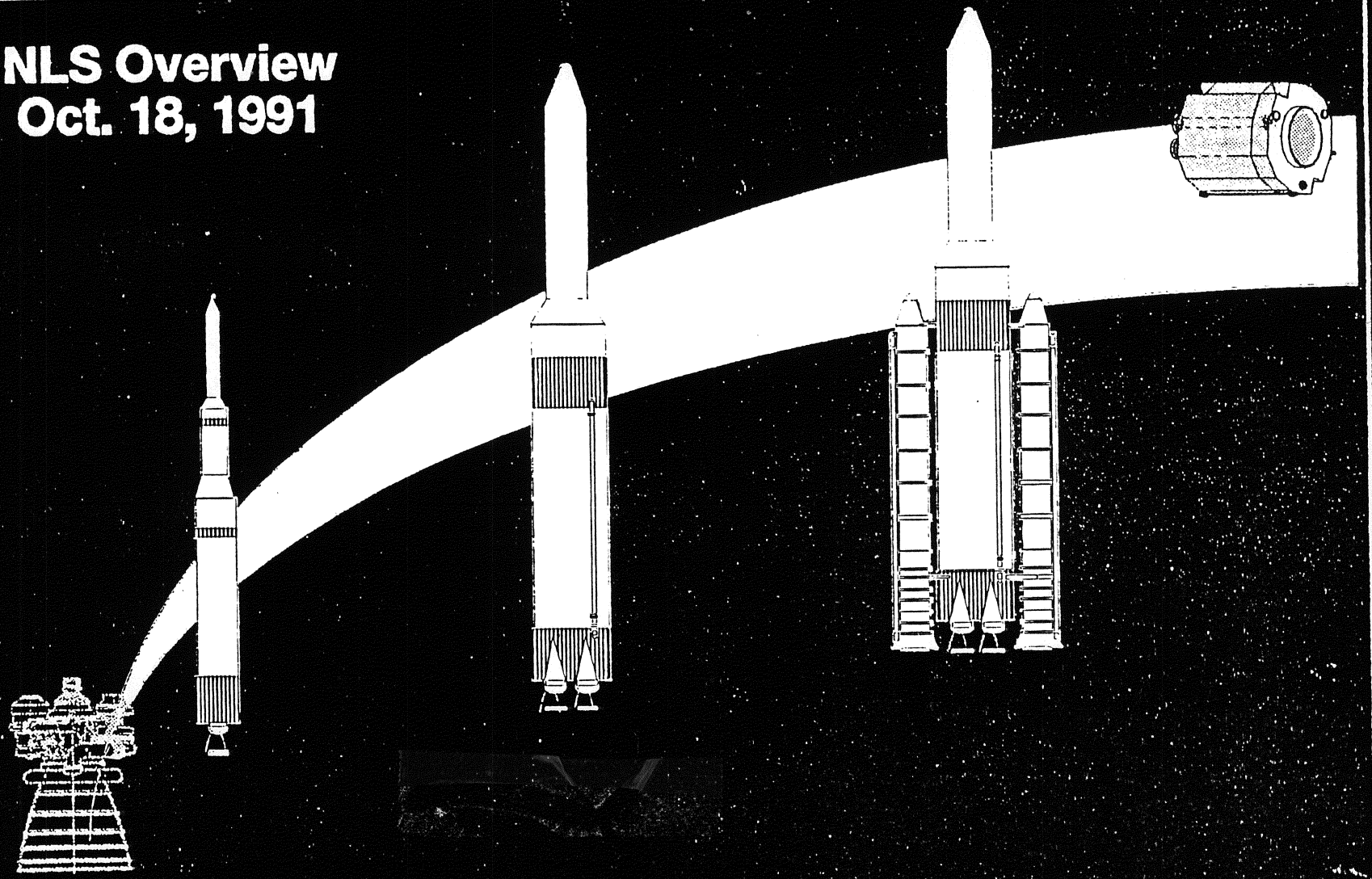
NLS PROGRAM

NLS Overview
Oct. 18, 1991



Agenda

• Overview
  • Background
  • Vehicle Heritage
  • Management Structure
	Porter Bridwell

• Cost Estimates	Joe Hamaker
• Acquisition Planning	Lowell Zoller
• MSFC Design & Verification Approach	Len Worlund
• Evolution	Uwe Hueter

AUGUSTINE COMMITTEE RECOMMENDATIONS

- OFF-LOAD STS IN ALL BUT THE INITIAL PHASES OF SSF DEPLOYMENT
- PROVIDE AN EVOLUTIONARY VEHICLE, POTENTIALLY CAPABLE OF FULFILLING THE SEI REQUIREMENTS
- INCORPORATE ADVANCED LAUNCH VEHICLE TECHNOLOGIES WHERE AND WHEN FEASIBLE
- REDUCE OPERATIONAL MANPOWER REQUIREMENTS
- THE VEHICLES SHOULD BE CAPABLE OF BEING MAN-RATED

DOD CONCERNS

- CAPACITY CONSTRAINED AT LAUNCH COMPLEXES AND RANGES
- SCHEDULE DRIVEN BY HARDWARE AVAILABILITY
- LIMITED RESILIENCY FOR CATASTROPHIC FAILURE
- BOOSTERS TIED TO SPECIFIC PAYLOAD DESIGNS
- OBSOLETE AND DECAYING LAUNCH OPERATIONS SUPPORT ELEMENTS
- INCREASING ENVIRONMENTAL IMPACTS
- INADEQUATE TECHNOLOGY INVESTMENT
- HIGH LAUNCH COSTS

NATIONAL SPACE COUNCIL DIRECTION
APRIL 16, 1991

DOD AND NASA WILL JOINTLY FUND AND MANAGE THE DEVELOPMENT OF A NEW SPACE LAUNCH SYSTEM THAT WILL:

- GREATLY IMPROVE NATIONAL LAUNCH CAPABILITY
- REDUCE OPERATING COSTS
- IMPROVE RELIABILITY, RESPONSIVENESS AND MISSION PERFORMANCE
- SUPPORT A RANGE OF MEDIUM TO HEAVY LIFT REQUIREMENTS
- FACILITATE EVOLUTIONARY CHANGE AS REQUIREMENTS EVOLVE
- MAY TAKE ADVANTAGE OF EXISTING COMPONENTS
- INITIALLY UNMANNED, BUT DESIGNED TO BE MAN-RATABLE

IN THE NEAR TERM PLAN FOR FIRST FLIGHT IN 1999

- MAINTAIN FLEXIBILITY FOR SEVERAL SCHEDULE OPTIONS
- IDENTIFY KEY INTERMEDIATE MILESTONES
- FINAL DECISION WILL BE MADE DURING 1993

What Is The Vehicle Heritage?

New

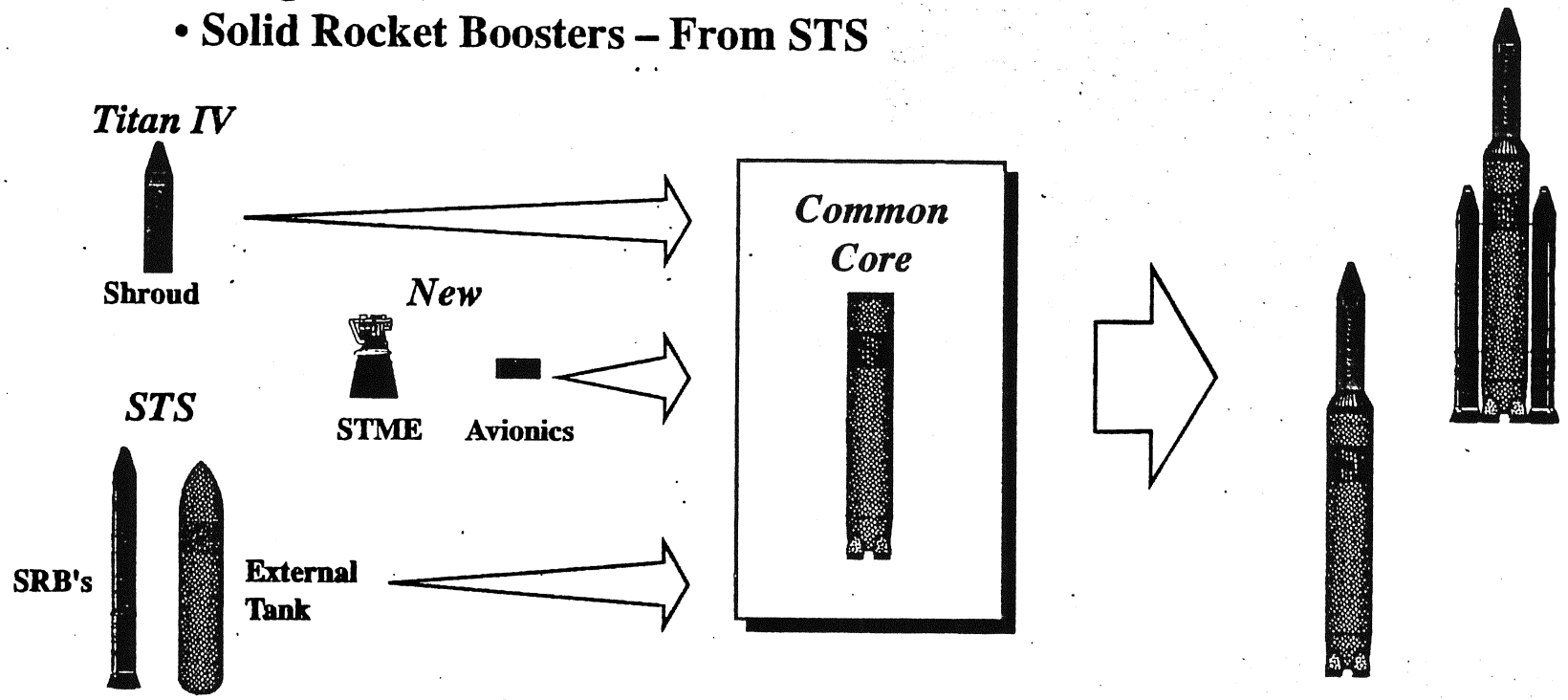
- **Space Transportation Main Engine (STME)**
- **Avionics – State-of-the-Art. No Advanced Requirements**

Derived

- **Tankage (Core) – STS External Tank – Minimum Modifications**
- **Payload Fairing – From Titan IV**

Existing

- **Solid Rocket Boosters – From STS**

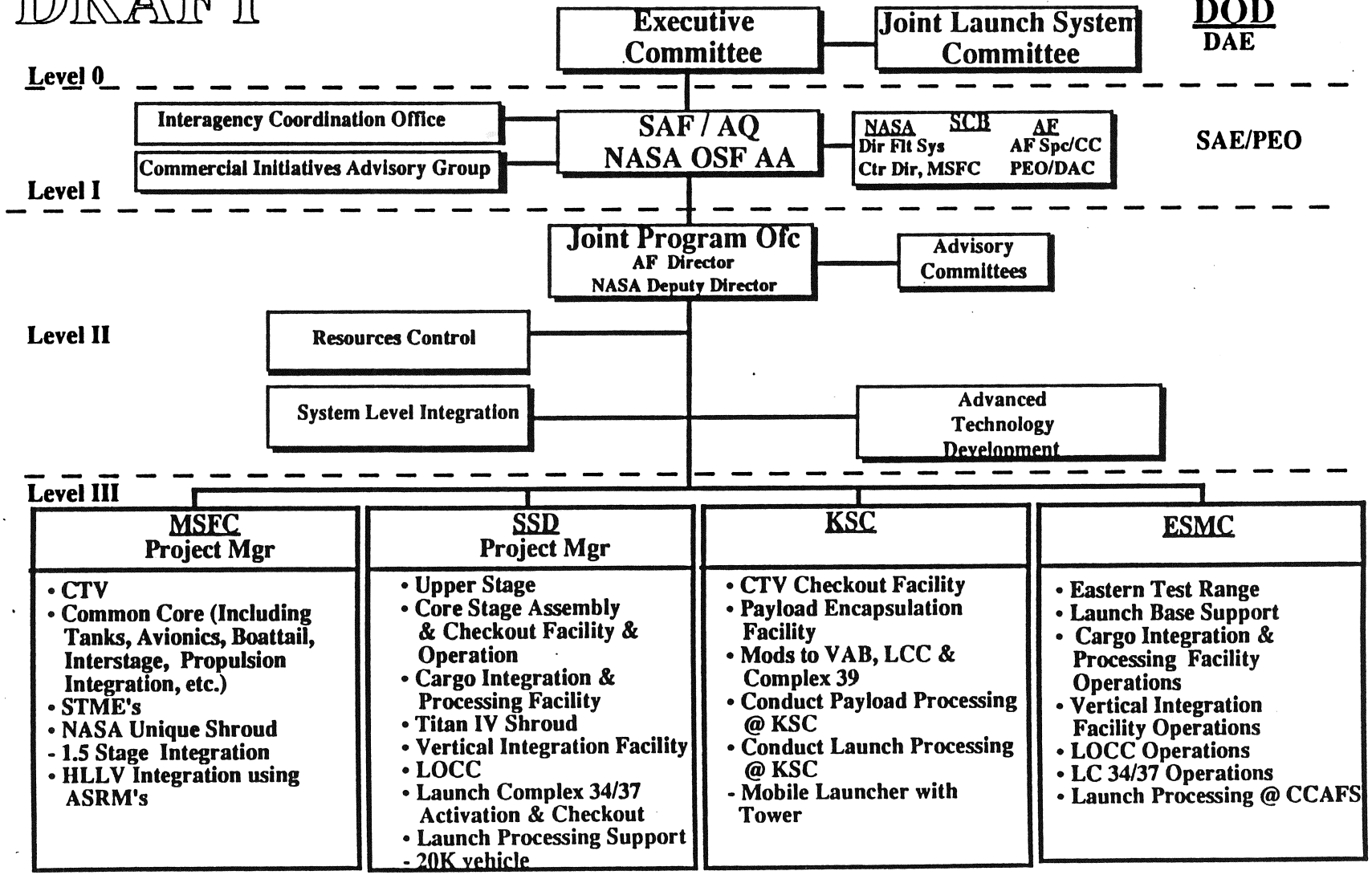


Management Approach

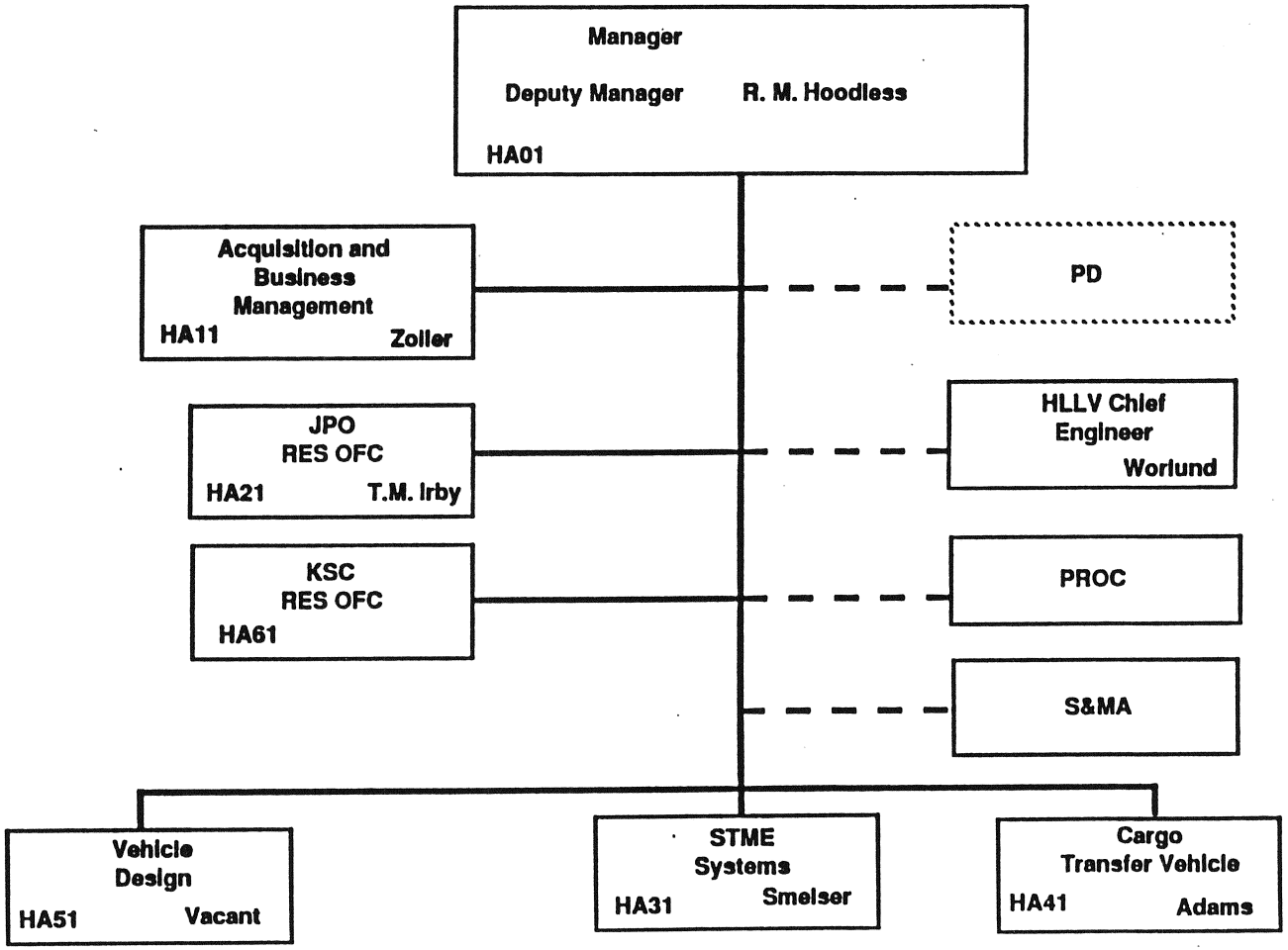
- A Program Managed By The Joint Project Office At Space Division
- An Intense Government (AF/NASA) & Industry Definition Phase Lead By The Government
- Initiate Development Of New Engine Early
- Hardware/Facility Infrastructure Development Accomplished At Level III
- Management Team In Place During Definition Phase To Assure Orderly & Responsible Transition To Hardware
- Procurement Approach For System Elements To Assure Hardware/Integration Responsibility

MANAGEMENT STRUCTURE

DRAFT



Heavy Lift Launch Vehicle Definition Office



COST ESTIMATES

NLS Cost Estimating

Background

- ALS and Shuttle-C concepts and costs had been worked for several years
- Numerous NLS concepts emerged in late 1990
- Activities focused down to NLS baseline in February 1991

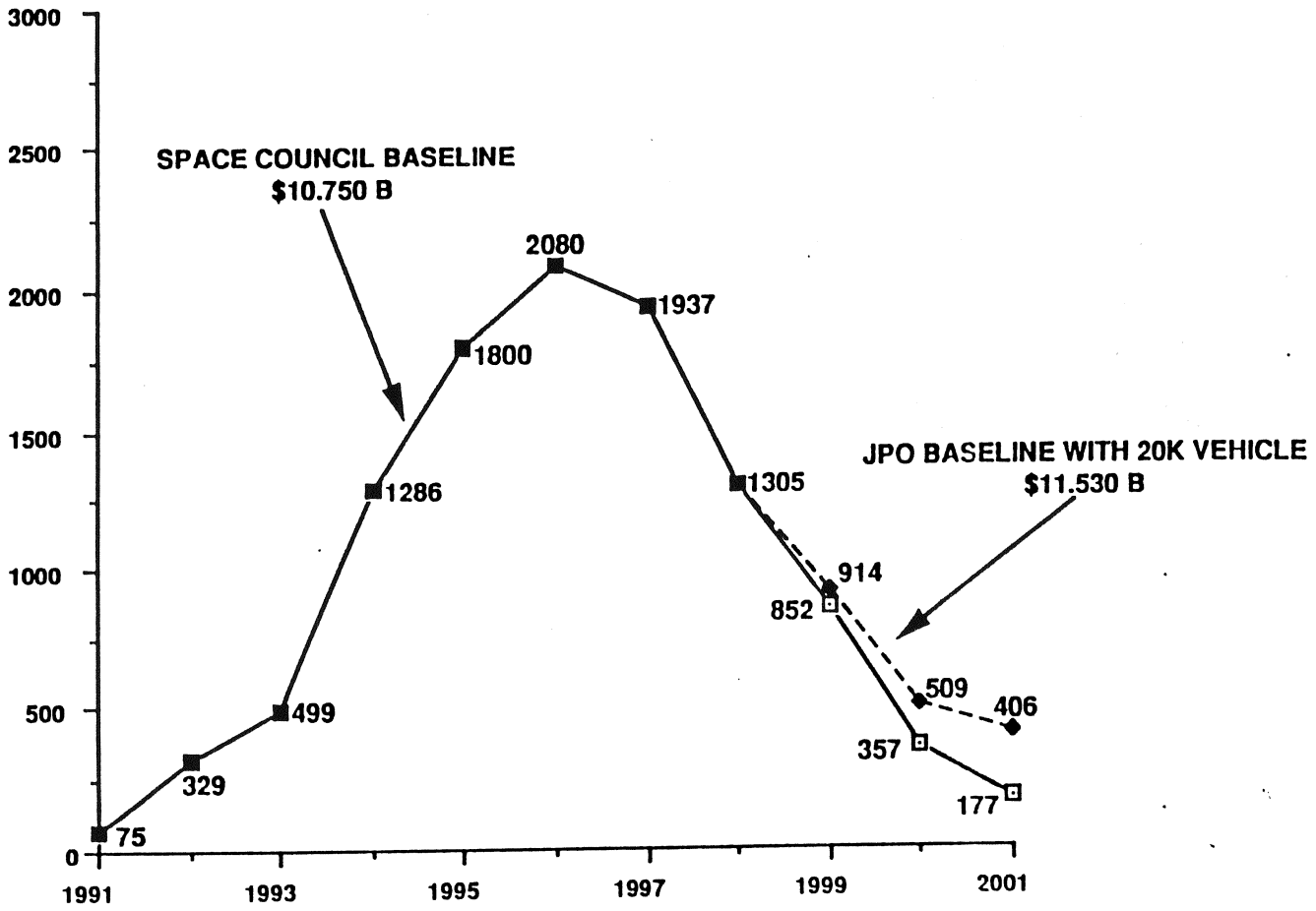
February 1991 NLS Baseline Cost Estimate

- $10.7 billion development estimate
- Based on conceptual definition and preliminary estimating
- Jointly prepared by NASA HQ, JPO/Tecolote, MSFC, KSC
- Briefed to Space Council
- Served as basis for NASA and DOD 1992 budget cycle inputs
- Adapted as design to cost goal

JOINT PROGRAM DEVELOPMENT ESTIMATE
(FY91 $M)

PROGRAM DEFINITION		$ 79	Pre-Full Scale Development
ADVANCED DEVELOPMENT		410	
STME DEVELOPMENT & FACILITIES		2540	Ground Testing to Support 1st flight
CORE STAGE DEVELOPMENT		3131	External Tank / Prop. Mod. / Str.
SHROUD ADAPTER		42	New Transition Structure
CARGO TRANSFER VEHICLE DEVELOPMENT		700	New Stage / Single Prop. Module
GEOSYNCH CAPABILITY DEVELOPMENT		500	New Upper Stage / RL10-A4 Engines
FACILITIES:		2361	
KSC	(540)		Mod STS Launch Facilities
CCAFS	(1585)		New Facilities
MICHOUD	(87)		Mod External Tank Facilities
SSC	(104)		B2 Mod for MPTA
MSFC	(45)		Mod Test Facilities
MICHOUD TOOLING		113	
LAUNCH MGMT. & CNTRL. SYS.		635	
DEVELOPMENT SUBTOTAL		10511	
FIRST FLIGHT HARDWARE (50K VEHICLE B/L)		239	Core / 6 STME's / T-IV Shroud
SUBTOTAL		10750	Space Council B/L
20K VEHICLE & SHROUD DEVELOPMENT		297	
CCAFS FACILITIES		483	
TOTAL		11530	JPO B/L
NASA SHROUD & ADAPTER		163	Modified 60' Titan IV Shroud
STME CERTIFICATION COMPLETION		524	90% Confidence Testing
TOTAL		12217	

NLS JOINT PROGRAM DEVELOPMENT ESTIMATE
(FY91 $M)



NATIONAL LAUNCH SYSTEM

MSFC PROGRAM SUPPORT AND FACILITIES COSTS
(MILLIONS OF FY 91$)

MSFC PROGRAM SUPPORT	FY 92	93	94	95	96	97	98	99	00	TOTAL
CORE DEVELOPMENT		7	53	88	92	65	29	3	3	340
CTV DEVELOPMENT				4	17	25	21	10	2	79
STS COMPATIBLE SHROUD		2	4	6	6	4	1	1		24
STME	17	39	47	60	84	97	81	52		477
MSFC FACILITIES			10	20	15					45

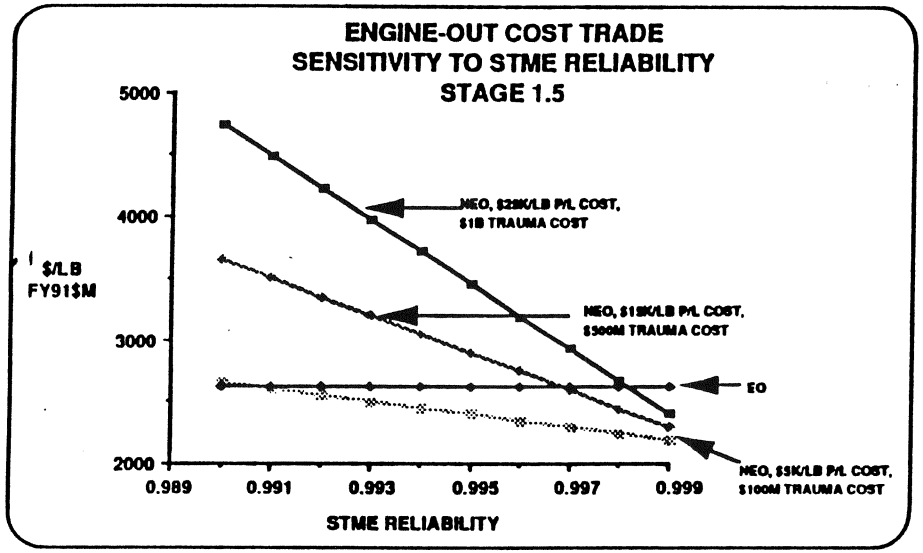
MPS-LOX
LH2 SIMULATOR
MVGVT
CRYOGENIC STR. TEST FAC.
VEH. AVIONICS SIM. LAB
STR. STATIC LOAD TOWER
HYDR. & EMA LAB

NOTE: COST BASED ON FEB. 1991 B/L ESTIMATE WITH TOTAL FUNDING IN FY 92 OF 350m RY$

FY 1992 Budget Impacts

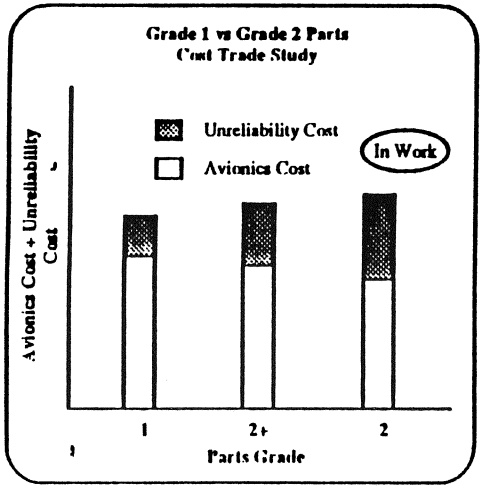
	February 1991 Baseline Estimate	Probable FY 1992 Budget Reality
FY 1992 funding availability (NASA + DOD)	$350M	$150M?
STME FSD start	FY 1992 (Hot Firing FY 1995)	FY 1992 (Delay Hot Firing To FY 1996)
Vehicle FSD start	FY 1993	FY 1995?
First flight	1999	2001?
Development estimate	$10.7B	TBD (SBE being developed) (Add 20K Vehicle)
Space Council decision on FSD	1993	1993
NAR and DAB reviews	Spring/Summer 1992	Spring/Summer 1992

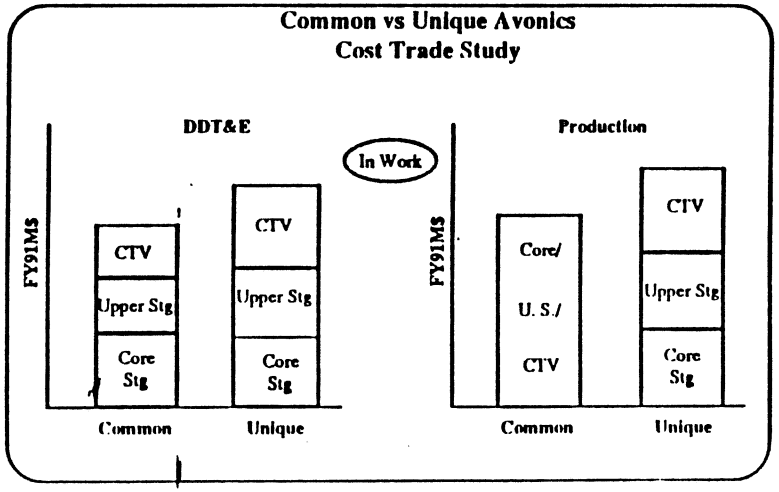
Cost Support To NLS Trade Studies

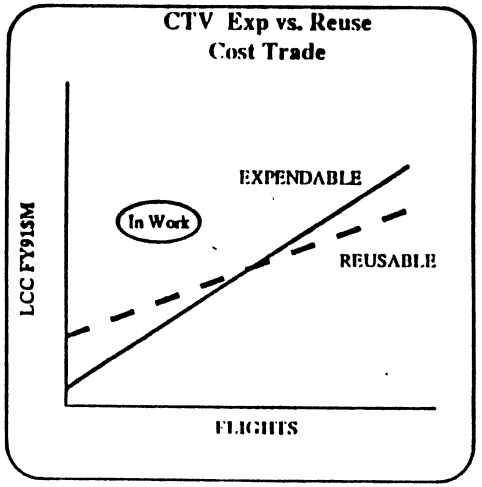


CPACK Avionics Estimate
FY91$M

	DDT&E Cost	Unit Cost
Communication	$7.54	$3.60
C&DH	$10.44	$5.02
GN&C	$22.13	$3.26
	$40.11	$11.88

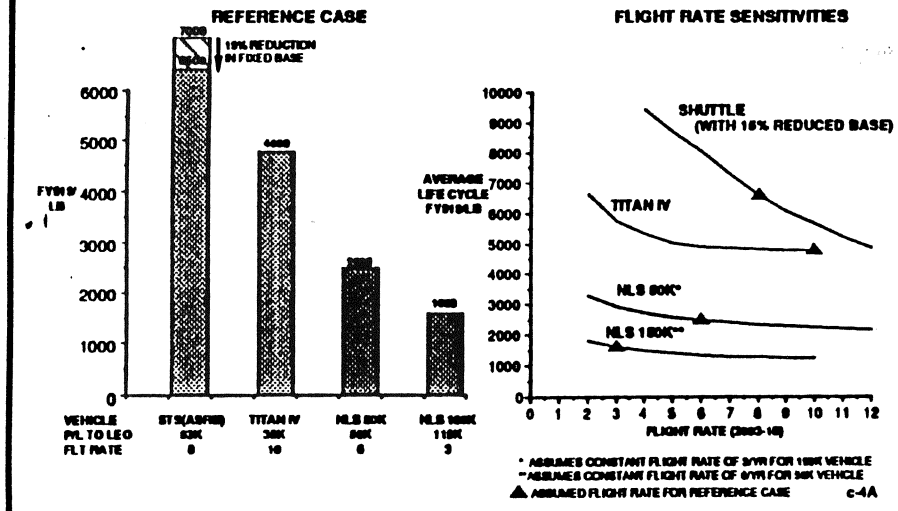




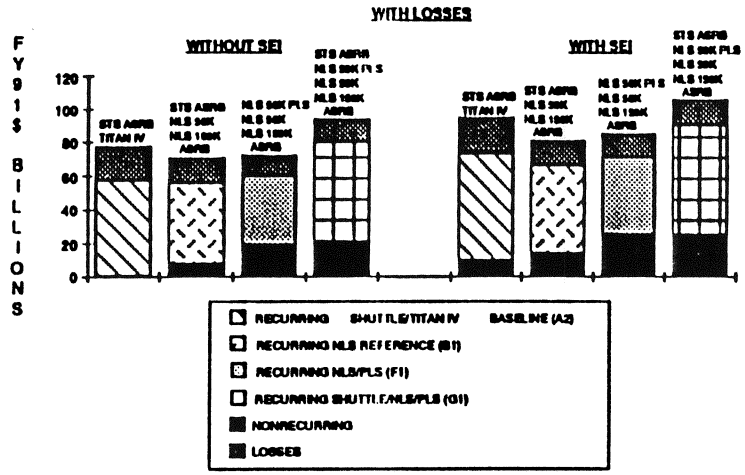


NLS Comparative Economic Studies

$1lb LEO Trends

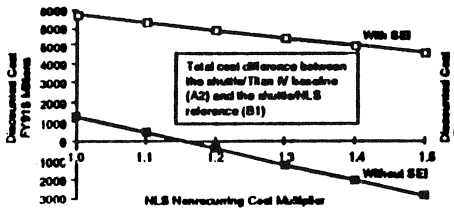


Discounted Total Launch Cost of Payload to LEO and SSF Orbits

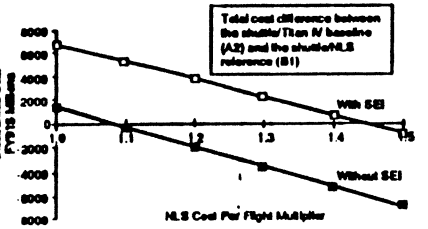


Other Key Sensitivities

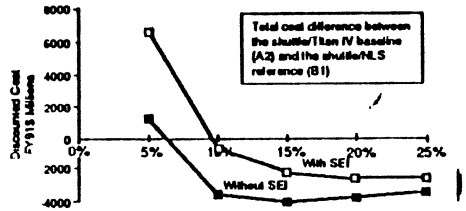
NLS Nonrecurring Cost Benefit Sensitivities



NLS Cost Per Flight Benefit Sensitivities



Discount Rate Benefit Sensitivities

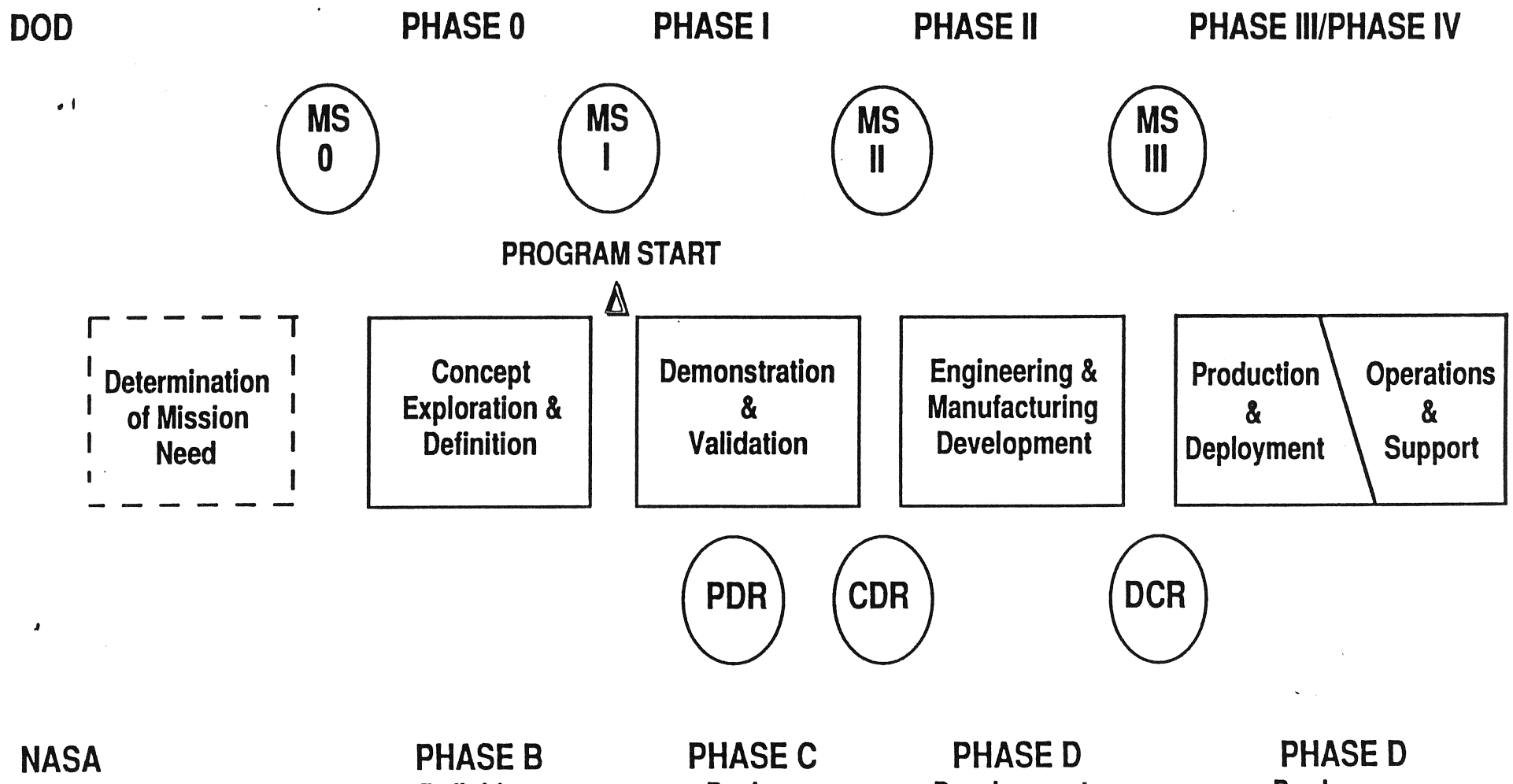


Concluding Observations

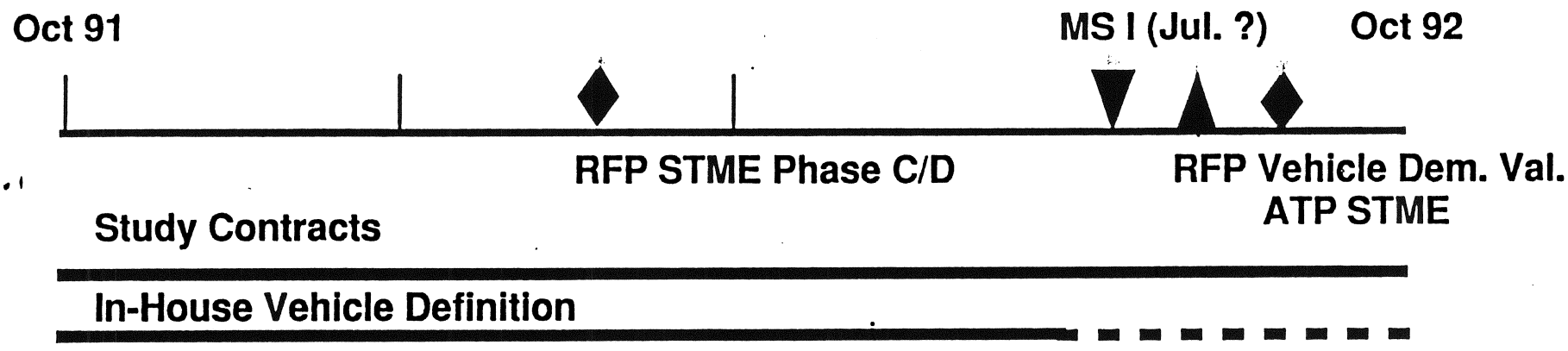
- **Without SEI and Without Losses, the Reference NLS Architecture Maintains Positive Benefits at a 5% Discount Rate When Compared to the Shuttle/Titan Baseline**
  - The Addition of SEI Traffic Significantly Increases the NLS Advantage
  - The Addition of Losses Further Magnifies NLS Savings
- **Introduction of PLS...**
  - As a Shuttle Replacement, Offers Lower Overall Recurring Operations Cost
    - PLS/CRV Development, However, Is Not Amortized At A 5% Discount Rate by the Above Savings
  - As An Adjunct to Shuttle, Offers Redundancy but at Higher Recurring Cost Than The NLS Reference (but Lower Recurring Cost than the Shuttle/Titan Baseline)

ACQUISITION PLANNING

PHASED PROJECT PLANNING TERMINOLOGY

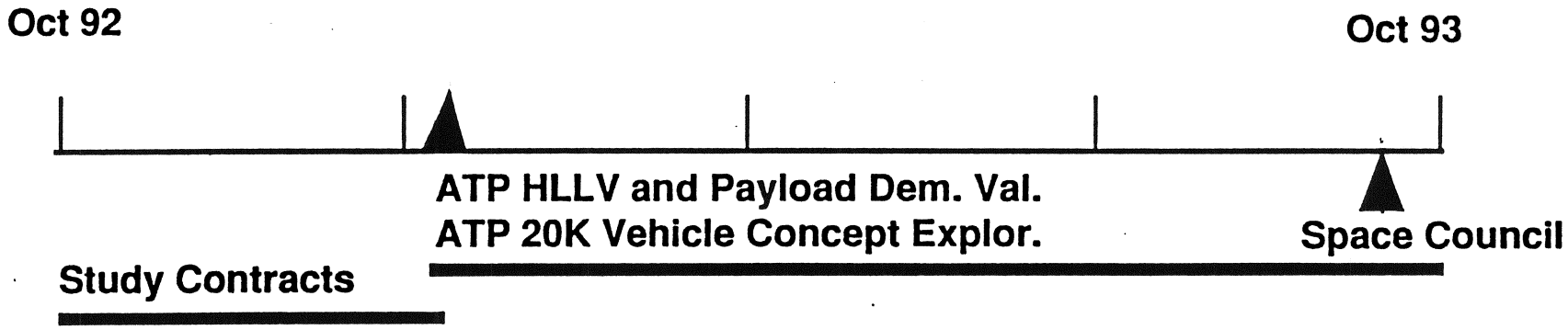


ACQUISITION STRATEGY
FY 92



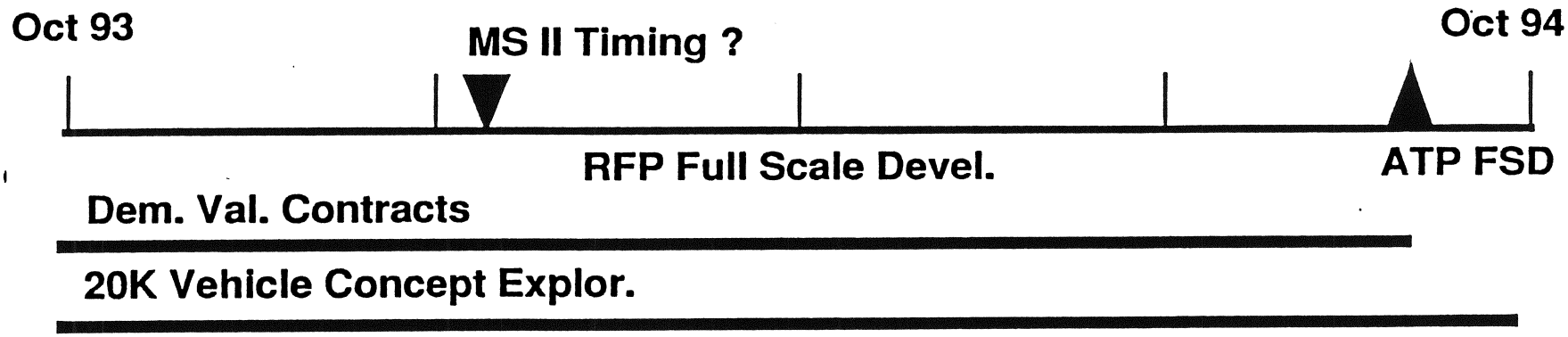
- Level II Integration to be done by Government (Ballistic Missile Office and MSFC)
- Implement Space Transportation Main Engine (STME) Development
- Approximately 10 Vehicle Study Contracts to be Extended Until Demonstration Validation ATP)
- Need to Press Hard for Early Program Authority (Defense Acquisition Board, Milestone I)
- Release RFPs After Milestone I (Up to 3 Contracts Each)
  - HLLV (Demonstration-Validation = NASA Phase C) - MSFC
  - Payload Accommodation-Cargo Transfer Vehicle & Shroud (Demonstration-Validation = NASA Phase C) - MSFC
  - 20K Vehicle (Concept Exploration = NASA Phase B) - USAF

ACQUISITION STRATEGY
FY 93



- Up to 3 Teams for Demonstration - Validation Contracts
  - Develop Ownership of In-house Study, Explore Team Innovations, Proof of Concept, and Programmatic Planning
  - Necessity to Pursue Vehicle and Payload Accommodations Simultaneously
  - External Tank Contractor Would Have to be a Directed Subcontractor (Core Vehicle)
  - Provisions for Down-Selection to Single Contractor for Full Scale Development

ACQUISITION STRATEGY
FY 94



- Downselect from Dem.-Val. Contracts to Single Full Scale Development (FSD) Contracts (Teams) After Milestone II Review

  Vehicle
  - Core Vehicle Contract (Incl. Vehicle Analytical Integration) - MSFC
  - Launch Processing Contract - KSC
  - Launch Processing Contract - CCAFS

  Payload Accommodations
  - CTV/Shroud Contract (Incl. Payload Analytical Integration) - MSFC
  - Payload Processing Contract - KSC
  - Payload Processing Contract - CCAFS

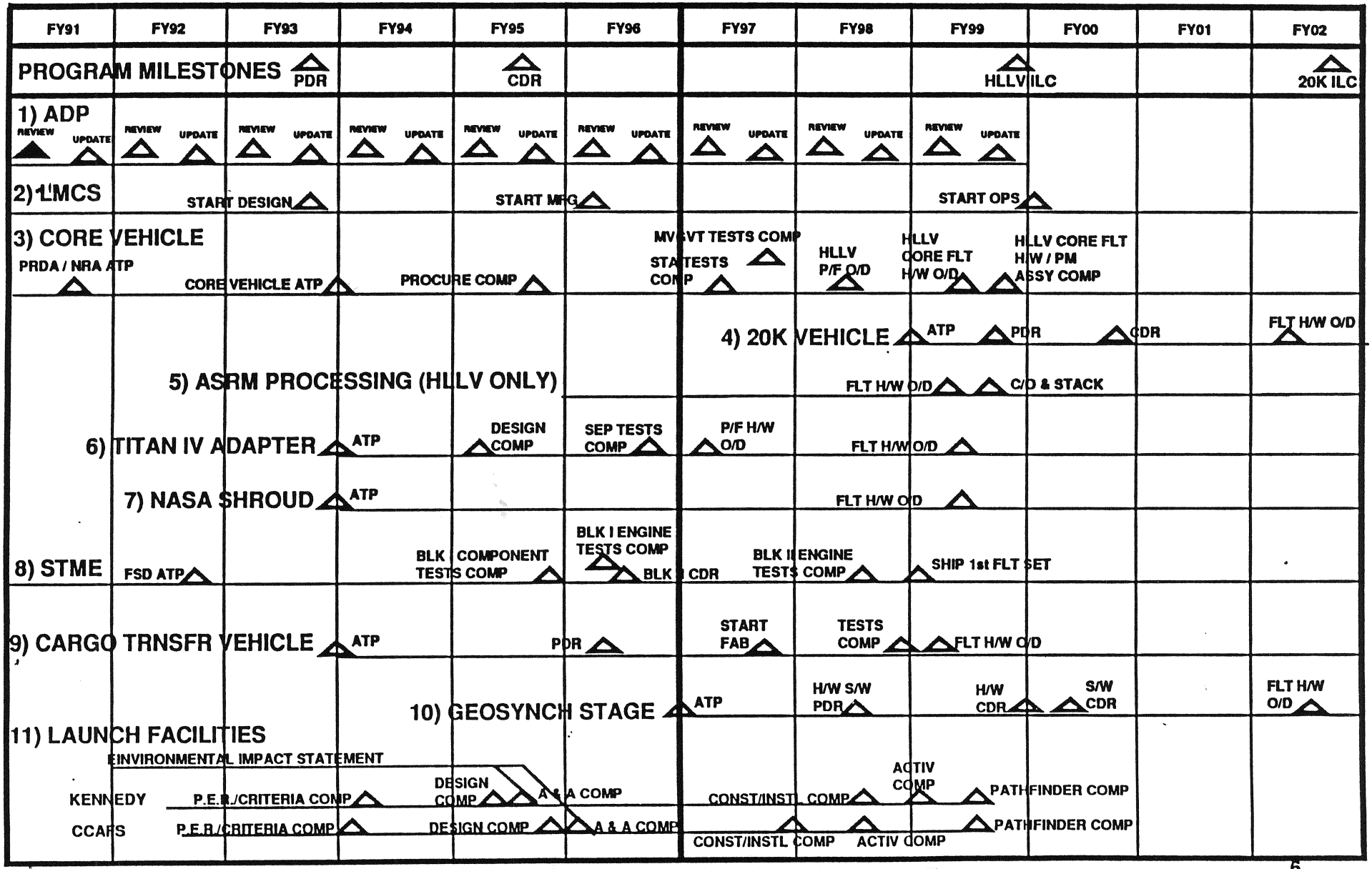
- Separate Procurements for Facilities - KSC & CCAFS

- Subsequent Procurements for 20K Vehicle and Upper Stage - USAF

NLS PROGRAM MASTER SCHEDULE

FOR PLANNING PURPOSES ONLY

AS OF 23 AUG 91



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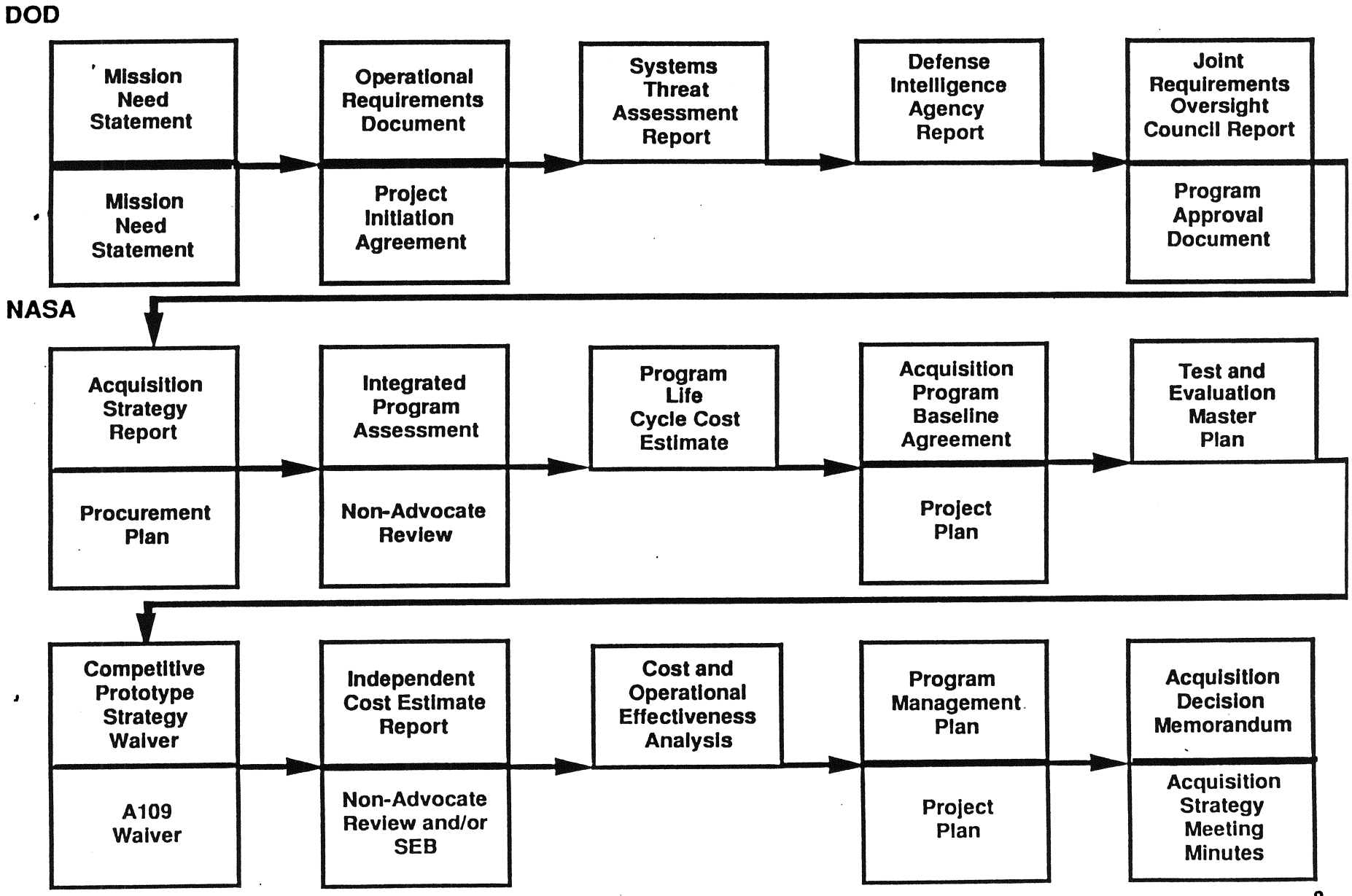
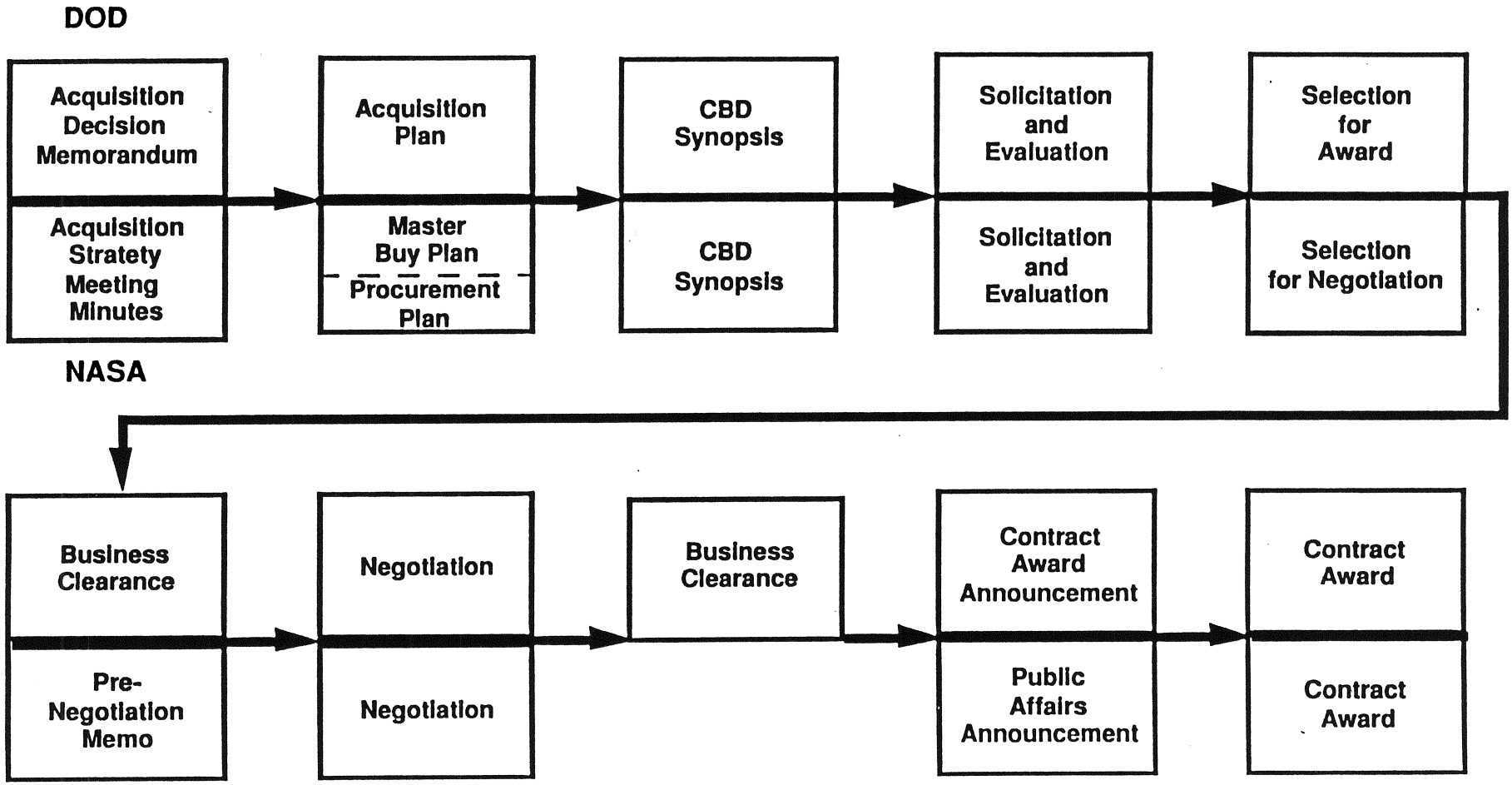
DOD/NASA NEW START PROCESS



PRELIMINARY

DOD/NASA PROCUREMENT PROCESS



MSFC DESIGN AND VERIFICATION APPROACH

DESIGN VERIFICATION & APPROACH

- CONDUCT DEFINITION STUDY THAT PRODUCES VALIDATED REQUIREMENTS AND DESIGNS FOR FULL SCALE DEVELOPMENT.

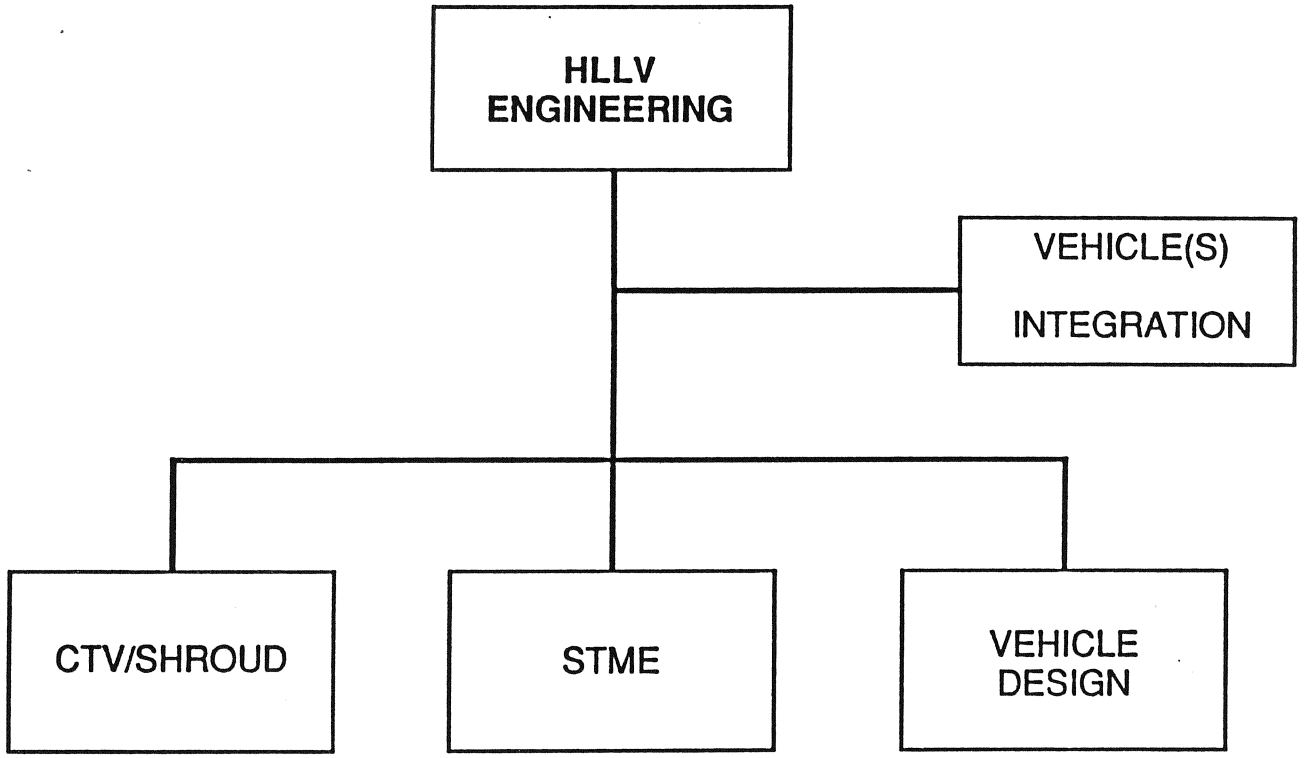
- JOINT DOD/NASA LED STUDY THAT SPANS ENTIRE NLS PROGRAM WITH FOCUSSED CONTRACTOR SUPPORT IN AREAS OF INTEREST AND EXPERTISE.

    - LEVEL II TRADE STUDIES AND SYSTEM INTEGRATION - JPO
    - LEVEL III DESIGN/INTEGRATION - MSFC

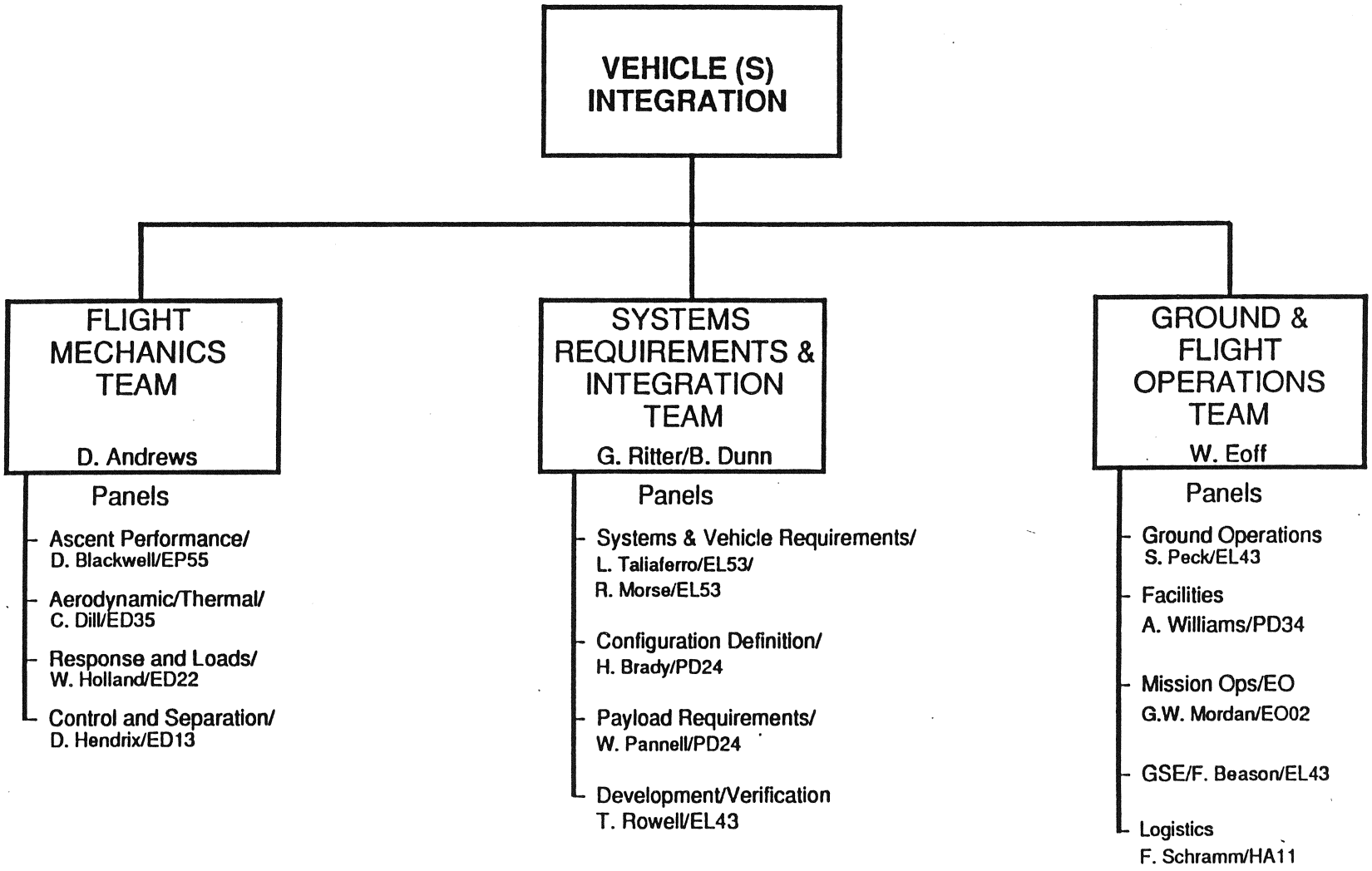
        - VEHICLE INTEGRATION
        - VEHICLE DESIGN
        - CTV/SHROUD
        - STME

- MAINTAIN FULL AND OPEN COMPETITION FOR DEVELOPMENT

    - OPEN DATA RIGHTS


HLLV
ENGINEERING
VEHICLE(S)
INTEGRATION
CTV/SHROUD
STME
VEHICLE
DESIGN

10/1/91


VEHICLE (S) INTEGRATION
FLIGHT MECHANICS TEAM
D. Andrews
Panels
Ascent Performance/ D. Blackwell/EP55
Aerodynamic/Thermal/ C. Dill/ED35
Response and Loads/ W. Holland/ED22
Control and Separation/ D. Hendrix/ED13
SYSTEMS REQUIREMENTS & INTEGRATION TEAM
G. Ritter/B. Dunn
Panels
Systems & Vehicle Requirements/ L. Taliaferro/EL53/ R. Morse/EL53
Configuration Definition/ H. Brady/PD24
Payload Requirements/ W. Pannell/PD24
Development/Verification T. Rowell/EL43
GROUND & FLIGHT OPERATIONS TEAM
W. Eoff
Panels
Ground Operations S. Peck/EL43
Facilities A. Williams/PD34
Mission Ops/EO G.W. Mordan/EO02
GSE/F. Beason/EL43
Logistics F. Schramm/HA11

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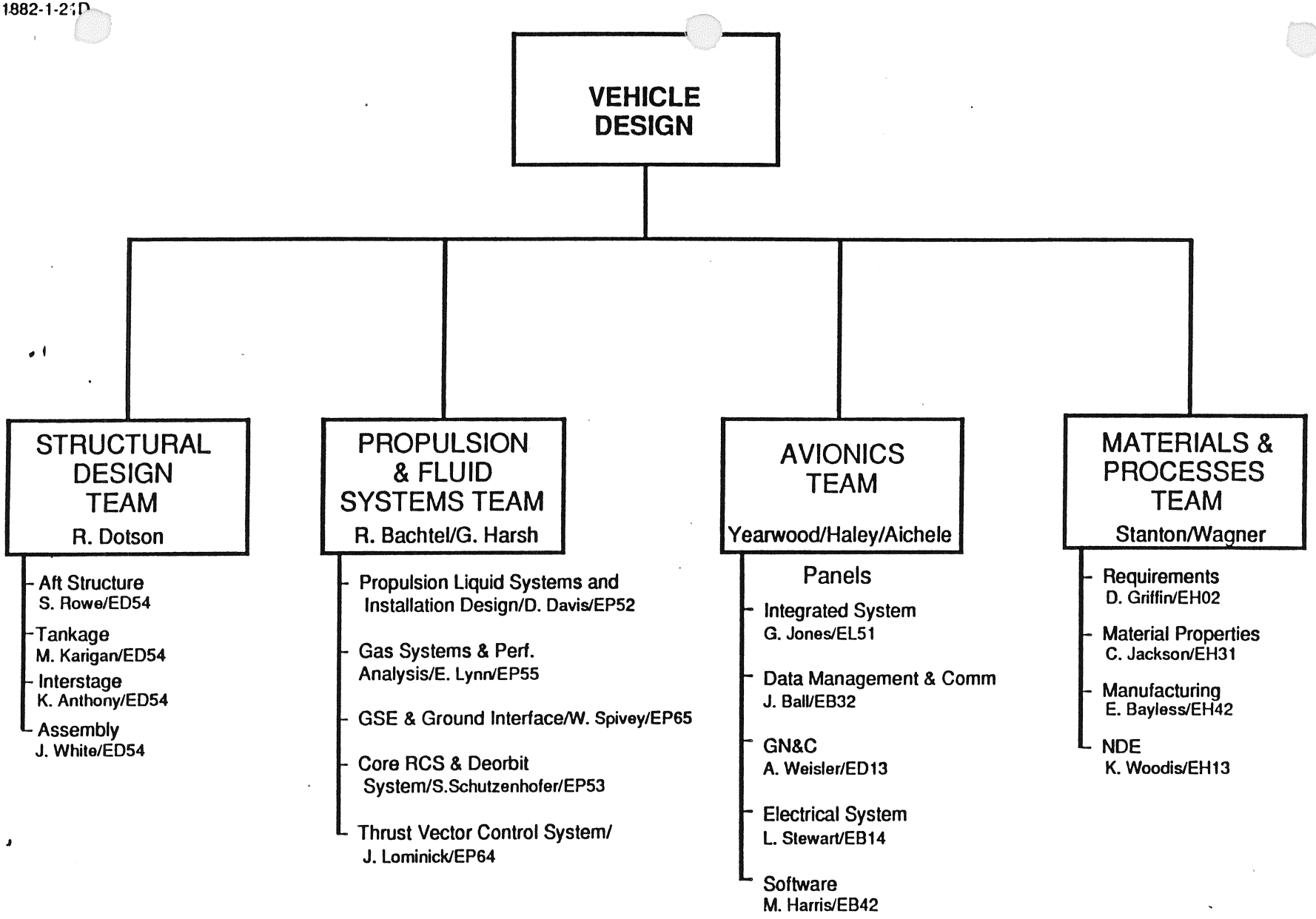
VEHICLE DESIGN
STRUCTURAL DESIGN TEAM
R. Dotson
Aft Structure
S. Rowe/ED54
Tankage
M. Karigan/ED54
Interstage
K. Anthony/ED54
Assembly
J. White/ED54
PROPULSION & FLUID SYSTEMS TEAM
R. Bachtel/G. Harsh
Propulsion Liquid Systems and Installation Design/D. Davis/EP52
Gas Systems & Perf. Analysis/E. Lynn/EP55
GSE & Ground Interface/W. Spivey/EP65
Core RCS & Deorbit System/S.Schutzenhofer/EP53
Thrust Vector Control System/
J. Lominick/EP64
AVIONICS TEAM
Yearwood/Haley/Aichele
Panels
Integrated System
G. Jones/EL51
Data Management & Comm
J. Ball/EB32
GN&C
A. Weisler/ED13
Electrical System
L. Stewart/EB14
Software
M. Harris/EB42
MATERIALS & PROCESSES TEAM
Stanton/Wagner
Requirements
D. Griffin/EH02
Material Properties
C. Jackson/EH31
Manufacturing
E. Bayless/EH42
NDE
K. Woodis/EH13

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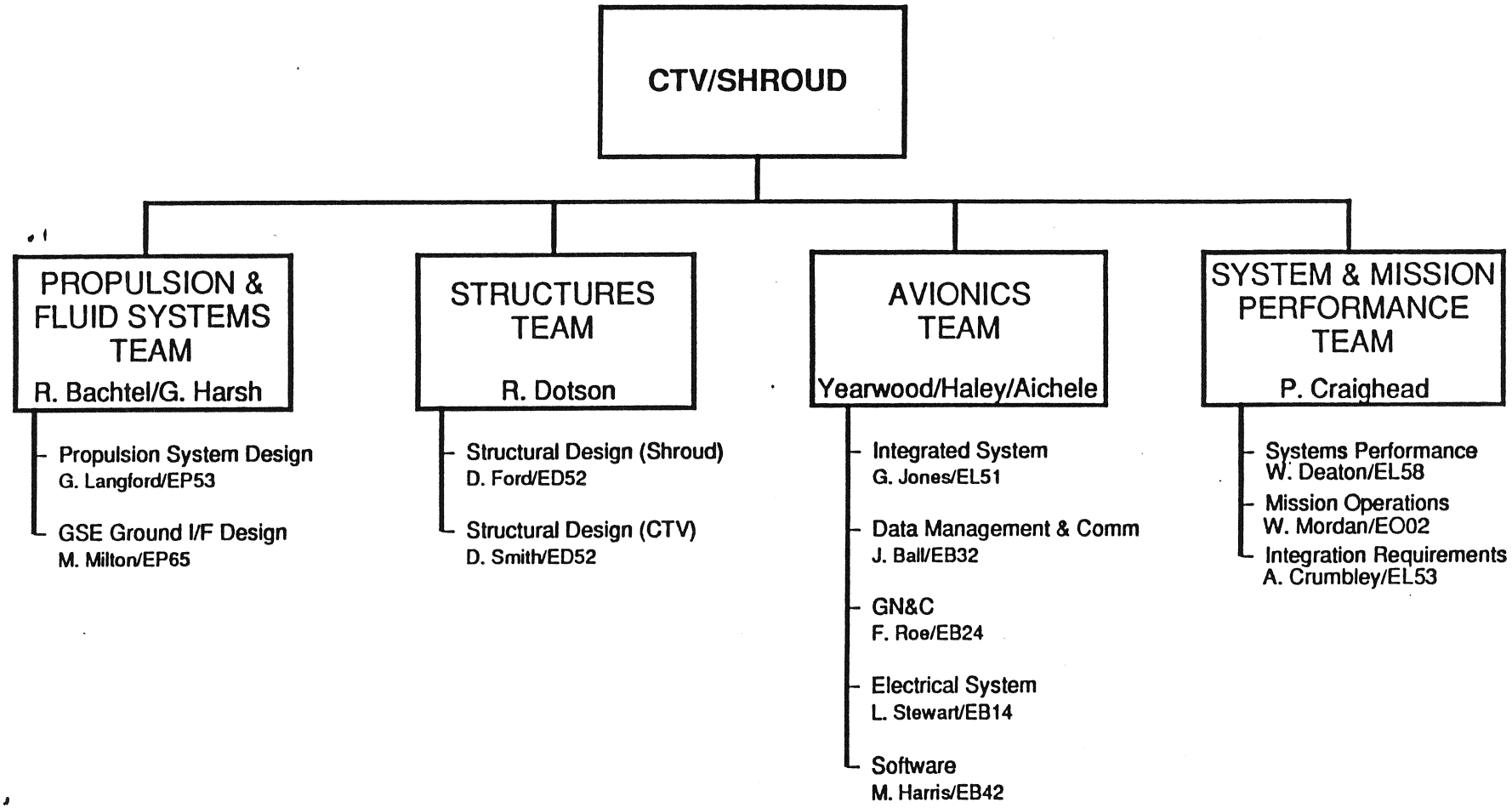
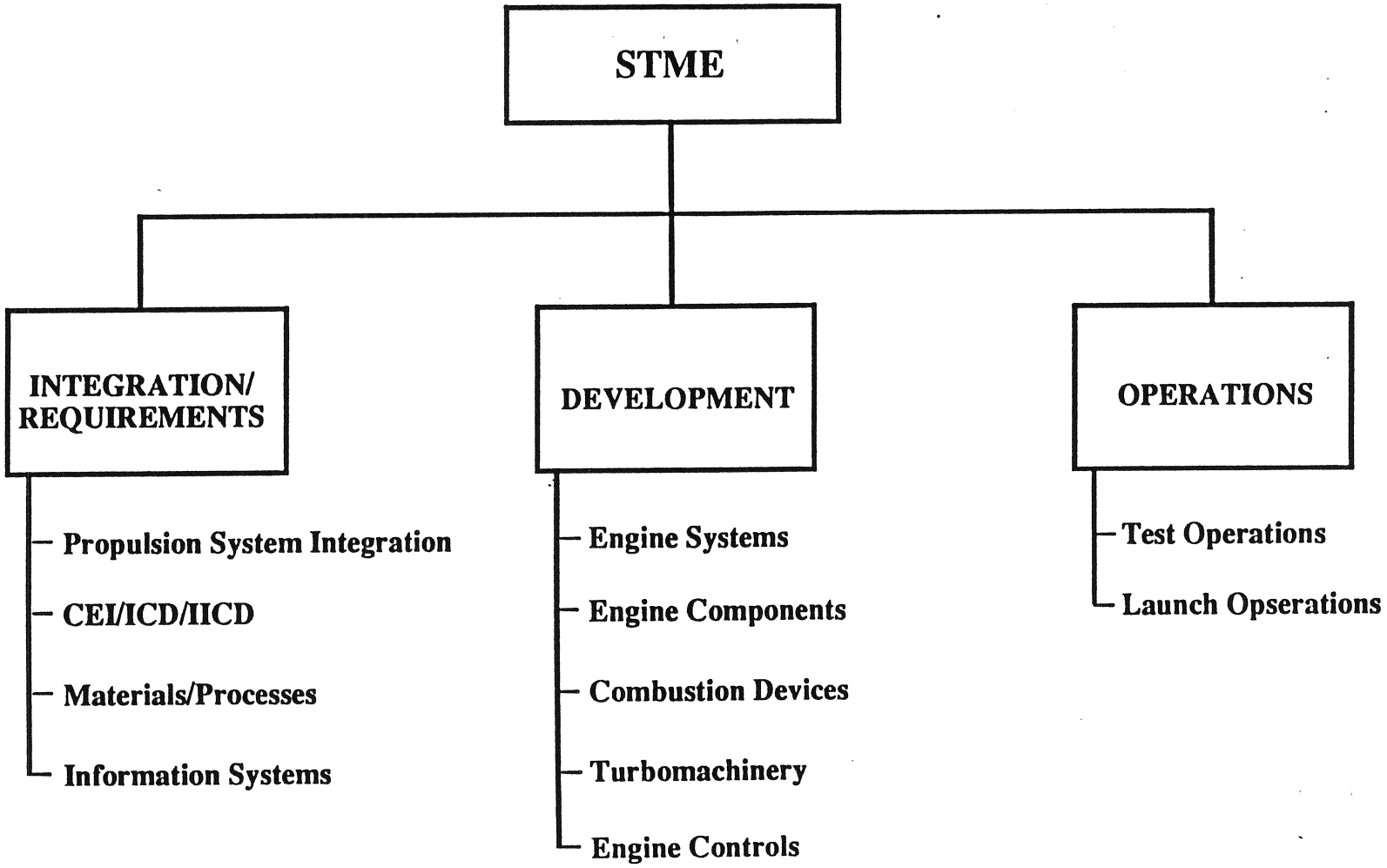

CTV/SHROUD
PROPULSION & FLUID SYSTEMS TEAM
R. Bachtel/G. Harsh
Propulsion System Design
G. Langford/EP53
GSE Ground I/F Design
M. Milton/EP65
STRUCTURES TEAM
R. Dotson
Structural Design (Shroud)
D. Ford/ED52
Structural Design (CTV)
D. Smith/ED52
AVIONICS TEAM
Yearwood/Haley/Aichele
Integrated System
G. Jones/EL51
Data Management & Comm
J. Ball/EB32
GN&C
F. Roe/EB24
Electrical System
L. Stewart/EB14
Software
M. Harris/EB42
SYSTEM & MISSION PERFORMANCE TEAM
P. Craighead
Systems Performance
W. Deaton/EL58
Mission Operations
W. Mordan/EO02
Integration Requirements
A. Crumbley/EL53

10/1/91

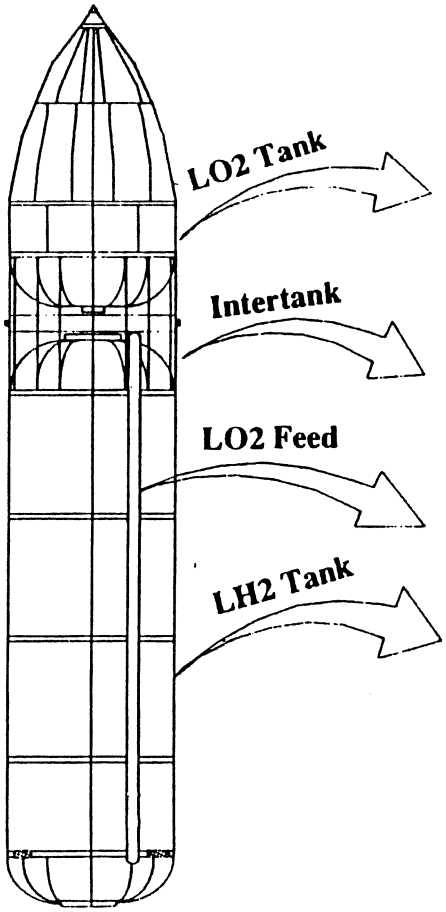

STME
INTEGRATION/ REQUIREMENTS
DEVELOPMENT
OPERATIONS
Propulsion System Integration
CEI/ICD/IICD
Materials/Processes
Information Systems
Engine Systems
Engine Components
Combustion Devices
Turbomachinery
Engine Controls
Test Operations
Launch Opserations

ISSUES

- COMMON HARDWARE
- PERFORMANCE SENSITIVITY OF 1 1/2 STAGE
- CTV PAYLOAD/MISSION REQUIREMENTS
- HIGH RELIABILITY LOW COST ENGINE
- COST EFFECTIVE DESIGN VERIFICATION
- SIGNIFICANT IMPROVEMENT IN OPERATION COST

Common Core

Std ET



Modifications/Changes

Add Avionics/Payload Adapter

Add Forward Skirt

Add Fwd Dome (Same As Lh2 Fwd Dome)
Add Barrel Section
Modify Feedline Outlet

Stiffen Panels

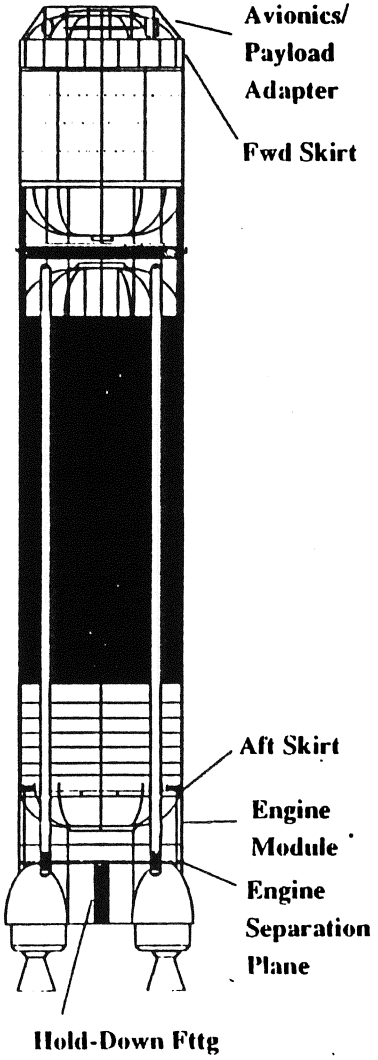
Add Feedline

Stiffen Barrels 1, 2, 3, & 4
Modify Aft Dome Frame For Engine Module Attach
Modify Feedline Outlet

Add Aft Skirt

Add Engine Module

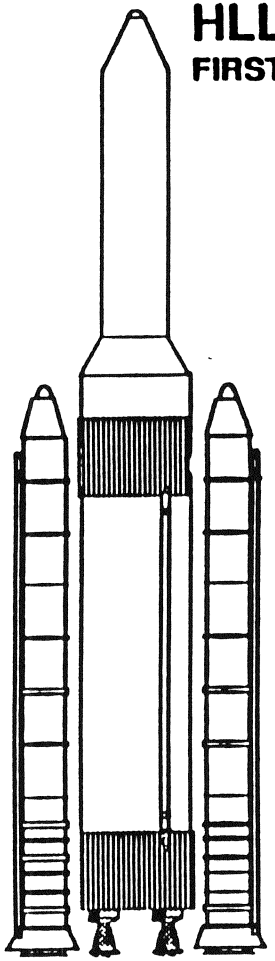
Common Core



LC-34 Driven | LC-34&39 | LC-39 Driven

ALL LIQUID OPTION

HLLV
FIRST FLIGHT 2003

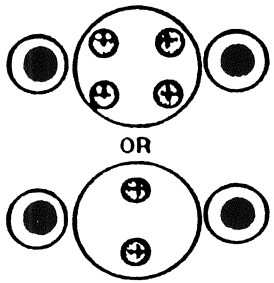


TITAN IV 86ft SHROUD

OPTIONAL SHROUD FOR STS PAYLOADS (40' STRONG-BACK)

CTV

ASRMs

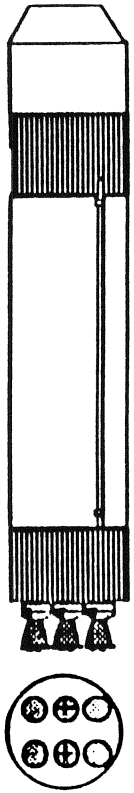


OR

DON'T INSTALL:

- INFLIGHT SEPARATION SYSTEMS
- HOLDDOWN MECHANISMS

COMMON CORE



FORWARD INTERSTAGE

FORWARD SKIRT

TANKAGE / INTERTANK

- STD SIZE / MATERIALS
- BEEFUP FOR 1.5 STG APPLICATION

AVIONICS

THRUST STRUCTURE / PROPULSION SYSTEM

- INFLIGHT SEPARATION

SYSTEMS

STMEs

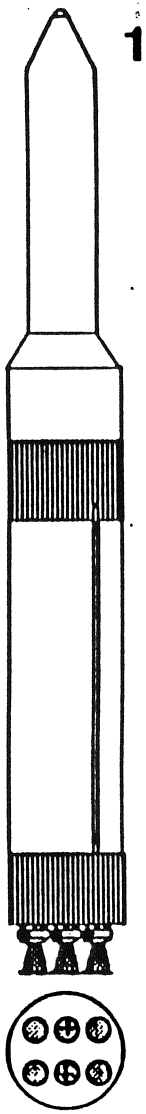
- THRUST

STRUCTURE / PROPULSION FOR 2 CENTER STMEs

AFT SKIRT

- VEHICLE HOLDDOWN

1.5 STAGE



TITAN IV 86ft SHROUD

NEW ADAPTER

UPPER STAGE OPTION

INSTALL:

- 2 CENTER ENGINES
- HOLDDOWN MECHANISMS

⊕ SUSTAINER STMEs

Commonality Weight Impacts

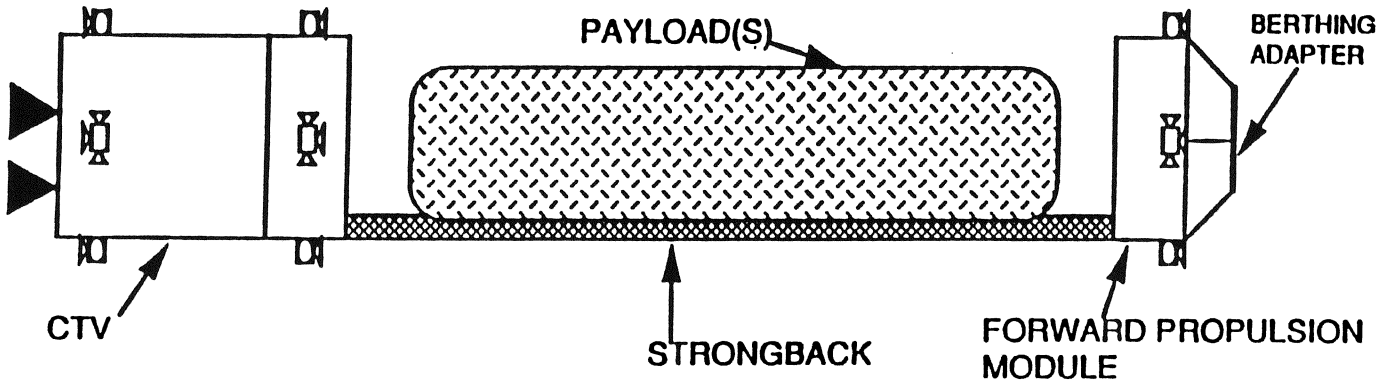
Items	Common Core Weight Impacts on:	
	ASRM Inline	1.5 Stage
Forward Skirt	–	850
Lox Tank	–	1,300
Intertank	–	2,000
LH_2 Tank	8,800	260
Aft Skirt	4,400	–
Engine Heat Shield	800	–
Main Engine Feed System	1,200	–
Total	15,200	4,410

1 1/2 STAGE PERFORMANCE SENSITIVITY

- 32% OF DRY WEIGHT IS DROPPED (1/2 STAGE)
- 68% OF DRY WEIGHT IS CARRIED TO ORBIT (STAGE)
- 1/2 STAGE WEIGHT SENSITIVITY IS LOW - 6 POUNDS WT. = 1 POUND P/L
- STAGE WEIGHT SENSITIVITY IS HIGH - 1 POUND WT. = 1 POUND P/L

THEREFORE, MOST OF THE 1 1/2 STAGE VEHICLE (68%) IS VERY SENSITIVE TO WEIGHT INCREASES DUE TO DESIGN MATURITY.

Cargo Transfer Vehicle
&
Forward Propulsion Module



NLS/CTV PAYLOAD/MISSION REQUIREMENTS

- SSF ASSEMBLY MISSIONS
  - NLS/CTV DELIVERY CAPABILITY (100KLBS) COULD SIGNIFICANTLY ASSIST STATION BUILD-UP BUT SCHEDULES ARE NOT COMPATIBLE.
  - DELIVERY OF GROWTH STATION ELEMENTS LOOKS ATTRACTIVE, BUT "SOFT".

- SSF LOGISTICS MISSIONS
  - FOUR MAN, PMC STATION LOGISTICS WILL TAX PLANNED NSTS CAPACITY.
  - ANY GROWTH WILL CLEARLY OVERLOAD NSTS CAPACITY.
  - NEED FOR AUGMENTATION OF NSTS CAPABILITY IS CLEAR.
  - PRESENT LOGISTICS SCHEME BASED ON NSTS CAPABILITY FOR EARTH RETURN - DOWNMASS IS HIGH PERCENTAGE OF UPMASS.

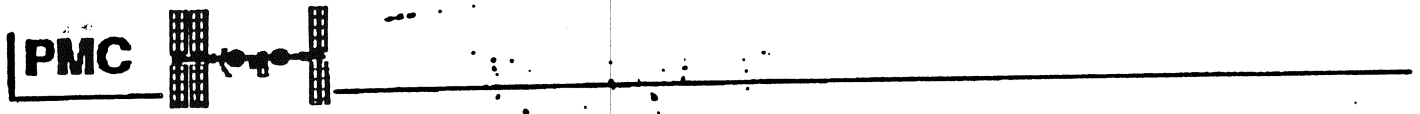
- NON-SSF DELIVERY MISSIONS
  - LEO
  - GEO
  - LUNAR/PLANETARY

IN THE POST 2000 TIMEFRAME
THESE MISSIONS/PAYLOADS
ARE SOFT OR UNDEFINED
HEAVY RELIANCE ON CNDB

Logisitics Resupply Requirements Assessment

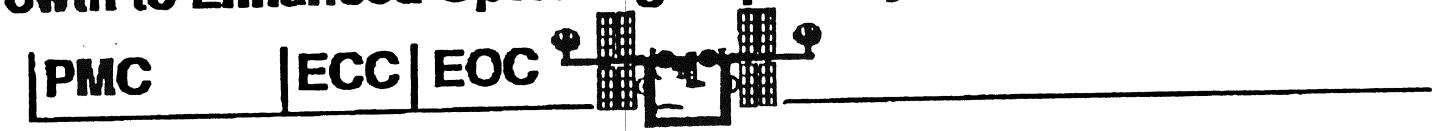
Alternative Cases Examined for Logistics Assessment

Steady State PMC

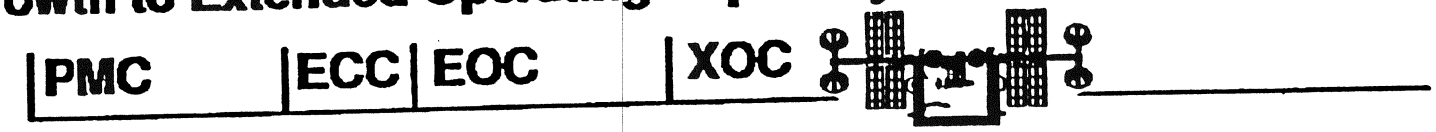


Growth to Eight Crew Capability

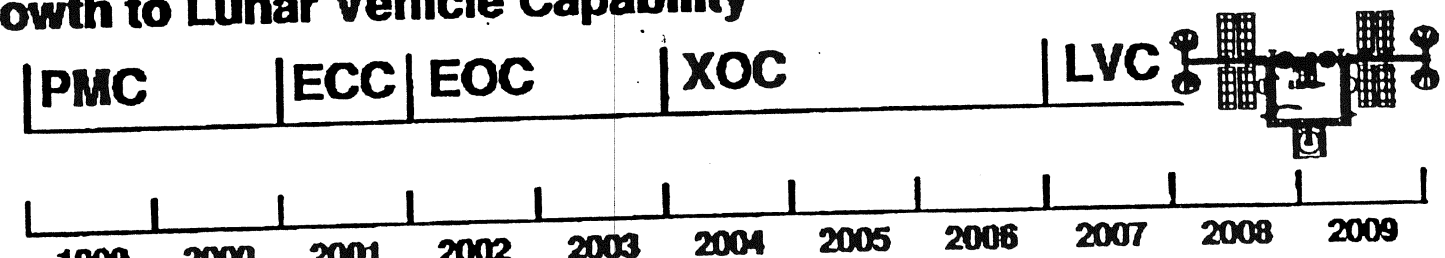
Growth to Enhanced Operating Capability



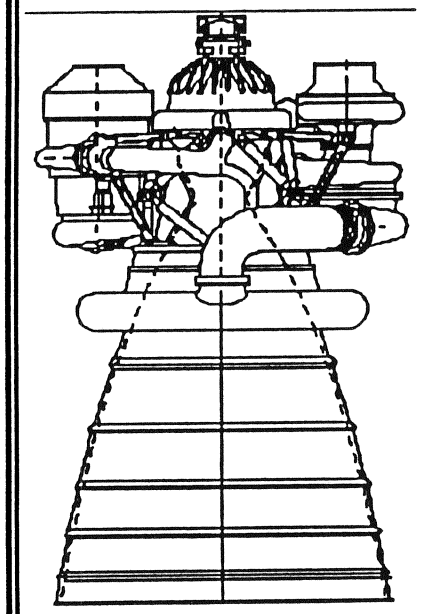
Growth to Extended Operating Capability



Growth to Lunar Vehicle Capability

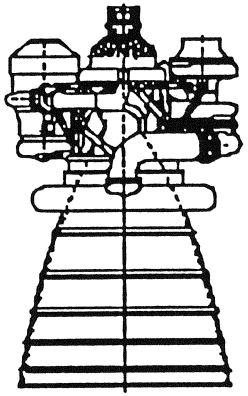


STME DESIGN REQUIREMENTS



Dual Thrust (Step)	
Normal Thrust (100%):	**583,400 lbf**
Minimum Thrust (70%):	**408,400 lbf**
Mixture Ratio:	**6.0**
Specific Impulse (100%):	**430.5 sec.**
Specific Impulse (70%):	**429.3 sec.**
Chamber Pressure:	**2250 psia**
Dry Weight:	**8000 lbm**
Area Ratio:	**45:1**
Length:	**152 inches**
Nozzle Diameter:	**91 inches**
Design Life:	**10 missions**
Design Reliability:	**0.999**
Cat I Probability:	**1.-.99995**

KEY CONSIDERATIONS



SIMPLE
ROBUST DESIGN

MANUFACTURABILITY

LOW COSTS

STME ROBUST DESIGN FEATURES

- **MINIMUM LIFE REQUIREMENTS**
  Initially expendable, when recoverable normal mission requirement is three
- **SERIES TURBINES**
  Results in benign system responses to fuel turbine and turbopump failures
- **MECHANICALLY LINKED GG VALVES**
  Prevents GG from going LOX rich
- **DESIGN MARGINS**
  Maximum design conditions defined as Nominal plus Worst Case flight conditions plus RSS'ed 3 sigma component performance plus 10% Development Margin
- **NO SHEET METAL LINERS**
  Removes failure modes and nuisense maintenance items
- **LOW TURBINE TEMPERATURES**
  Eliminates high temperature life problems
- **MINIMUM NUMBER OF WELDS**
  Reduces failure modes and maintenance items

KEY FEATURES

OPERATIONS

- TANK HEAD START
- NO PRECONDITIONING (BLEEDS)
- SINGLE PURGE FLUID

RELIABILITY

- DESIGN MARGINS
- OPEN LOOP CONTROL

COSTS

- DESIGN TO FABRICATION CAPABILITY
- EXTENSIVE USE OF CASTINGS
- MINIMUM HANDS ON LABOR (WELDS)

INTEGRATED REQUIREMENTS

- POGO ON VEHICLE
- FEED SYSTEM PROVIDES GIMBAL DEFLECTIONS
- AUTOGENOUS TANK PRESSURIZATION
- DESIGNED FOR SALT SPRAY (RECOVERY)

NLS MSFC FACILITY REQUIREMENTS
(2001 LAUNCH)

FACILITY	MODIFY / NEW	TEST START DATE	INSTIT($M)	PROGRAM FUNDED CONSTR / REFURB	PROGRAM FUNDED STE	TOTAL ($M)	
MPS-LOX (4696) [EP]	M	1 / 95	——	8.50	3.50	12.00	(+1.45 $M for PER & design)
LH2 SIMULATOR [EP]	N	3 / 95	——	5.30	4.70	10.00	
MVGVT (4550) [ED]	M	9 / 97	2.50	——	M.A.C.	2.50	(+)
CRYOGENIC STR. TEST FAC. [ED]	N	9 / 97	6.00	——	M.A.C.	6.00	(+)
AETF, SECOND POSITION (STME) [EP]	M	1 / 96	——	5.00	10.40	15.40	
VEH. AVIO. SIM LAB (4476) [EB]	M	4 / 96	——	0.19	12.80	13.00	(+)
STR. STATIC LOAD TOWER (4619) [ED]	M	2 / 97	——	0.20	——	0.20	
HYDR. & EMA LAB (4656) [EP]	M	5 / 96	0.60	——	*	0.60	
TOTAL ($M)			9.10	14.20	21.00	45.75	(+)

MSFC BASELINE 45 $M

M.A.C. - MINIMAL ADD'TL COST (+) - ADD'TL STE COST * - TBD - INCLD IN STME BUDGET (not included in totals)

NLS MAF MODIFICATIONS

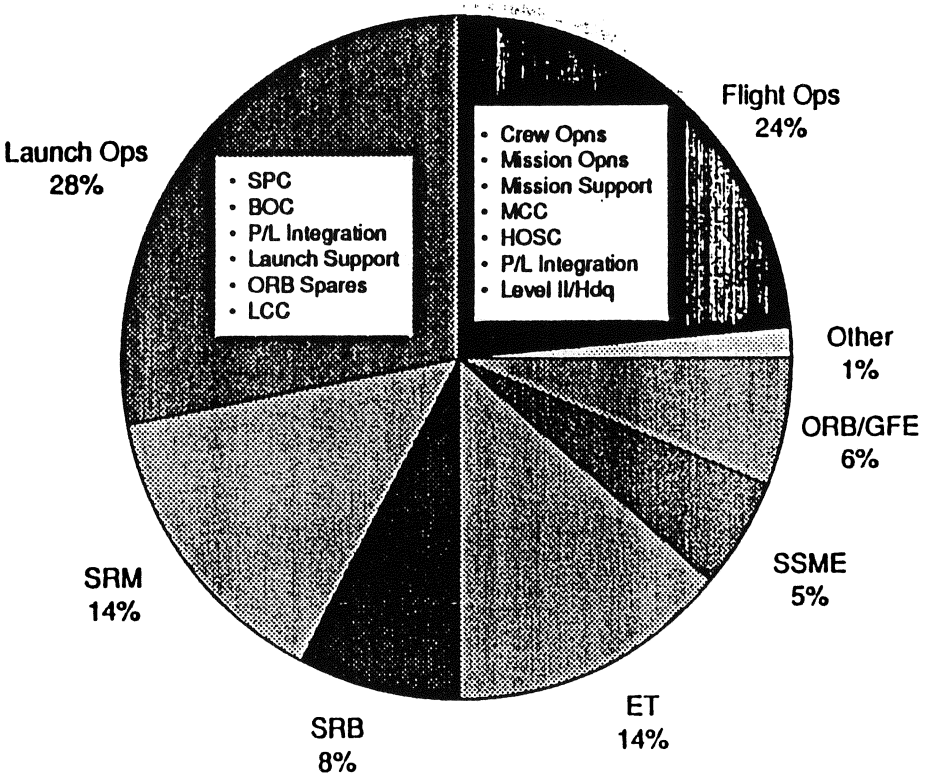
(RY $M)

FACILITY IMPACT AREAS	FACILITY MODS	EQUIP	R & A / ENGR. SUPT.	TOTAL ($M)
CORE TANKAGE PRODUCTION	15.08	5	8.6	28.68
PROPULSION MOD. & INTERSTAGE	13.28	4	5.1	22.38
VEHICLE IACO	6.67	2	1.1	9.77
RATE FACILITIES	5.88	1	0.5	7.38
5 FT. STRETCH IMPACTS	10.99	3	4.4	18.39
TOTAL ($M)	51.90	15	19.7	86.60

MAF BASELINE 87 $M

PROGRAM FUNDED

FY89 – FY91
Cost Per Flight
Comparison

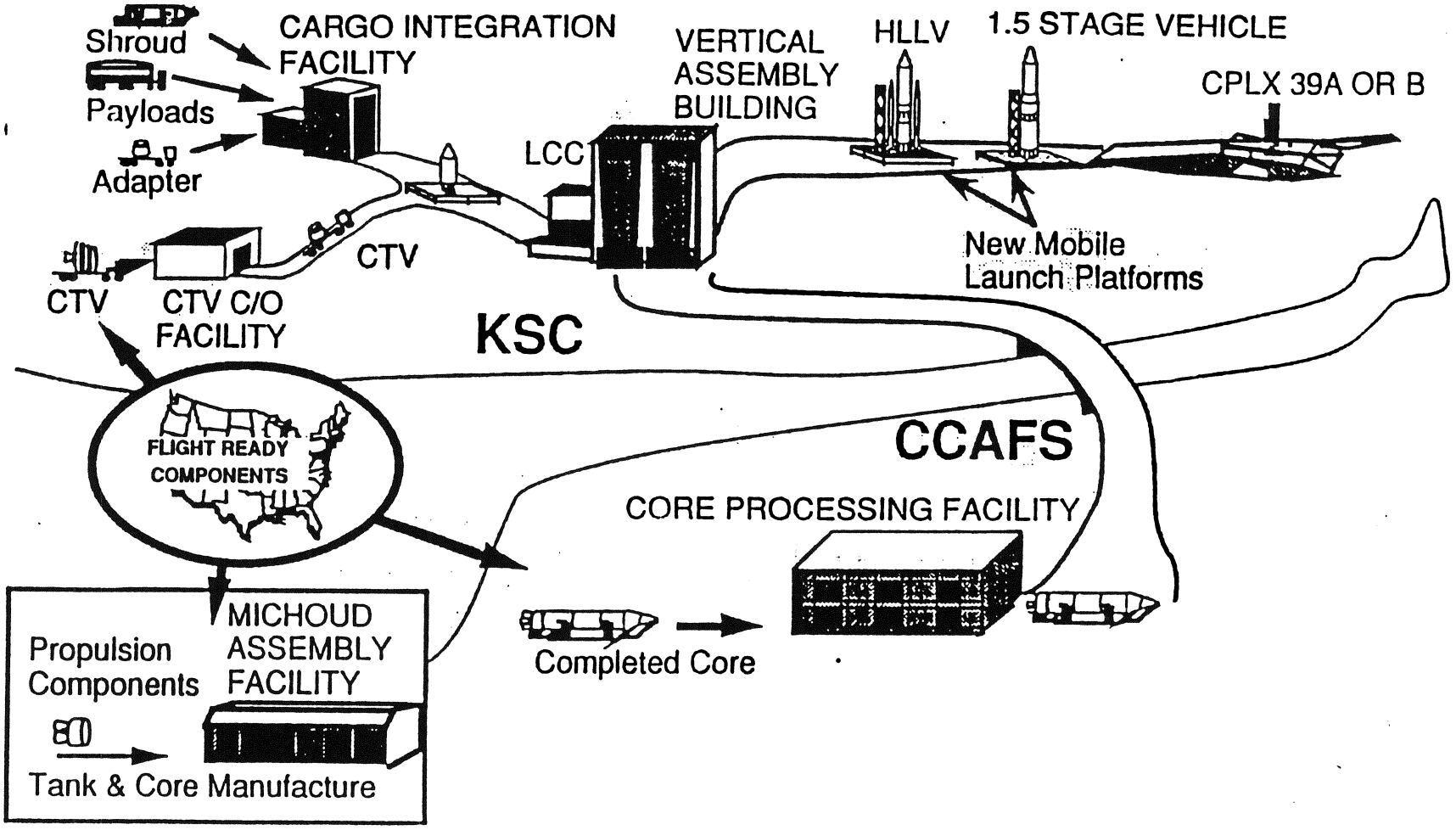


FY91 OMB

Shuttle Operations

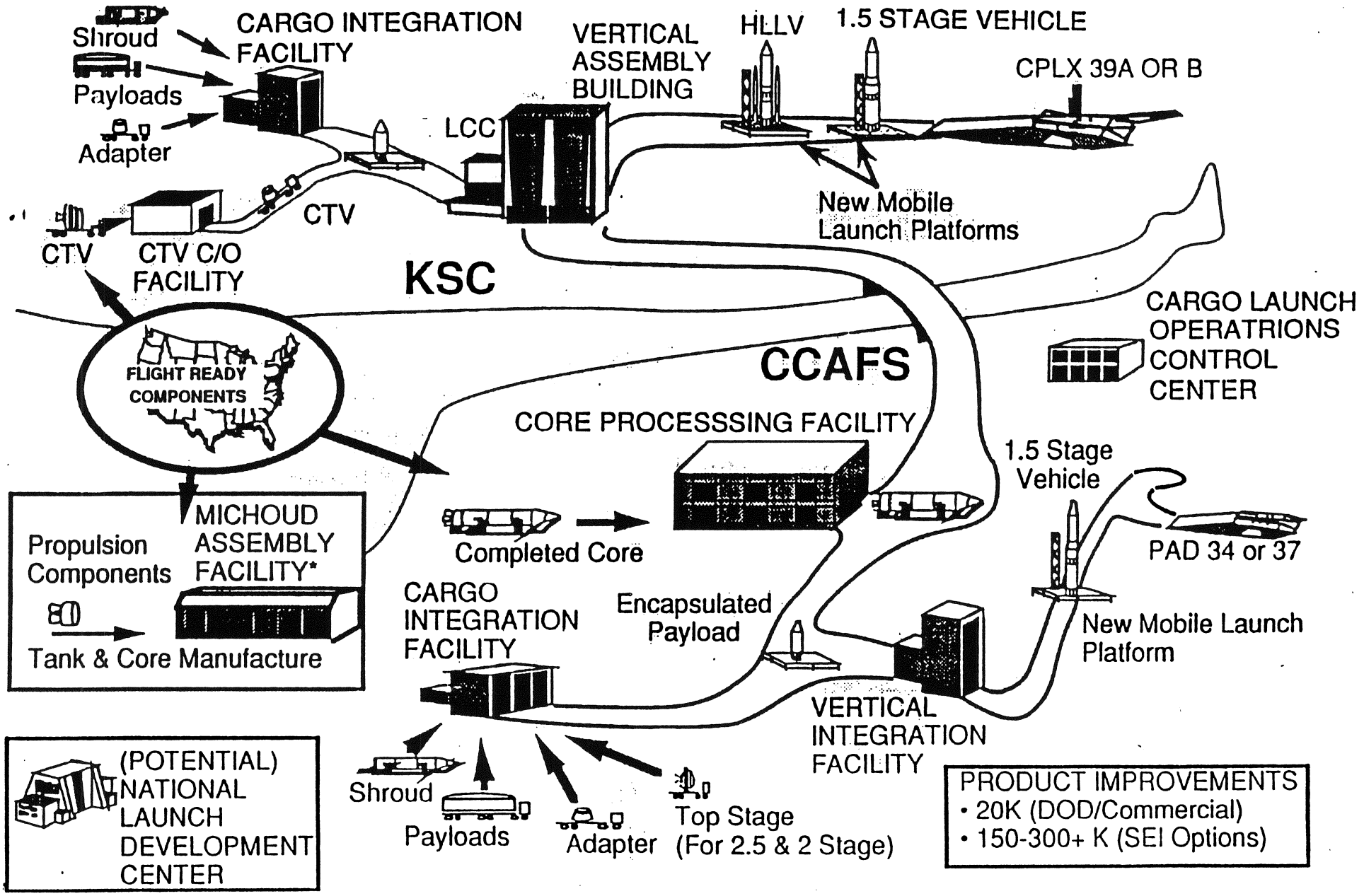
NLS GROUND OPERATIONS FLOW

CURRENT NLS Baseline-1999



NLS GROUND OPERATIONS FLOW

CURRENT NLS Baseline-2002



EVOLUTION

Cargo Vehicle Options

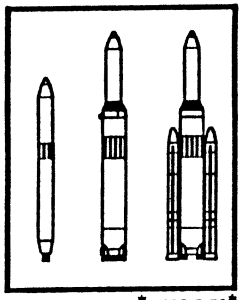
Lunar

150 - 300 klb

Mars

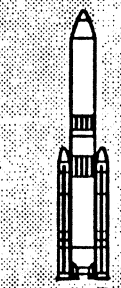
300 -600 klb

NLS Reference Vehicles

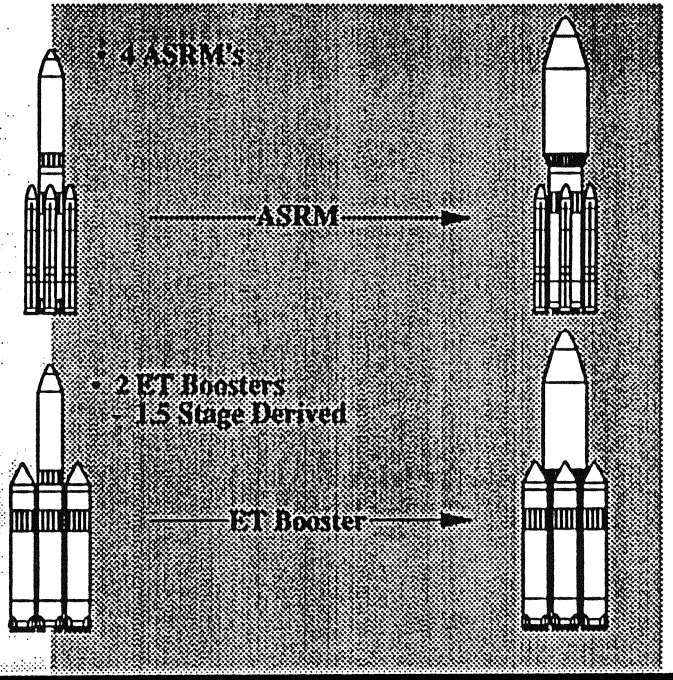


20K 50K* HLLV*

- ET Dia . Core*
- STME
- ASRM
- Titan IV Shroud



- 25 ft Shroud



- 4 ASRM's
- Larger Dia. Core

- 4 ET Boosters
- Larger Dia. Core

"Clean Sheet"

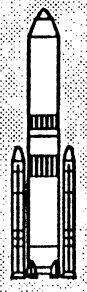
NLS

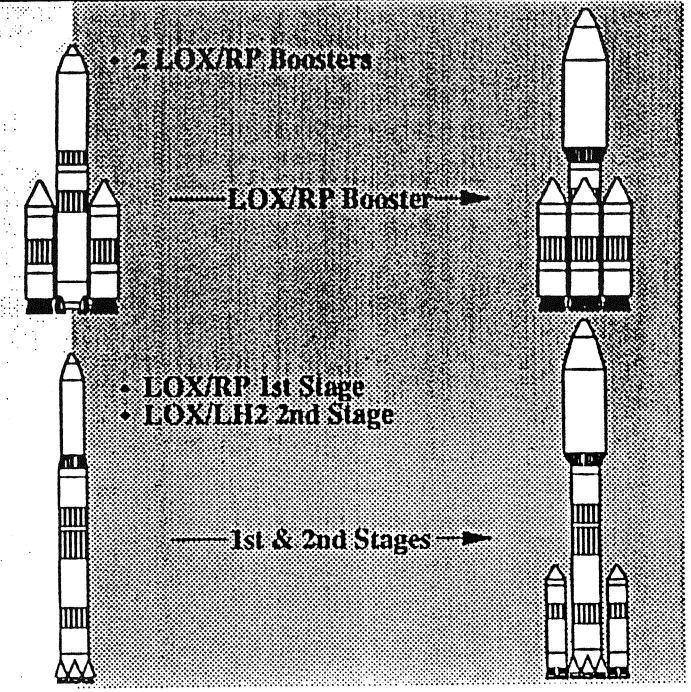
???

20K 50K HLLV

- Large Dia. Core / New Liq Boosters
- F-1 Deriviative Engines
- STME
- ASRM

Parallel Burn





- 4 LOX/RP Boosters

- LOX/RP Strap-On Boosters

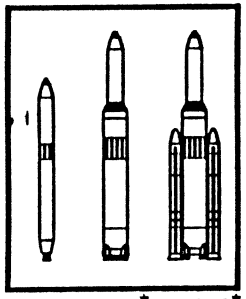
Series Burn

Cargo Vehicle Options
NLS + "Clean Sheet"

Lunar
150 - 300 klb

Mars
300 - 600 klb

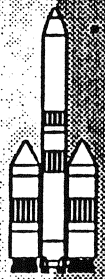
NLS
Reference Vehicles



20K 50K* HLLV*

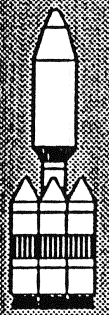
- **ET Dia . Core ***
- **STME**
- **ASRM**
- **Titan IV Shroud**

- **25 ft Shroud**



- **2 LOX/RP Boosters**

LOX/RP Booster



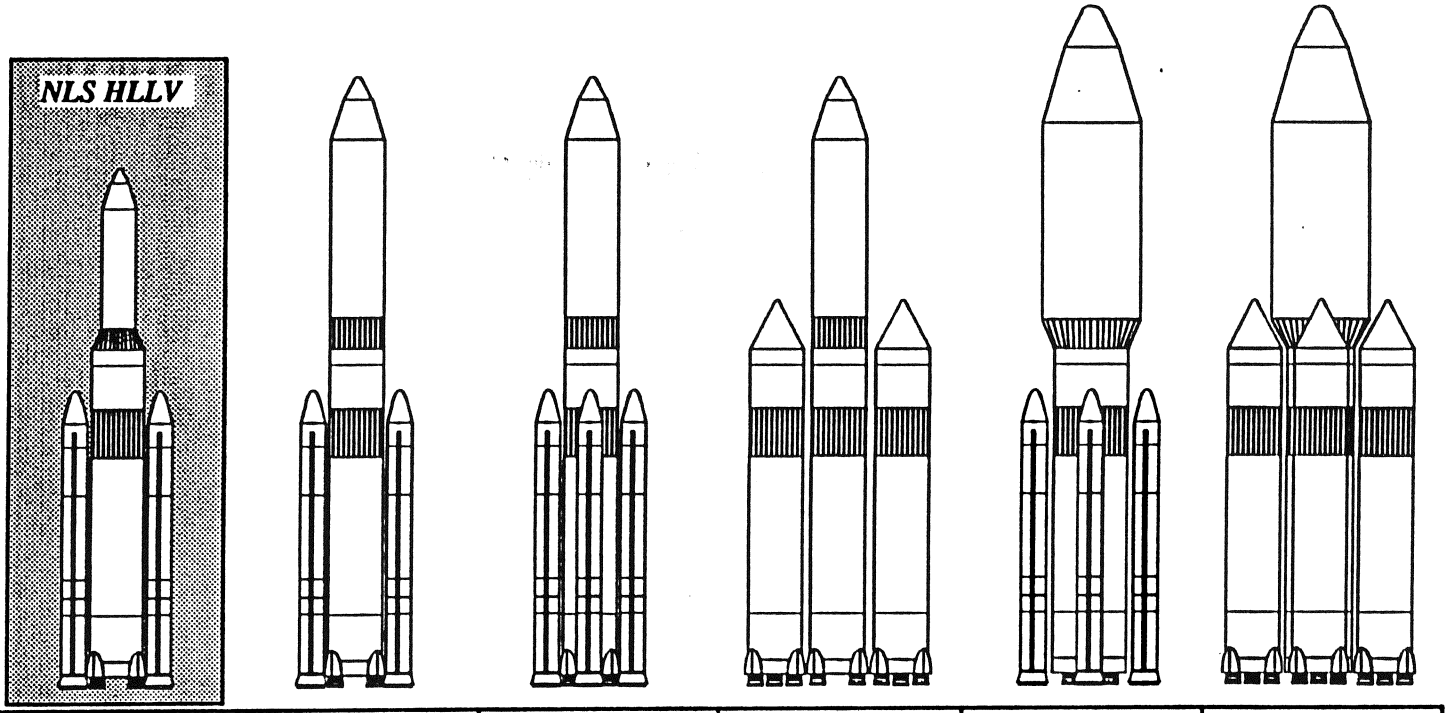
- **4 LOX/RP Boosters**

"Clean Sheet"

- **New LOX/RP Booster**
- **F-1 Deriviative Engines**

Cargo Vehicle Options

NLS Evolved

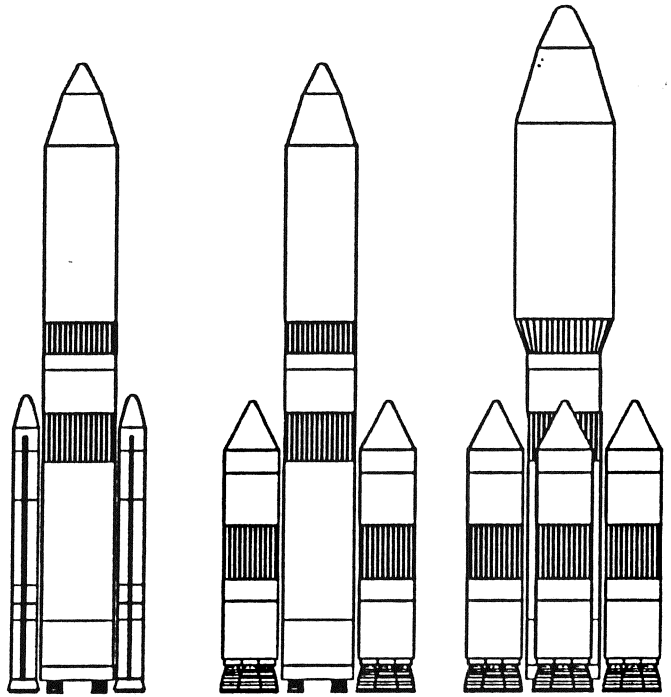


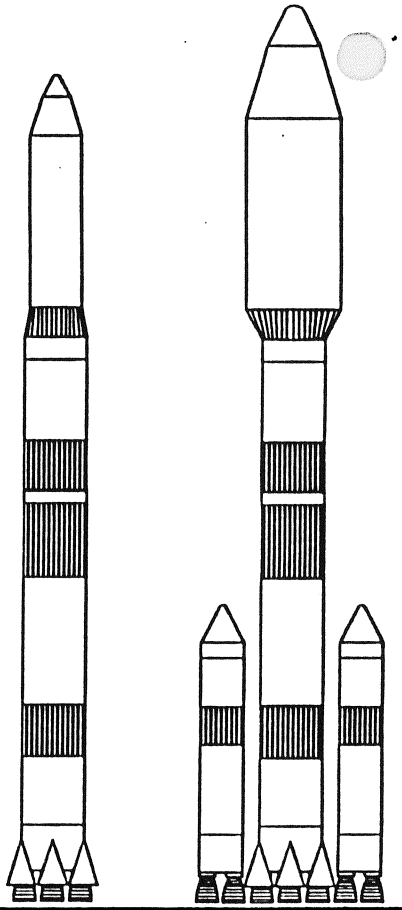
	NLS HLLV					
Structure	Al 2219	Al - Li	Al 2219	Al - Li	Al - Li	Al - Li
Core	ET Derived	ET Derived	ET Derived	ET Derived	37 ft Dia	32 ft Dia
Prop. Capacity	1.69 Mlb	1.69 Mlb	1.69 Mlb	1.69 Mlb	Optimum (3 Mlb)	Optimum (2.3 Mlb)
Prop. Type	LOX / LH_2	LOX / LH_2	LOX / LH_2	LOX / LH_2	LOX / LH_2	LOX / LH_2
Engines	4 STME (583 Klb)	4 STME (583 Klb)	4 STME (583 Klb)	4 STME (583 Klb)	5 STME (583 Klb)	4 STME (583 Klb)
Booster	ASRM	ASRM	ASRM	ET Derived	ASRM	ET Derived
Number	2	2	4	2	4	2
Prop. Capacity	--	--	--	1.69 Mlb	--	1.69 Mlb
Prop. Type	Solid	Solid	Solid	LOX / LH_2	Solid	LOX / LH_2
Engines	--	--	--	6 STME (583 Klb)	--	6 STME (583 Klb)
Upperstage	CTV	CTV Circ. Module	CTV Circ. Module	CTV Circ. Module	New Kickstage	New Kickstage
Shroud (Usable)	15 ft x 80 ft	25 ft x 90 ft	25 ft x 90 ft	25 ft x 90 ft	46 ft x 100 ft	46 ft x 100 ft
Payload to 220 circ	101 klb*	155 klb	230 klb	315 klb	300 klb	570 klb

* Payload to SSF

Cargo Vehicle Options

"Clean Sheet"

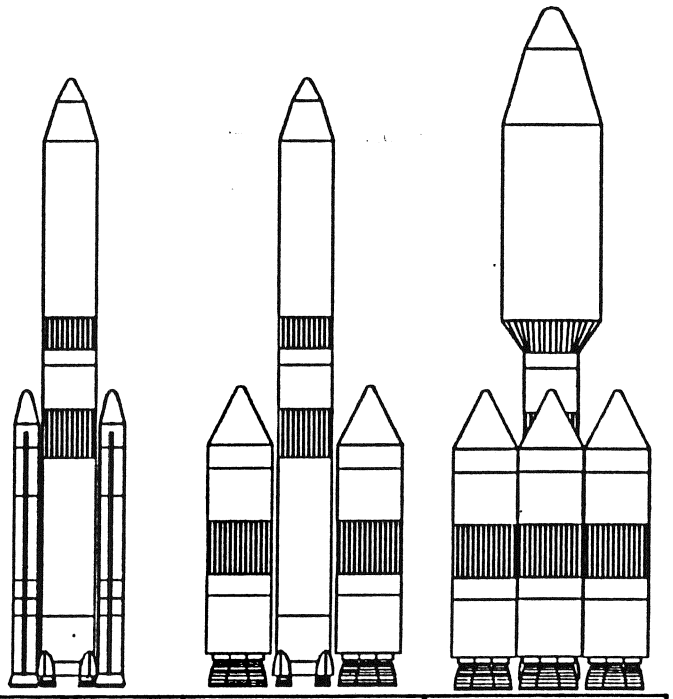




Structure	Al - Li	Al - Li	Al - Li	Al - Li	Al - Li
Core	Sized for 2 Liq. Boost.	TBD ft Dia	Sized for 2 Liq. Boost.	**1st Stage**	33 ft Dia	33 ft Dia
Prop. Capacity	TBD Mlb	Optimum (TBD Mlb)	TBD Mlb	Prop. Capacity	6.6 Mlb	6.6 Mlb
Prop. Type	LOX / LH2	LOX / LH2	LOX / LH2	Prop. Type	LOX / RP	LOX / RP
Engines	4 STME (583 Klb)	4 STME (583 Klb)	4 STME (583 Klb)	Engines	6 F-1A	6 F-1A
Booster	ASRM	TBD ft Dia	Sized for 2 Liq. Boost.	**2nd Stage**	33 ft Dia	33 ft Dia
Number	2	2	4	Prop. Capacity	1.4 Mlb	1.4 Mlb
Prop. Capacity	- -	Optimum (TBD Mlb)	TBD Mlb	Prop. Type	LOX / LH2	LOX / LH2
Prop. Type	Solid	LOX / RP	LOX / RP	Engines	5 J-2S	5 J-2S
Engines	- -	3 F-1A	3 F-1A	**Booster**	N.A.	2 - 23 ft Dia
				Prop. Capacity		2.2 Mlb
Upperstage	New Kickstage	New Kickstage	New Kickstage	Prop. Type		LOX / RP
				Engines		2 F-1A
Shroud (Usable)	25 ft x 90 ft	25 x 90 ft	46 x 100 ft	**Shroud (Usable)**	25 ft x 90 ft	46 x 100 ft
	TBD	TBD	TBD	**Payload to 220 circ**	385 klb	520 klb

Cargo Vehicle Options

NLS + "Clean Sheet"



Structure	Al - Li	Al - Li	Al - Li
Core	ET Derived	ET Derived	ET Derived
Prop. Capacity	1.69 Mlb	1.69 Mlb	1.69 Mlb
Prop. Type	LOX / LH_2	LOX / LH_2	LOX / LH_2
Engines	4 STME (583 Klb)	4 STME (583 Klb)	4 STME (583 Klb)
Booster	ASRM	Sized for 4 Booster	33 ft
Number	2	2	4
Prop. Capacity	- -	3.6 Mlb	Optimum (3.6 Mlb)
Prop. Type	Solid	LOX / RP	LOX / RP
Engines	- -	3 F-1A	3 F-1A
Upperstage	CTV Circ. Module	CTV Circ. Module	New Kickstage
Shroud (Usable)	25 ft x 90 ft	25 x 90 ft	46 x 100 ft
Payload to 220 circ	155 klb	360 klb	565 klb

Payload to 220 circ

LAUNCH VEHICLE DEVELOPMENT SCHEDULE