AIAA Space 2011 Conference & Exposition

Heavy Lift Capability with a New Hydrocarbon Engine (NHE)

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Agenda

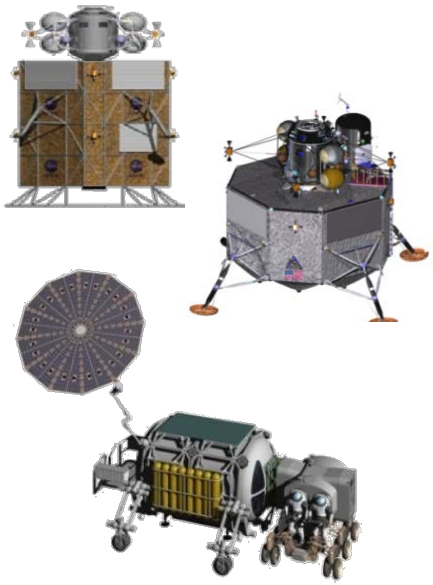
- MSFC ACO Overview
- Study Objective/Approach
- Heavy Lift Concept Configurations
- Configurations Derived from the LRB
- Effect of Engine Out on 100 MT Configuration
- Summary

MSFC Advanced Concepts Office

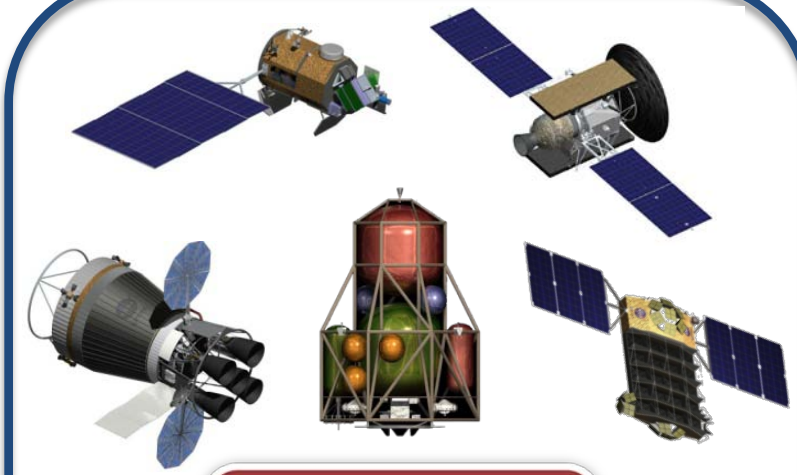
We Are An Office Specializing In Pre-Phase A & Phase A Concept Definition

Advanced Concepts

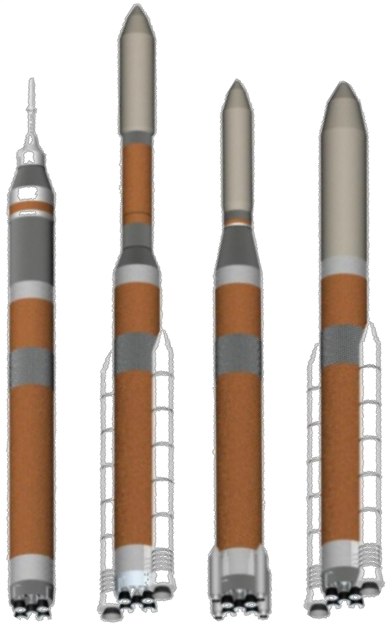
George C. Marshall Space Flight Center



Human Exploration Systems

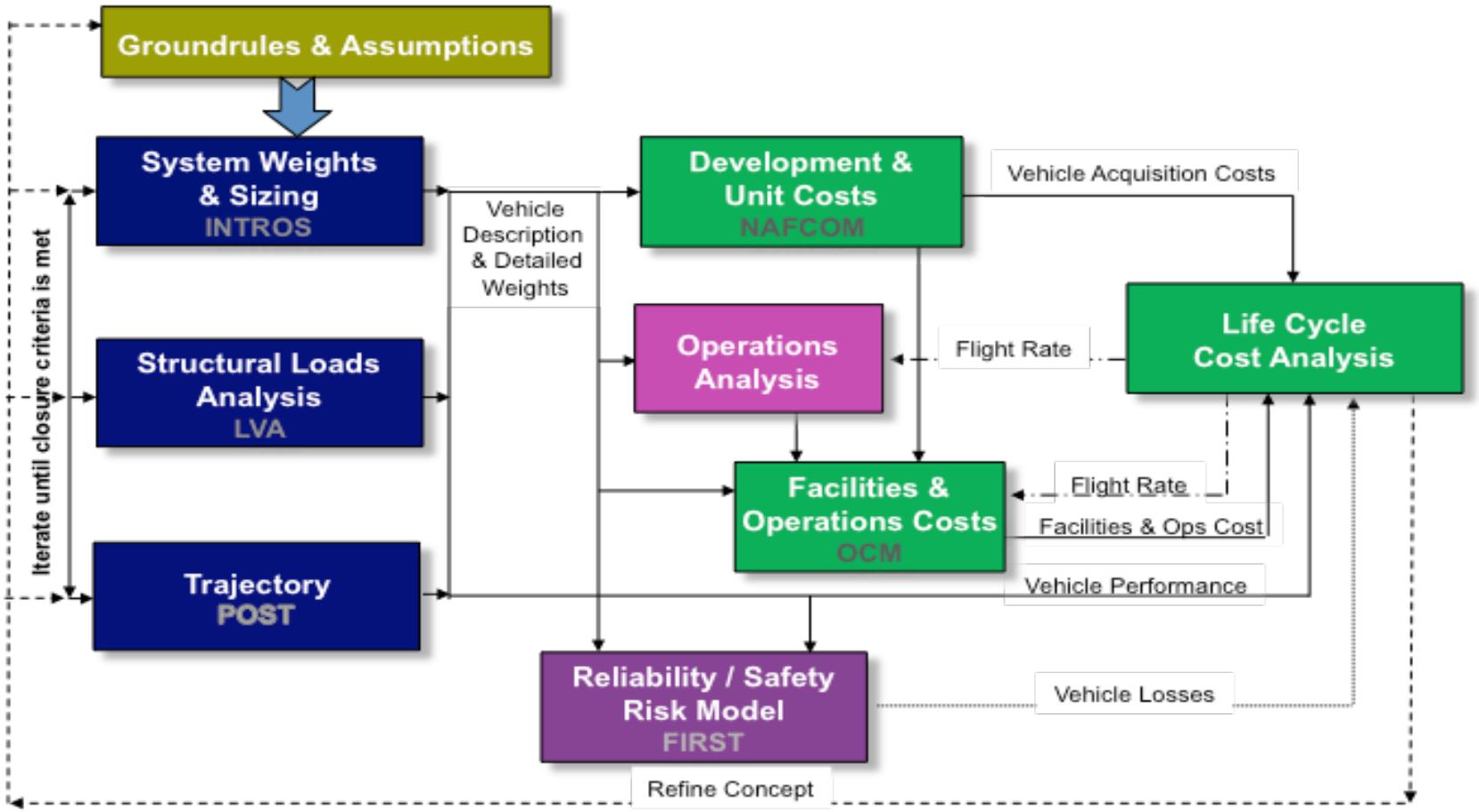


In-Space Transportation and Science Systems



Launch Vehicle Systems

Launch Vehicle Design Process



Note: Cost and Reliability Analyses were not performed for this study

Study Objective

Determine the thrust requirement for a new LOX Rich Stage Combustion Kerosene (RP) Engine that can lift 100 MT to LEO in a 2 Stage series configuration… and by adding strapon LRBs with the same engine lift 140 MT using common stages to minimize design and development costs. Evaluate other potential concepts derived from the engine/stages.

Launch Vehicle Architecture and Element Commonality Approach Using NHE

NASA Heavy Lift 1
100 MT

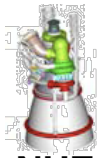
NASA Heavy Lift 2
140 MT

Design for Common 2nd Stage with J-2X-285

Design for Common 1st Stage Add LRBs for increased Payload Requirements

Single Engine LRB Could become 1st Stage In New Launch Vehicle

Potential DoD / Commercial Application



NHE

Potential Use in New Reusable First Stage for Air Force

Not Analyzed in this Study

Thrust Trades (1.0 Mlbf Vac – 1.3 Mlbf Vac Class)

General Top Level Ground Rules and Assumptions

- **Vehicle Stages up to 33 ft diameter**
- **Vehicle not higher than 390 ft**
- **Thrust / Weight at liftoff not less than 1.2**
- **NHE engine thrust to not exceed 1.3 Mlbf vacuum**
- **Ascent axial acceleration to not exceed 5.0 g**
- **NHE has continuous throttling capability**
- **Second Stage is LOX/LH2 using J2X-285**

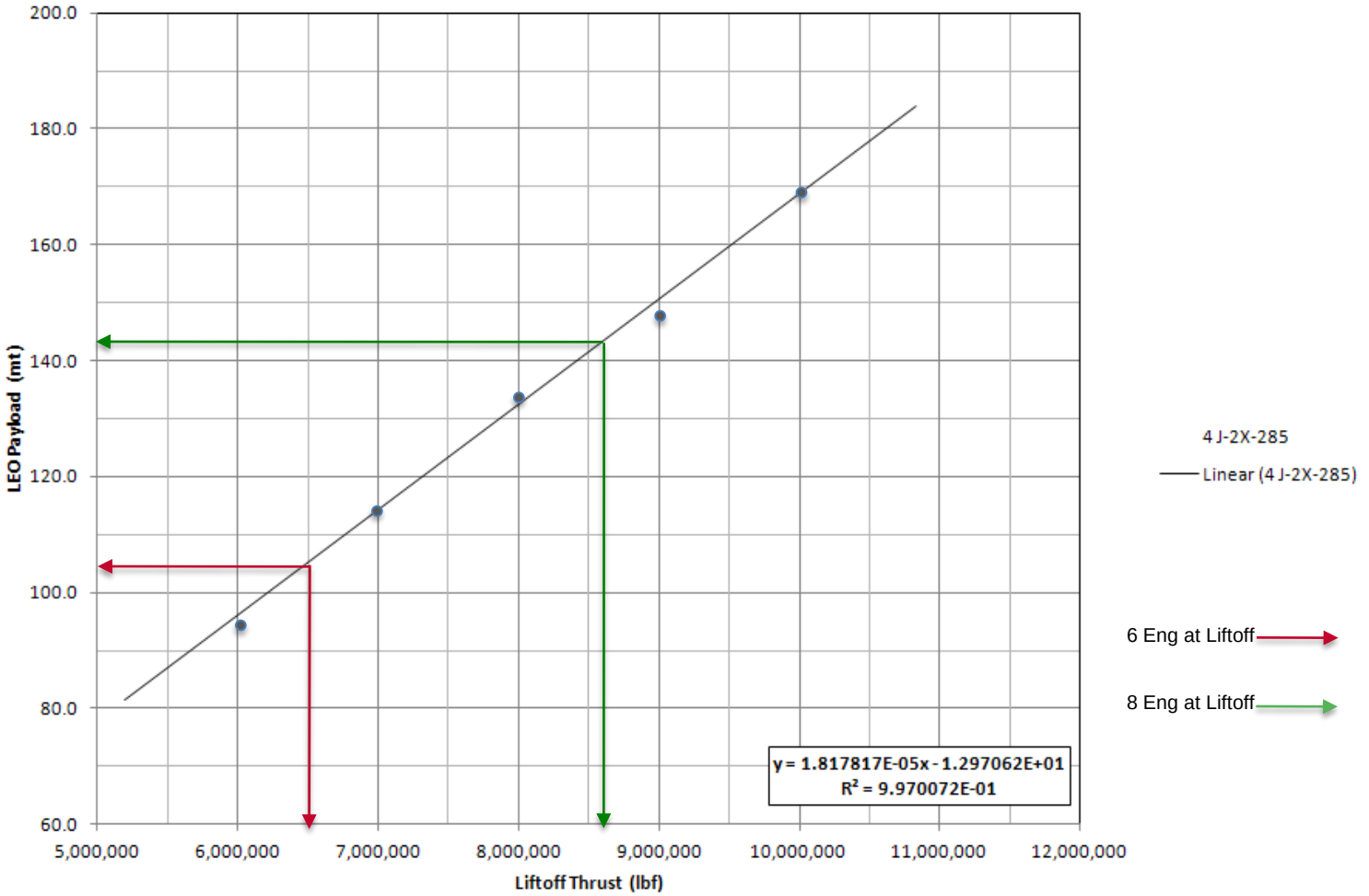
NHE Engine Assumptions*

- Vac Isp: 332 s
- T/W = 70
- Mixture Ratio: 2.7
- Engine Length: 180 in.
- Engine Nozzle Diam: 120 in.

* Engine Assumptions Provided by ER21 Propulsion Team at MSFC

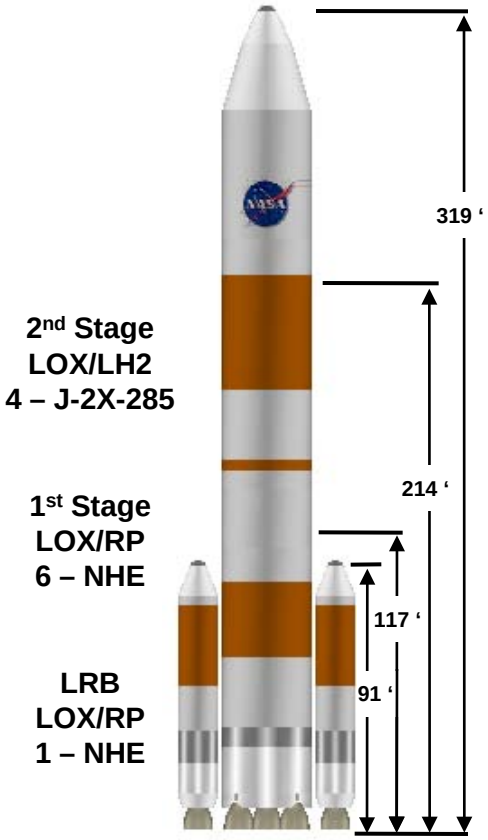
Payload to LEO as a Function of First Stage Thrust at Liftoff

For 100 MT Capability with Six First Stage Engines, NHE Thrust Requirement is 1.08 Mlbf @ SL / 1.25 Mlbf @ Vac per Engine



Heavy Lift Vehicle Results

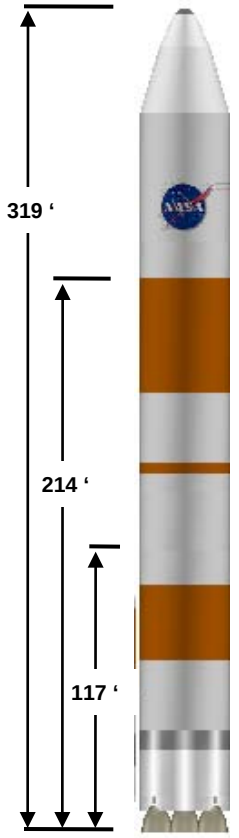
140 MT Vehicle



Vehicle Data
(Emphasizing Commonality)

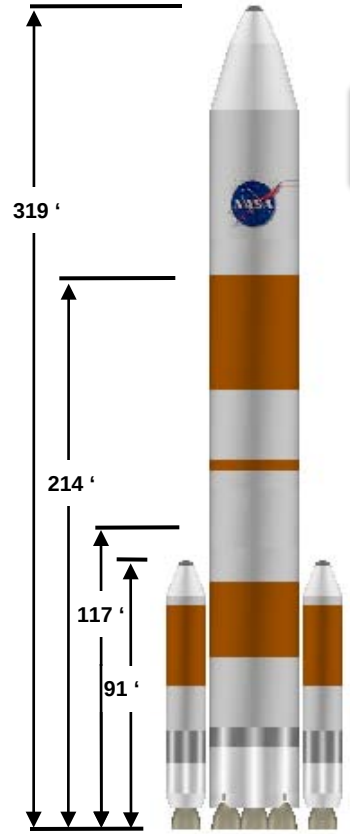
140 MT		100 MT
7.22 Mlb	GLOW	5.42 Mlb
33.2 Klb	Shroud	33.2 Klb
112 Klb	2nd Stage Dry Wt.	112 Klb
1.08 Mlb	2nd Stage Prop.	955 Klb (12.1% Offload)
339 Klb	1st Stage Dry Wt.	337 Klb
4.07 Mlb	1st Stage Prop.	3.69 Mlb (9.5% Offload)
91.8 Klb	LRB Dry Wt.	n/a
501 Klb	LRB Prop.	n/a
143.7 MT	Payload	104.2 MT

100 MT Vehicle



Launch Vehicles from the NHE LRB

140 MT

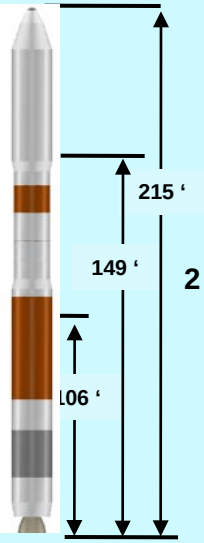


New Launch Medium Class Launch Capability Could Be Derived from the LRB Used as a first stage in a series burn concept

LRB with NHE

Modify LRB by Increasing Propellant Load

Use LRB as is Remove Nosecone



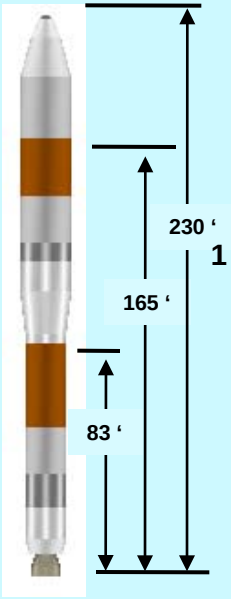
2nd Stage
LOX/LH2
2 – RL-10-A4-3

1st Stage
LOX/RP
1 – NHE

GLOW
902 Klb

Payload
11.5 MT LEO
4-7 MT GTO
depending on structural design

1st Stage Propellant – 719 Klb



2nd Stage
LOX/LH2
1 – J-2X-285

1st Stage
LOX/RP
1 – NHE

GLOW
901 Klb

Payload
12.9 MT LEO

1st Stage Propellant – 501 Klb

100 MT Vehicle Engine Out Capability

Engine Out Capabilities of the 100 MT Vehicle

	Nominal	2nd Stage EO	1st Stage EO	EO Both Stages
GLOW	5.42 Mlb	5.42 Mlb	4.51 Mlb	4.51 Mlb
2nd Stg Dry Mass	112 Klb	112 Klb	112 Klb	112 Klb
2nd Stage Prop	955 Klb	655 Klb	963 Klb	656 Klb
2nd Stg % Offload	12.1% Offload	40.0% Offload	11.4% Offload	39.6% Offload
1st Stg Dry Mass	337 Klb	337 Klb	337 Klb	337 Klb
1st Stg prop	3.69 Mlb	4.02 Mlb	2.83 Mlb	3.17 Mlb
1st Stg % Offload	9.5% Offload	1.3% Offload	30.5% Offload	22.2% Offload
Payload LEO	**104.2 MT**	**89.0 MT**	**77.9 MT**	**65.1 MT**

Summary

- **A Family of Launch Vehicle Concepts can be Derived from a New Hydrocarbon Stage Combustion Engine (NHE) to Meet Future Civil, Military, and Commercial Space**
  - NHE Thrust Requirement Determined at 1.25 Mlbf @ Vacuum
  - Heavy Lift Capability in the 100 MT – 140 MT Class Defined
  - ELV Payload Class Capability with Single NHE
- **Stage Commonality Can Be Utilized and Still Meet Performance Requirements**
  - Reduced Development, Manufacturing, and Operations Costs
- **Missions Can Be Flown with Engine Out For Crewed Flights or High Value Payloads For Increased Launch Reliability**
  - Payload Capabilities of 65 MT to Nearly 90 MT can Still be Obtained with the 100 MT Vehicle Depending on the Amount of Engine Out is Desired