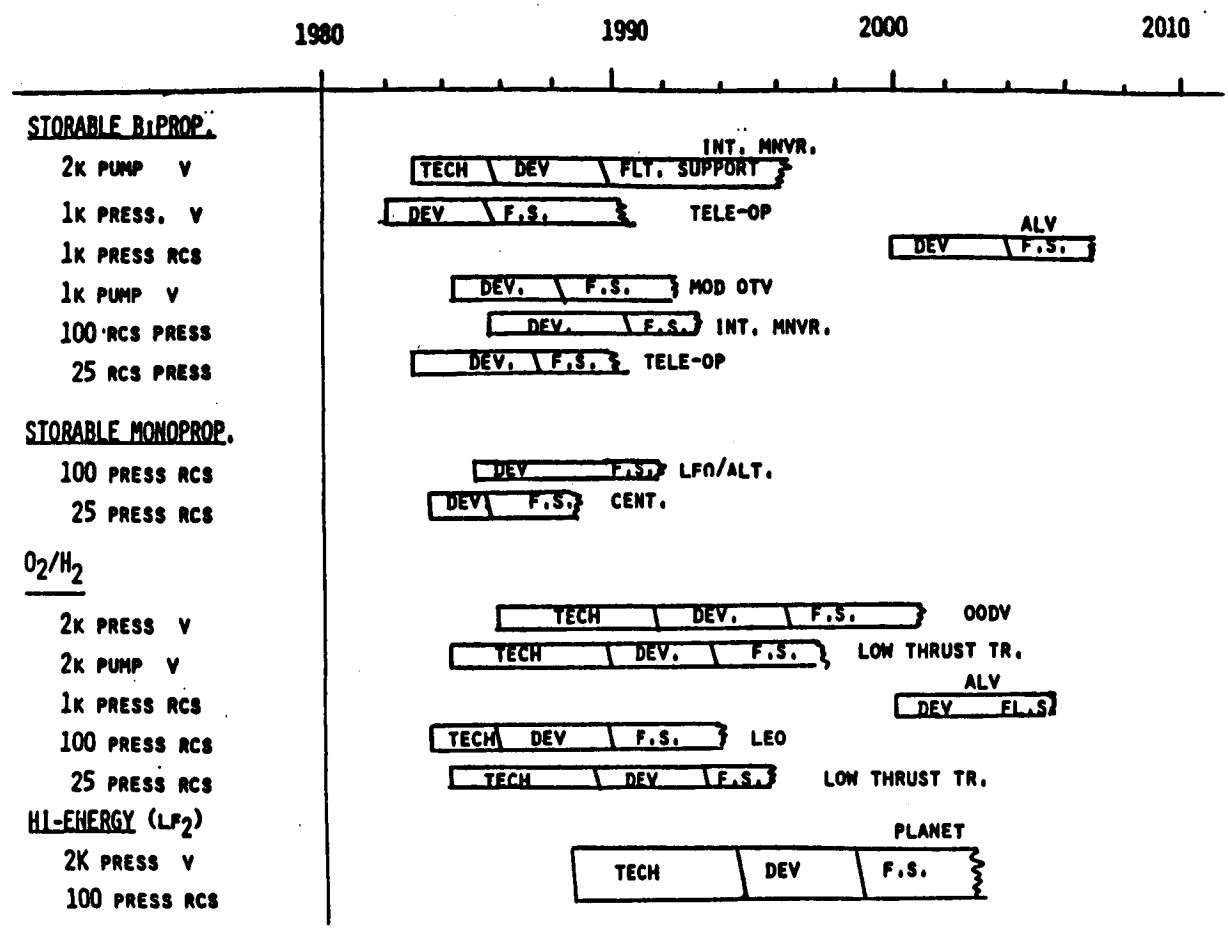
PROVIDE CAPABILITY AT LeRC OR AFRPL FOR BEARING R&T (NEED DATE: 1985)
OAST AND AFRPL DETERMINE BEST LOCATION PRIOR TO JAN. 1984.

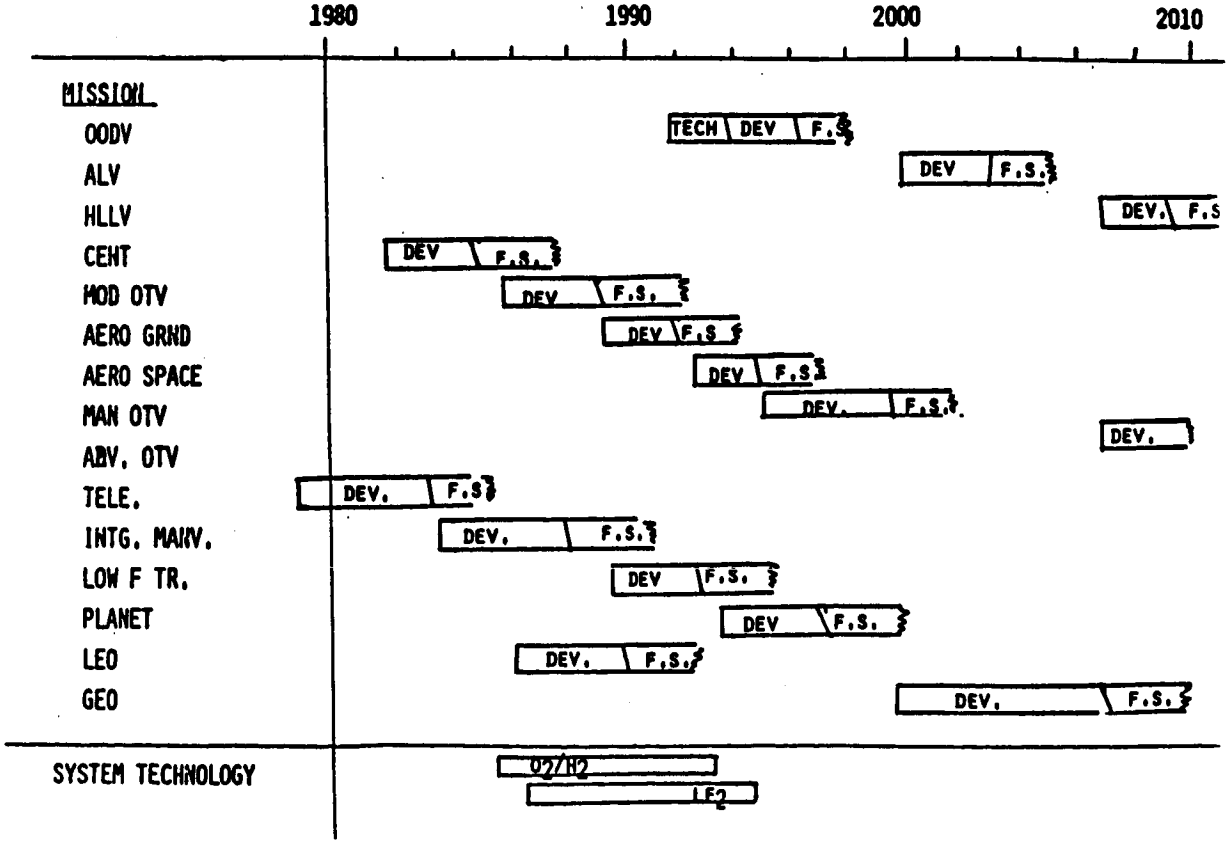
MEDIUM ENGINE THRUST LEVEL

ISSUE #4 - BEARING TESTER

CONSIDERATION OF POTENTIAL FACILITIES

MINOR MODS	MODERATE MODS	MAJOR MODS
LeRC		
AFRPL		
MSFC		
JPL-ETS		
JSC		
WSTF		
ALRC		
RKD		
P&WA		


1980
1990
2000
2010
STORABLE BIPROP.
2K PUMP V
1K PRESS. V
1K PRESS RCS
1K PUMP V
100 RCS PRESS
25 RCS PRESS
STORABLE MONOPROP.
100 PRESS RCS
25 PRESS RCS
O2/H2
2K PRESS V
2K PUMP V
1K PRESS RCS
100 PRESS RCS
25 PRESS RCS
HI-ENERGY (LF2)
2K PRESS V
100 PRESS RCS
INT. MNVR.
TECH
DEV
FLT. SUPPORT
DEV
F.S.
TELE-OP
ALV
DEV
F.S.
DEV.
F.S.
MOD OTV
DEV.
F.S.
INT. MNVR.
DEV.
F.S.
TELE-OP
DEV
F.S.
LFO/ALT.
DEV
F.S.
CENT.
TECH
DEV.
F.S.
OODV
TECH
DEV.
F.S.
LOW THRUST TR.
ALV
DEV
F.S.
TECH
DEV
F.S.
LEO
TECH
DEV
F.S.
LOW THRUST TR.
PLANET
TECH
DEV
F.S.


1980
1990
2000
2010
MISSION
OODV
ALV
HLLV
CENT
MOD OTV
AERO GRND
AERO SPACE
MAN OTV
ADV. OTV
TELE.
INTG. MAINV.
LOW F TR.
PLANET
LEO
GEO
SYSTEM TECHNOLOGY
TECH
DEV
F.S.
DEV
F.S.
DEV.
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F.S.
DEV
F.S.
DEV.
F.S.
DEV.
F.S.
O2/H2
LF2

SCHEDULE SUMMARY

- ALL PLANNED VEHICLES REQUIRE ENGINES IN THE 2000 LBS OR LESS CLASS
  - 13 NEW ENGINE DEVELOPMENTS REQUIRED.
- ALL PLANNED NEW VEHICLES (17 TOTAL) REQUIRE NEW SYSTEMS (WHICH INVOLVE SYSTEM LEVEL TESTS) BETWEEN 1983 AND 2010.
- IN 1985 - 1990 TIME PERIOD:
  11 NEW ENGINE DEVELOPMENTS
  8 NEW SYSTEMS
- THESE PROGRAMS WILL RESULT IN SIGNIFICANT FACILITY TEST LOADS.

LOW ENGINE THRUST LEVEL
SUMMARY ASSESSMENT

ENGINE CLASS	ASSESSMENT
BIPROP STORABLE 2K & LESS	• NO DEFICIENCY. • MULTIPLE GOVERNMENT & INDUSTRY SITES AVAILABLE. • CURRENTLY UNDERUTILIZED - SEVERAL ALREADY INACTIVE.
MONOPROP (N_2H_4) 100 & LESS	• NO DEFICIENCY. • MULTIPLE GOVERNMENT & INDUSTRY SITES AVAILABLE.
O_2/H_2 2K & LESS	• TWO CONTRACTORS WITH CAPABILITY (AEROJET AND ROCKETDYNE. • INADEQUATE CAPABILITY AT GOVERNMENT SITES.
HIGH ENERGY (LF_2) 2K & LESS	• NO DEFICIENCY. • GOVERNMENT & INDUSTRY SITE AVAILABLE. • CURRENTLY INACTIVE BUT CAPABILITY SHOULD BE RETAINED.

LOW ENGINE THRUST LEVEL

CLASSIFICATION OF GOV'T. FACILITIES

SIGNIFICANT DIFFERENCES IN SUITABILITY FOR LOW THRUST ENGINES DUE TO SIZE, PRIMARY FUNCTION, CENTER ROLE AND FACILITY CHARTER.

- TECHNOLOGY DEVELOPMENT (R&T)
  - LeRC
  - RPL
- FLIGHT PROGRAM SUPPORTING DEVELOPMENT ("BACKYARD")
  - JSC - TTA
  - MSFC
  - JPL *
- GOVERNMENT-OWNED TEST SERVICE SITES
  - JSC - WSTF
  - NSTL
  - AEDC
  - JPL *

* CURRENTLY UNDERUTILIZED FOR PROGRAM SUPPORT AND IS BIDDING FOR USE AS A TEST SERVICE SITE.

LOW ENGINE THRUST LEVEL

RATIONALE FOR EXISTENCE OF SIMILAR GOV'T. FACILITIES

- TECHNOLOGY DEVELOPMENT (R&T)
  - PROVIDE TECHNICALLY COMPETENT PROCUREMENT & MANAGEMENT OF CONTRACTED R&T PROGRAMS.
  - PROVIDE COMPARATIVE EVALUATION OF COMPETING CONCEPTS.
  - ALLOW INNOVATIVE IDEAS TO BE EXPLORED AT LOW COSTS.
  - PERFORM IN-HOUSE R&T.
- FLIGHT PROGRAM SUPPORTING DEVELOPMENT ('BACKYARD')
  - PROVIDE TECHNICALLY COMPETENT PROCUREMENT & MANAGEMENT OF CONTRACTED FLIGHT HARDWARE PROGRAMS.
  - PROVIDE REAL-TIME ENGINEERING INVESTIGATIVE SUPPORT.
  - ASSIST IN DEVELOPMENT & REFINEMENT OF MISSION RULES & CONTINGENCY PROCEDURES.
- GOVERNMENT OWNED TEST SERVICE SITES
  - PREVENTS REQUIRING CONTRACTORS TO HAVE FULL-UP FACILITIES IN ORDER TO BE COMPETITIVE. USE AS REQUIRED TO PREVENT BUILDING OF NEW FACILITIES AT NON-GOVERNMENT SITE.

O_2/H_2 DEFICIENCIES AT GOVERNMENT SITE

- TECHNOLOGY DEVELOPMENT (R&T)

  LeRC

  - IMPLEMENTATION OF APPROVED FY 1984 CoF ($995.K) AT LeRC WILL INCREASE TOTAL CAPABILITY FROM NONE TO ONE HOUR DURATION.
  - RECOMMEND CONTINUE.

  RPL

  - IMPLEMENTATION OF REQUESTED FY 1985 MCP ($5.M) AT RPL TO INCREASE ALTITUDE DURATION CAPABILITY FROM 15 MIN. TO 5 HOURS.
  - RECOMMEND CONSIDER USE OF JPL IN LIEU OF MOD AT RPL (CAPABILITY REQUIRED).

- FLIGHT PROGRAM SUPPORTING DEVELOPMENT ("BACKYARD")

  JSC

  - NO CRYO ENGINE CAPABILITY AT ALL AT TTA - UNDERSUPPORTS JSC CENTER ROLE AS FLIGHT PROGRAM DEVELOPMENT AND MANAGEMENT CENTER.
  - RECOMMEND FY 1985 CoF UPGRADE BY ADDING CAPABILITY FOR SUB-SCALE ENGINES (BELOW 250 LB. THRUST).

  MSFC

  - NO APPROPRIATE ENGINE ALTITUDE CAPABILITY AT MSFC - UNDERSUPPORTS MSFC CENTER ROLE AS FLIGHT PROGRAM DEVELOPMENT AND MANAGEMENT CENTER.
  - RECOMMEND THAT MSFC IDENTIFY BEST METHOD AND INCLUDE IN FY 1986 CoF.

- GOVERNMENT-OWNED TEST SERVICE SITES

  JPL

  - JPL HAS TOTAL CAPABILITY EXCEPT FOR RUN DURATION (3 MINUTE CAPABILITY VS. HOUR(S) REQUIREMENT) DUE TO LIMITED VOLUME HIGH PRESSURE LH_2 TANKAGE.
  - RECOMMEND APPROVE RELOCATION OF SURPLUS LH_2 TANKAGE SYSTEM @ NTS TO INCREASE JPL'S CAPABILITY TO 2 HOURS AND PROVIDE TOTAL LOW THRUST CAPABILITY AT VERY LOW COST ($100.K).

  WSTF, NSTL, MSFC

  - IMPLEMENTATION OF OTV FACILITY DECISION WILL ALSO PROVIDE FULL SCALE LOW THRUST CAPABILITY AT ONE OF THESE SITES.

CONCENTRATE ON FACILITIES AT GOVERNMENT SITES

- **SPECIFICALLY: MAJOR, EXPENSIVE, ENGINE & STAGE FACILITIES.**
- **GOVERNMENT FACILITIE77S (AT GOVERNMENT SITES) AVAILABLE TO ALL USERS**
  - **CONTRACTOR & GOVERNMENT**
  - **R&T, R&D, OPERATIONAL PROGRAMS**
- **GOVERNMENT FACILITIES AT CONTRACTOR SITES GENERALLY LIMITED TO HIS USE**
  - **ALTERS COMPETITIVE ADVANTAGE**
  - **REDUCES HEALTH OF INDUSTRY**

TEAM RESULTS

- DETERMINED STATUS OF NATIONAL PROPULSION TEST FACILITIES (COMPILED FACILITY DATA PACKAGE).
- DEVELOPED BASELINE SPACE TRANSPORTATION VEHICLE MODEL.
- ESTABLISHED TEST REQUIREMENTS FOR THE GENERIC PROPULSION SYSTEMS IN THE VEHICLE MODEL.
- DEVELOPED INTEGRATED FACILITY PLAN (SHORT/LONG TERM).
- IDENTIFIED SURPLUS EQUIPMENT AVAILABLE FOR UTILIZATION AT OTHER FACILITIES.
- PROVIDED ASSESSMENT OF PROPULSION INDUSTRY HEALTH.
- ENHANCED COMMUNICATION CHANNELS BETWEEN LIQUID ROCKET TEST ORGANIZATIONS.

RECOMMENDATIONS:

- HQS. PROGRAM OFFICES PROVIDE MEANS OF DEVELOPING AND MAINTAINING INTEGRATED "TOP LEVEL PLANS".
  - REQUIRES TOP MANAGEMENT INVOLVEMENT.
  - REQUIRES DEDICATED LEAD STAFF.
  - MUST BE DEVELOPED BY THOSE RESPONSIBLE FOR MANAGING THE EXECUTION OF THE PLAN.
  - OFTEN REQUIRES INVOLVEMENT AND INTERACTION OF MORE THAN ONE HQS. PROGRAM OFFICE/SOMETIMES DOD.
- PLANS SHOULD INCLUDE:
  - NATIONAL MISSION REQUIREMENTS.
  - PROGRAM OBJECTIVES, APPROACHES, MAJOR MILESTONE, ETC.
  - CENTER RESPONSIBILITIES.
  - TECHNOLOGY REQUIREMENTS.
  - FACILITY REQUIREMENTS.
- INTEGRATED FACILITY PLANNING
  - DRIVEN AND SUPPORTED BY INPUTS FROM PROGRAM PLANS.
  - MUST INCLUDE PROGRAM MANAGEMENT AND FACILITY MANAGEMENT.
  - CONSIDERATION OF FACILITY OPTIONS/BY TRADE-OFF STUDIES.
  - EARLY R&D FUNDS NEEDED TO BE EFFECTIVE.
  - CENTRALLY (HQS) CONTROLLED REVIEW OF TRADE-OFF STUDY RESULTS AND CONCLUSIONS.

TEAM OBSERVATIONS OF NASA PLANNING

- A GENERALLY ACCEPTED TOP-LEVEL SPACE TRANSPORTATION SYSTEM PLAN DOES NOT EXIST; WOULD INCLUDE:
  - MISSION OBJECTIVES AND REQUIREMENTS
    - MAJOR EXCEPTION PERMANENT MAN OCCUPANY OF SPACE.
  - PROGRAM PLANS/MAJOR MILESTONES
    - PLANS FOR APPROVAL OF ONGOING PROGRAMS ARE INADEQUATE.
    - FUTURE PROGRAM PLANS ARE NEAR NONEXISTENT.
- THERE IS NO CLEAR ORGANIZATION MECHANISM TO DEVELOP AND VALIDATE PLANS
  - AD HOC PROPULSION FACILITY TEAM - REQUIRED TO DEVELOP PLAN FOR PROPULSION PROGRAM.
  - REVIEW AND CONCURRENCE BY TOP NASA AND AF MANAGEMENT INCOMPLETE.
- GOOD FACILITY PLANNING AND APPROVAL
  - REQUIRES ADEQUATE AGENCY/CENTER MISSION OBJECTIVES AND PROGRAM PLANS.

CONCLUSIONS

- ADEQUATE FACILITIES ARE AVAILABLE AT BOTH THE GOVERNMENT AND CONTRACTOR SITES TO SATISFY THE TESTING NEEDS OF SMALL ENGINES (SPACECRAFT ATTITUDE CONTROL AND MANEUVERING) FOR FORESEEABLE FUTURE.

  ONE EXCEPTION IS DEFICIENCY IN LOX/LH_2 TEST CAPABILITY.

- MODIFICATIONS AND ADDITIONS TO EXISTING FACILITIES ARE REQUIRED TO ADEQUATELY SUPPORT THE TEST REQUIREMENTS FOR DEVELOPING AND OPERATING HIGH PERFORMANCE MEDIUM THRUST ENGINES FOR FUTURE SPACE VEHICLES (OTV, ETC.).

  THERE ARE SPECIFIC NEEDS FOR IMPROVED COMPONENT TEST FACILITIES, AND ENGINE/ PROPULSION SYSTEM ALTITUDE TEST FACILITIES.

- THE PRESENT THREE ACTIVE TEST STANDS (TWO AT NSTL AND ONE AT ROCKETDYNE, SSFL) MAY NOT BE ADEQUATE OR OPTIMUM TO SUPPORT ALL THE TEST NEEDS OF THE SSME AND SSME DERIVATIVE ENGINE PROGRAMS. OPTIONS BEING CONSIDERED FOR TEST STAND MODIFICATIONS AT NSTL AND MSFC COULD SATISFY THIS NEED.

- PRESENT ACTIVE OR STANDBY LARGE ENGINE TEST FACILITIES ARE NOT CONFIGURED TO SATISFY NEEDS OF AIR FORCE "ORBIT-ON-DEMAND" VEHICLE.

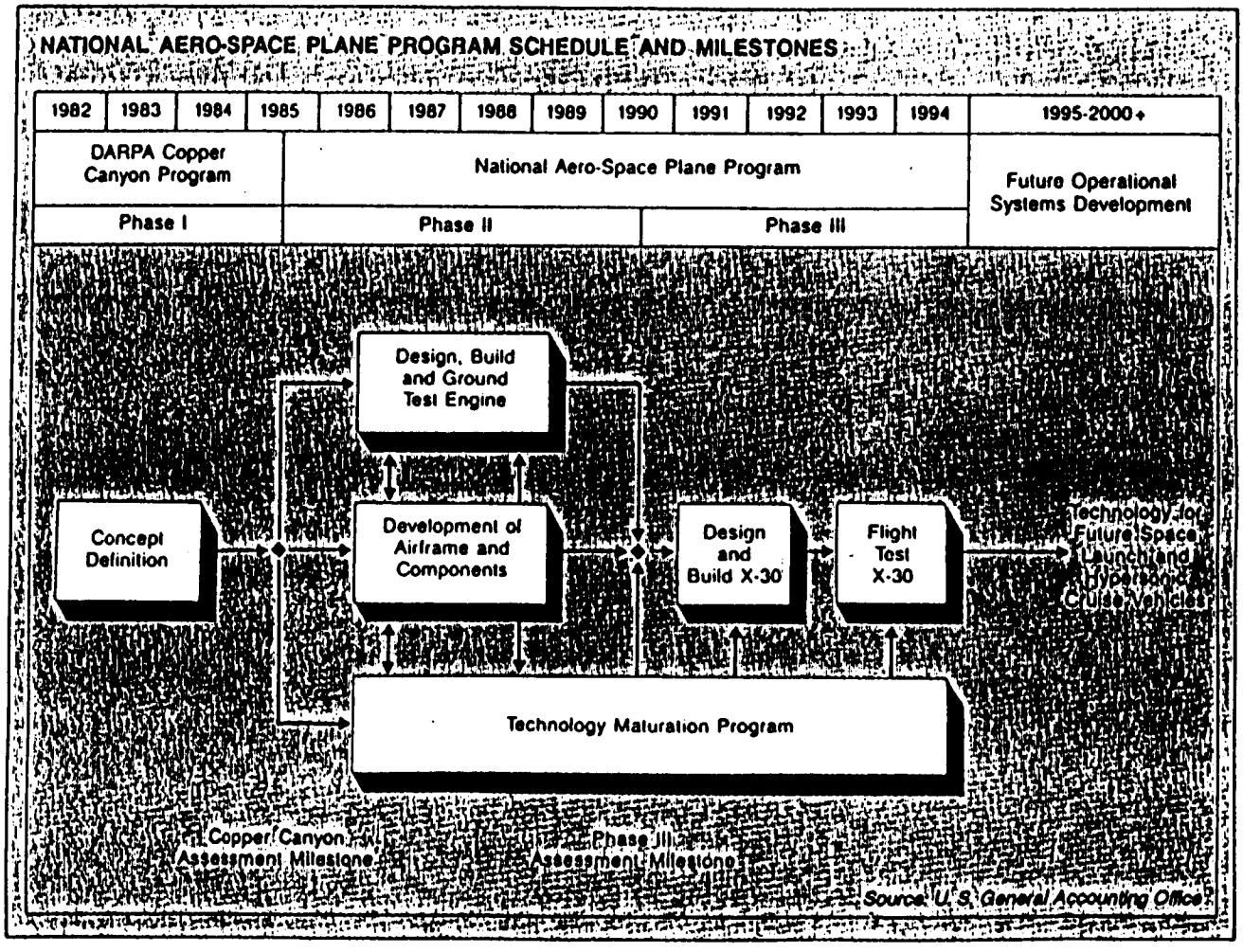
- THERE IS IMMEDIATE NEED FOR IMPROVEMENTS AND ADDITIONS TO SEVERAL CENTER "BACK-YARD" FACILITIES TO SUPPORT TECHNOLOGY ADVANCEMENT TESTING, AND SHUTTLE DEVELOPMENT AND OPERATIONS PROGRAMS SUPPORT.

- THERE ARE A LARGE NUMBER OF MEDIUM AND LARGE THRUST ENGINE AND SYSTEM TEST STANDS NOT IN ACTIVE USE AT BOTH GOVERNMENT AND CONTRACTOR SITES. MANY ARE BEING MAINTAINED; A FEW NOT. SOME SHOULD CONTINUE TO BE MAINTAINED BECAUSE OF LARGE INVESTMENT COST AND UNKNOWN FUTURE; OTHERS KEPT FOR SPARE PARTS; AND OTHER HAVE NO POTENTIAL USE AND SHOULD BE MADE AVAILABLE FOR DISPOSITION.

CHANGES

- **NATIONAL AEROSPACE PLANE**
- **ADVANCED LAUNCH SYSTEM**
- **SPACE EXPLORATION INITIATIVE**

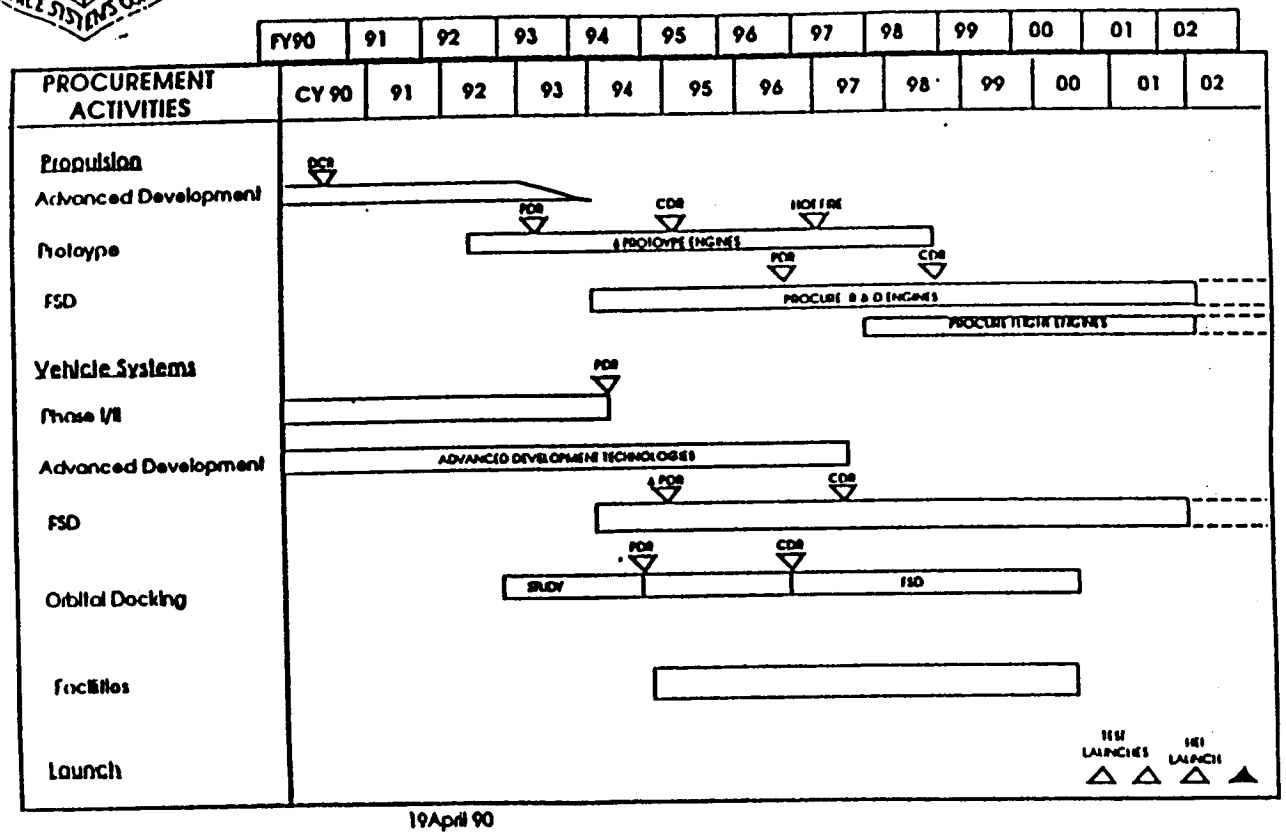
NATIONAL AERO-SPACE PLANE



ADVANCED LAUNCH SYSTEM

ADVANCED LAUNCH DEVELOPMENT PROGRAM SCHEDULE
(March 28, 1990 Aldrich Study)

NASA
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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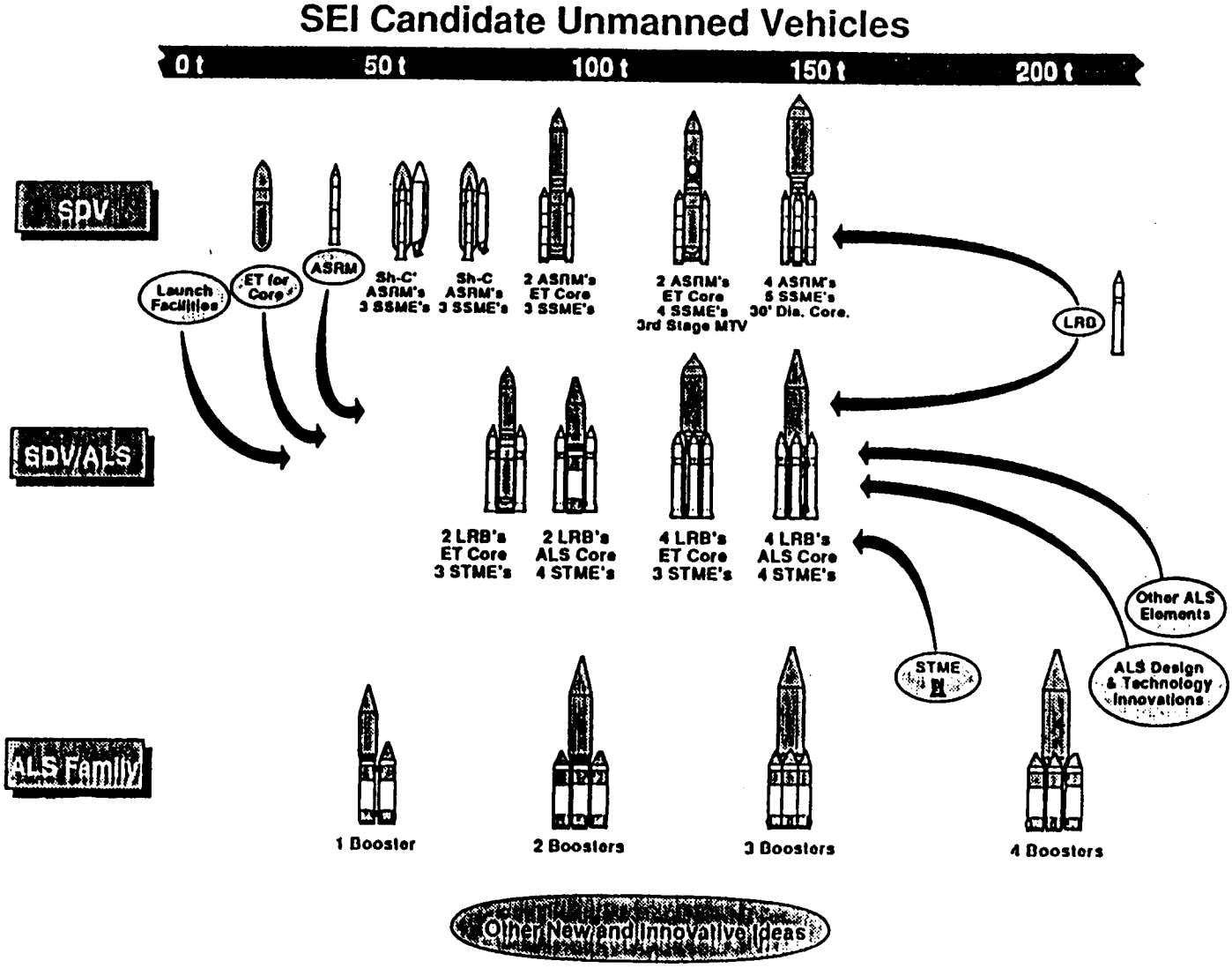
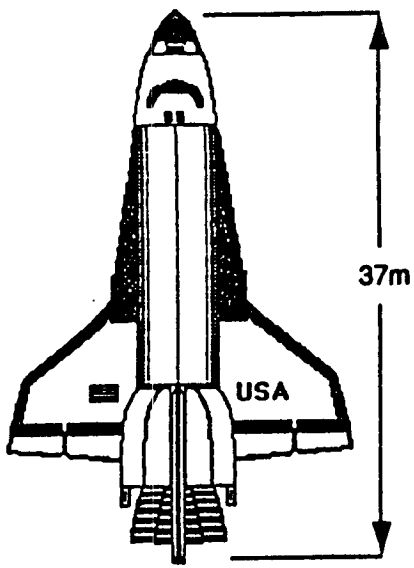
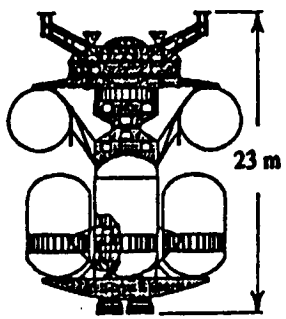

SEI Candidate Unmanned Vehicles
0 t
50 t
100 t
150 t
200 t
SDV
SDV/ALS
ALS Family
Launch Facilities
ET for Core
ASRM
Sh-C ASRM's 3 SSME's
Sh-C ASRM's 3 SSME's
2 ASRM's ET Core 3 SSME's
2 ASRM's ET Core 4 SSME's 3rd Stage MTV
4 ASRM's 5 SSME's 30' Dia. Core.
LRB
2 LRB's ET Core 3 STME's
2 LRB's ALS Core 4 STME's
4 LRB's ET Core 3 STME's
4 LRB's ALS Core 4 STME's
Other ALS Elements
STME
ALS Design & Technology Innovations
1 Booster
2 Boosters
3 Boosters
4 Boosters
Other New and Innovative Ideas

NASA

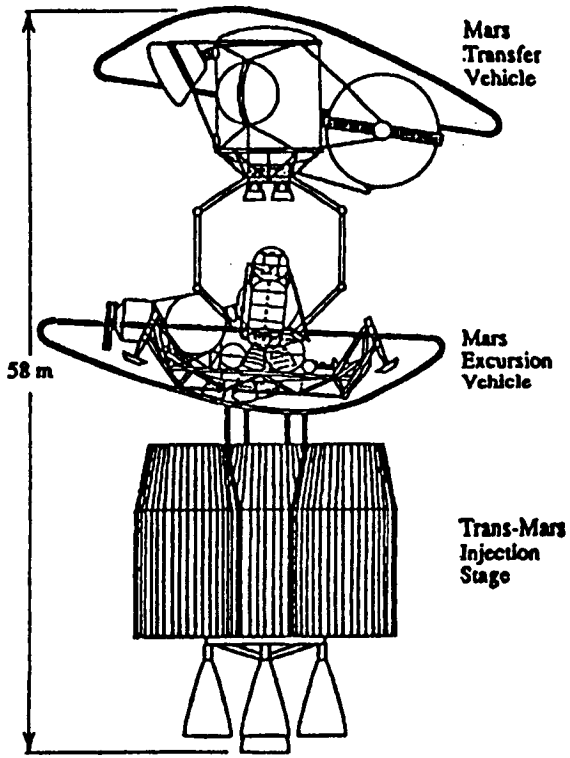
SHUTTLE AND LUNAR/MARS TRANSFER VEHICLES



37m



23 m



58 m

Space Shuttle
Mass = 92 metric tons
(Payload = 22 metric tons)

Lunar Transportation System
Mass = 200 metric tons

Mars Transportation System
Mass = 800 metric tons

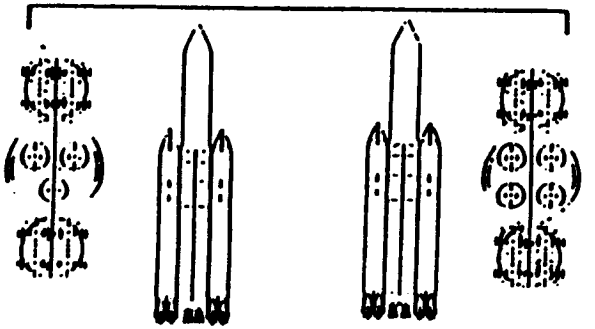
LRB/SDV OPTIONS

ET CORE

ET GROWTH

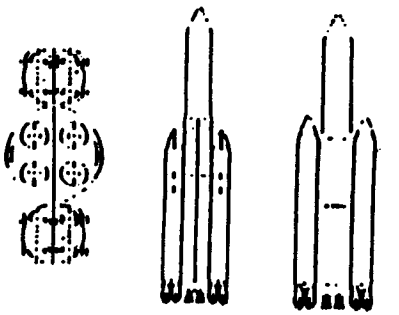
BOOSTER
- EXP SH NOZ SSME

CORE
- EXP SSME



90t

98t

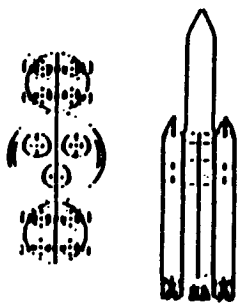


108t

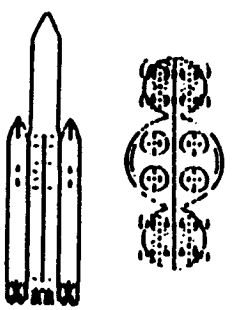
~181L PROP

BOOSTER
- SH NOZ STE

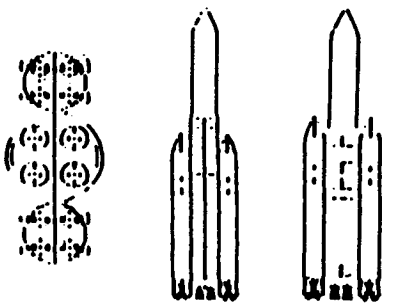
CORE
- EXP SSME



86t



93t

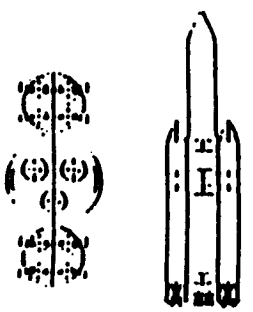


104t

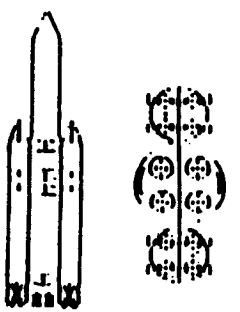
~200L PROP

BOOSTER
- SH NOZ STE

CORE
- STE



80t



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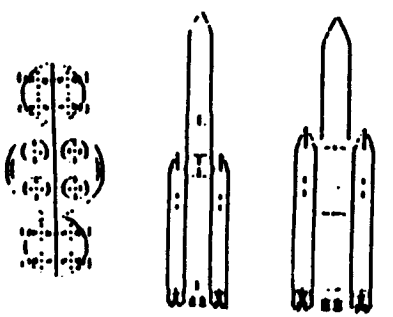
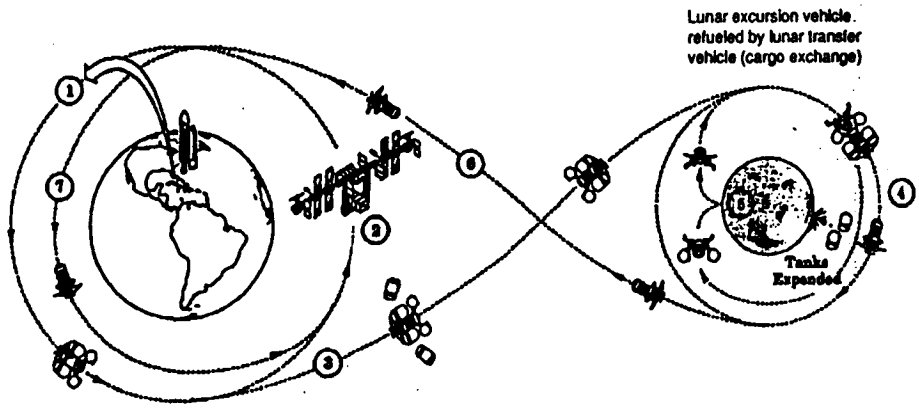


92t

~363L PROP

NASA

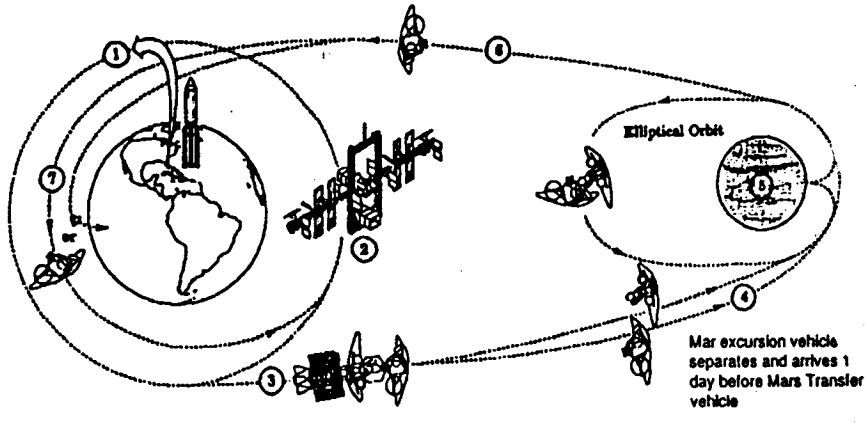
LUNAR MISSION PROFILE



1. Payload Delivered to Space Station Freedom
2. Lunar Transfer Vehicle Mated with Payload at Freedom
3. Trans-Lunar Phase with Lunar Transfer Vehicle
4. Lunar Transfer Vehicle Rendezvous with Lunar Excursion Vehicle from Moon
5. Excursion Vehicle Returns to Moon with Payload
6. Trans-Earth Phase with Transfer Vehicle
7. Transfer Vehicle Aerobrake Maneuver and Return to Freedom

NASA

MARS MISSION PROFILE

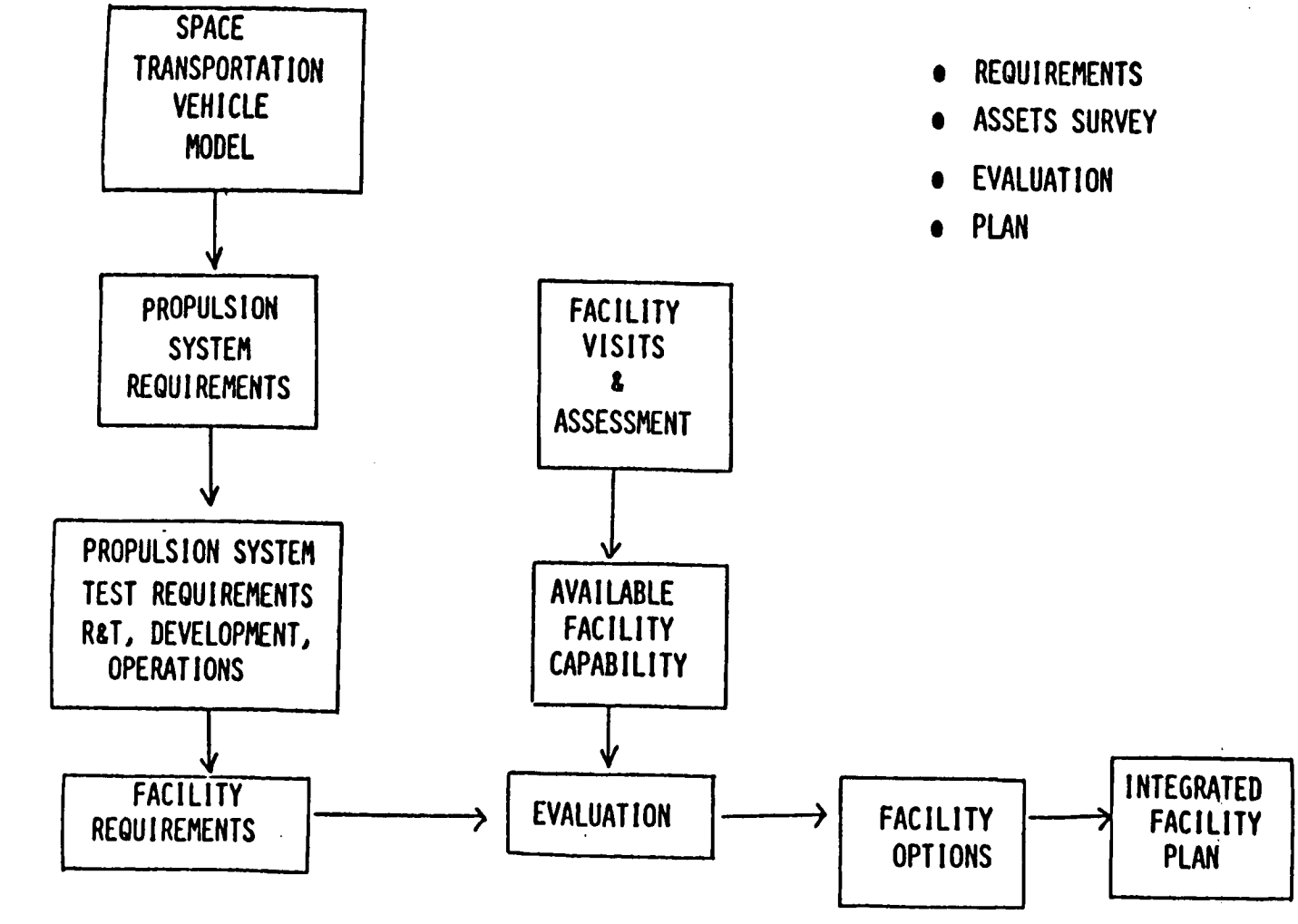


1. Payload Delivered to Space Station Freedom
2. Mars Transfer Vehicle Mated with Payload at Freedom
3. Trans-Mars Phase with Lunar Transfer Vehicle
4. Mars Transfer Vehicle Remains in Mars Orbit; Mars Excursion Vehicle Descends to Surface
5. Excursion Vehicle to/from Mars Surface
6. Trans-Earth Phase with Transfer Vehicle
7. Transfer Vehicle Aerobrake Maneuver and Return

LIFE CYCLE COST BASED DECISIONS RATIONALE

- FACILITY ASSESSMENT TEAM CHARTER
- FUTURE PROGRAM REQUIREMENTS
- CAPITAL INVESTMENT VS O&M COSTS

SCOPE



LIFE CYCLE COST

THE TOTAL COST OF A FACILITY - INCLUDING THE INITIAL CAPITAL INVESTMENT AND ALL OPERATING AND MAINTENANCE COSTS FOR THE LIFE OF THE PROGRAM.

RECOMMENDATION

- ESTABLISH A PROPULSION TEST WORKING GROUP WITHIN NASA - SEPARATE PANEL OF PROPULSION WORKING GROUP.
- DEVELOP A FINITE MODEL FOR COST ANALYSIS OF ALTERNATE SITES FOR PROPULSION TEST
- SUBJECT ALL CANDIDATE SITES TO INDEPENDENT ANALYSIS - NASA HEADQUARTERS LEAD
- PROGRAM DECISION BASED ON INDEPENDENT ASSESSMENT

APPLICABILITY

- NEW PROGRAM STARTS
- MAJOR PROGRAMMATIC CHANGES