AIAA Space 2011 Conference & Exposition

Launch Vehicle Demonstrator Using Shuttle Assets

Dennis M. Creech, Jacobs Engineering – Jacobs ESTS Group

Grady E. Threet, Jr., and Alan Phillips, NASA MSFC

Eric D. Waters, Dynamic Concepts Inc. – Jacobs ESTS Group

Advanced Concepts

George C. Marshall Space Flight Center

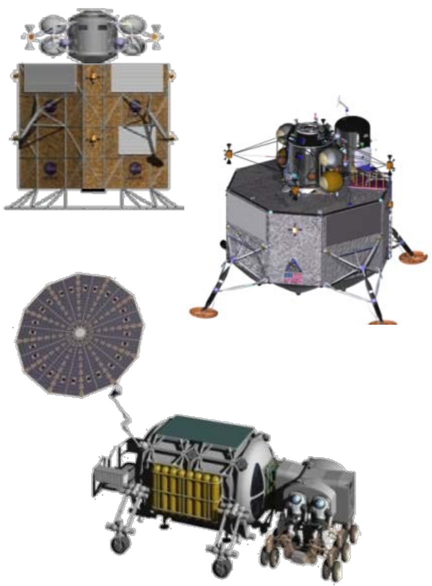
Agenda

- MSFC ACO Overview
- Study Objective/Methodology
- Baseline Concept Configurations
- Early Demonstrators
- Operational Concepts
- Evolutionary Pathway
- Conclusions

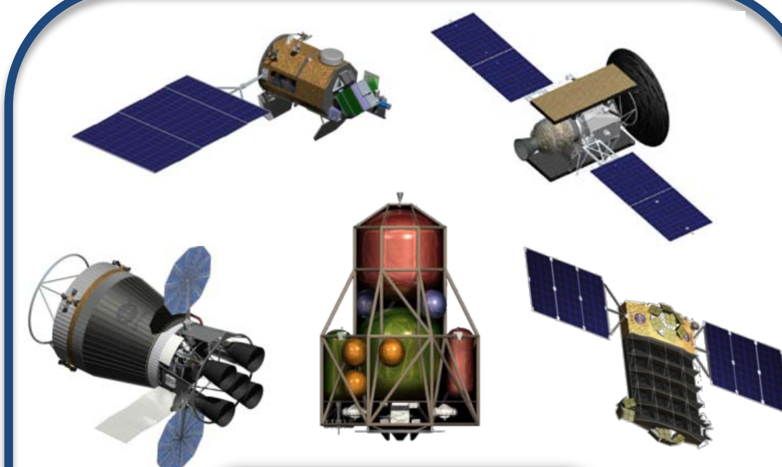
MSFC Advanced Concepts Office

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

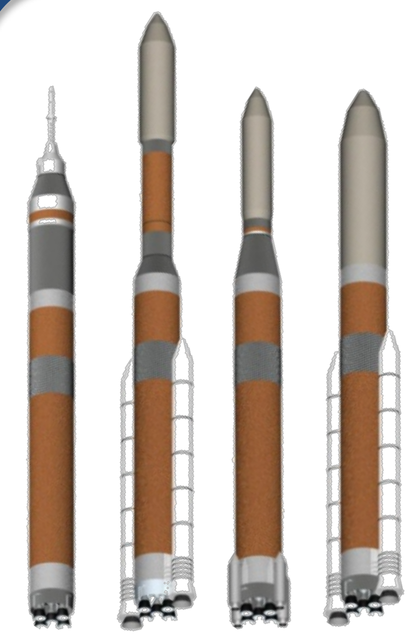
George C. Marshall Space Flight Center



Human Exploration Systems

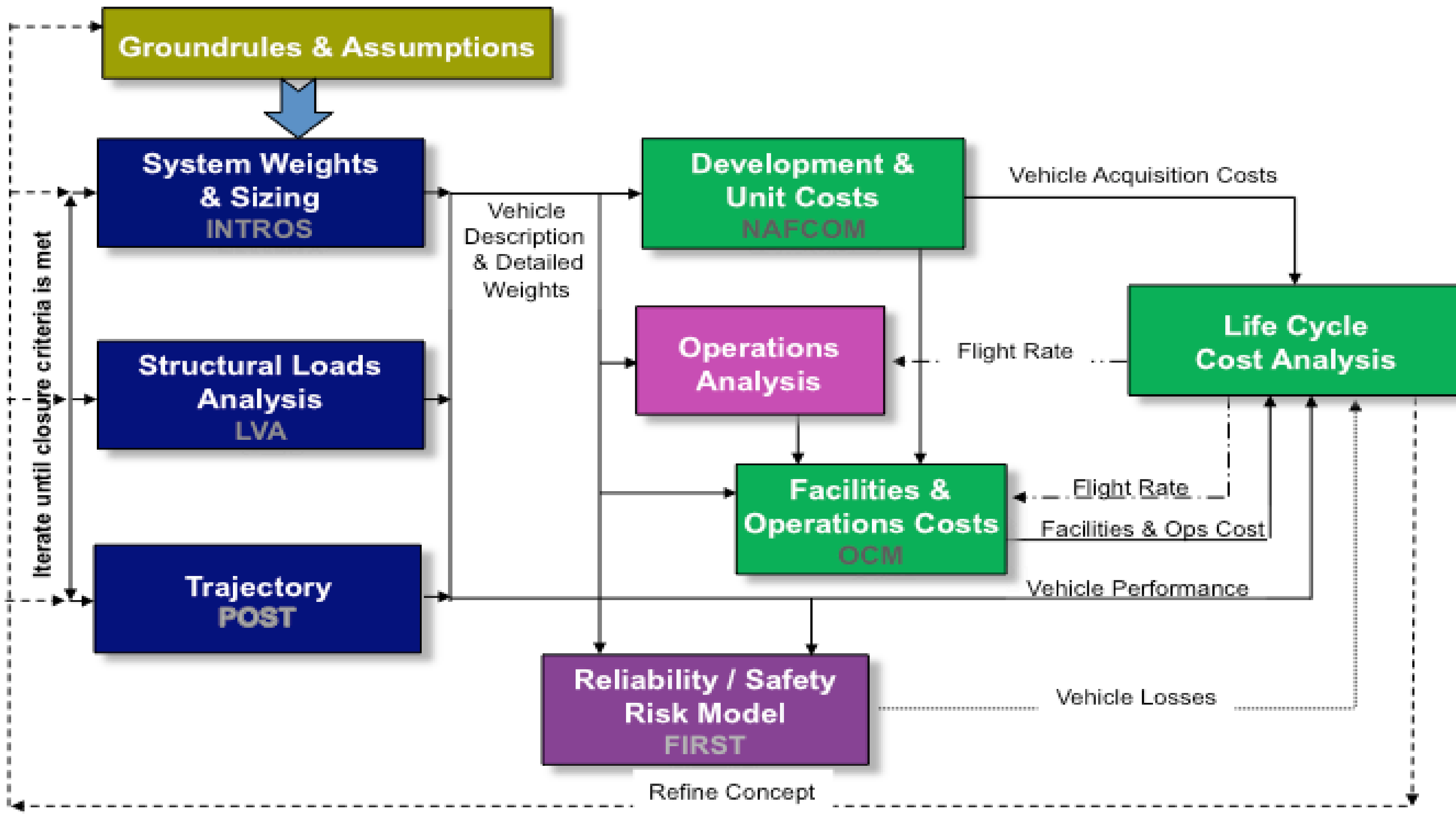


In-Space Transportation and Science Systems



Launch Vehicle Systems

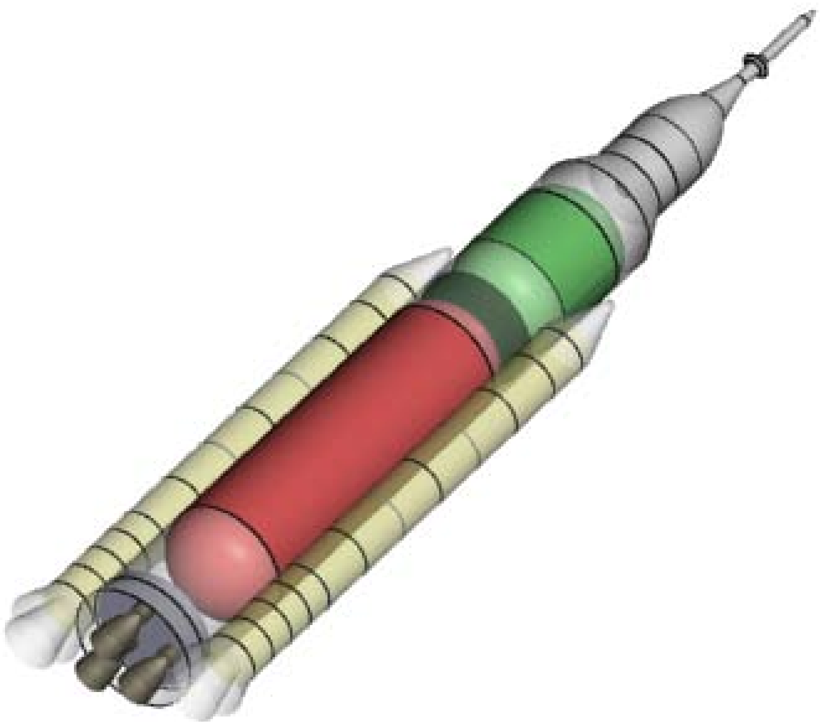
Launch Vehicle Design Process



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

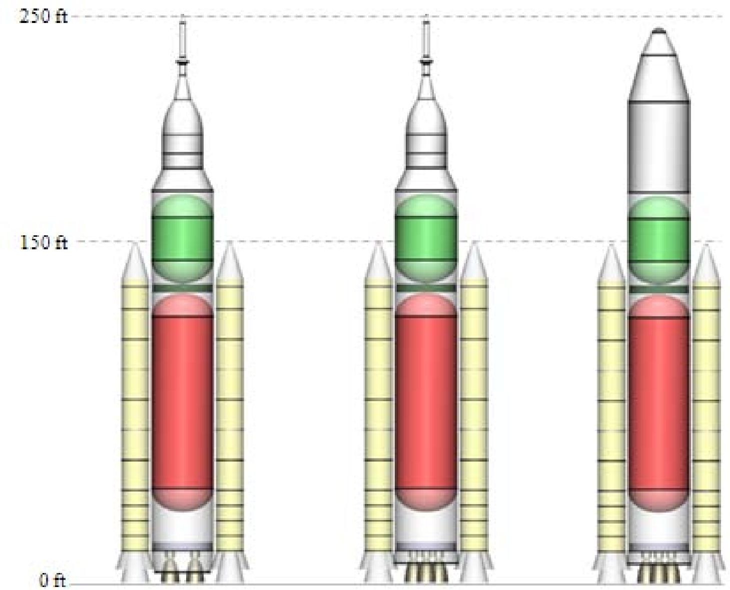
Study Objective

To characterize the performance capabilities of an inline, shuttle-derived launch vehicle using two design strategies: the first as an early program demonstrator utilizing high structural margins, maximum shuttle assets, and minimal pad impact, the later having undergone structural optimization, flying operational mission GR&A and serving as a baseline for evolutionary upgrades.



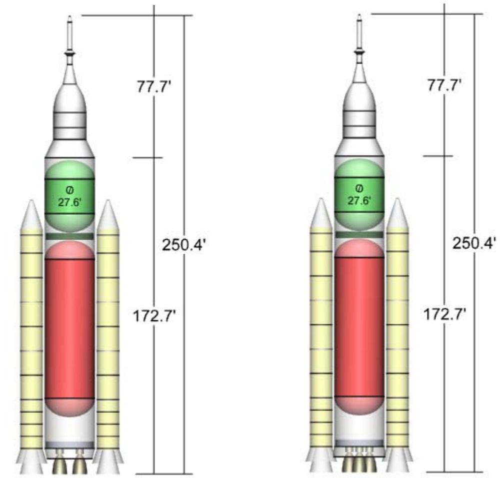
Baseline Concept Configurations

- **Common GR&A between demo and operational concepts**
  - 1.5 Stage
  - 2 or 3 RS-25D @ 104.5%
  - 2, 4-segment PBAN SRB
  - ET diameter (27.6 ft)
  - ET LH2 tank cylindrical length
  - Approximately 1.6M-lbm loaded propellant
- **Crewed concepts**
  - MPCV dimensions (current as of 03/11)
  - 16,500 lbm LAS (jett. 30 sec after SRB sep.)
  - -11 x 100 nmi insertion
  - 4.0g limit
- **Cargo concepts**
  - 27.6 x 40 ft cylindrical shroud (jett. when FMHR reached)
  - 30 x 130 nmi insertion
  - 5.0g limit



Early Demonstrators

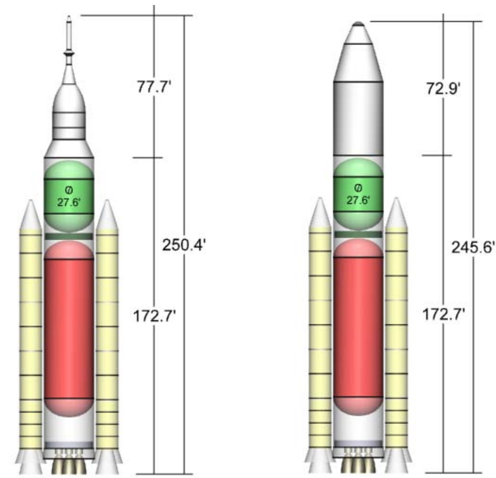
- **Minimize development timeline and cost**
- **"Battleship" structural design**
  - Monocoque
  - 2.0 safety factor (1.4 standard)
  - Uniform tank dome thickness
  - Approx 25% increase in main dry structural mass
- **Air start RS-25 at tower clear**
- **-11 x 100 nmi @ 29.0˚**
- **LEO mass delivery**
  - 42.6t / 67.0t
  - Two engine variant could support MPCV
  - Three engine may yield more valuable data



Vehicle ID	107.02.00	107.03.00
# RS-25D	2	3
Booster	4-seg PBAN SRB	4-seg PBAN SRB
Payload Element	MPCV	MPCV
GLOW (M-lbf)	4.14	4.54
Propellant Offload	21.3%	-
Payload (t)	42.6	67.0
Insertion Orbit	-11x100nmi @ 29.0˚	-11x100nmi @ 29.0˚

Operational Concepts

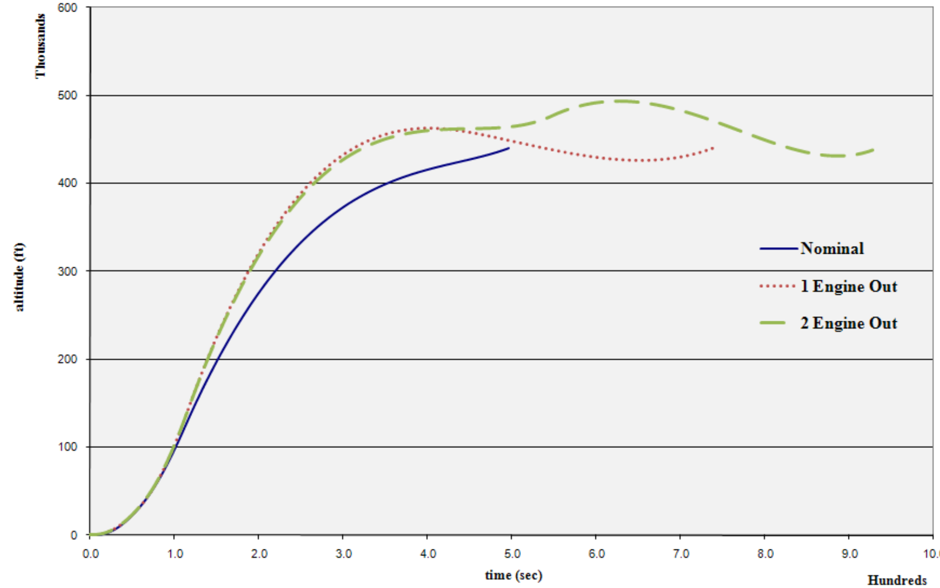
- **Operational design/baseline for concept evolution**
- **Optimized structures**
  - Isogrid stiffening pattern
  - 1.4 safety factor
  - In-depth mechanical testing
- **Ground start RS-25**
- **-11 x 100 nmi @ 51.6˚ (Crew)**
- **30 x 130 nmi @ 29.0˚ (Cargo)**
- **LEO mass delivery**
  - More than sufficient for MPCV to ISS and significant LEO cargo
  - Marginal increase over demonstrator suggests 5-seg evolution

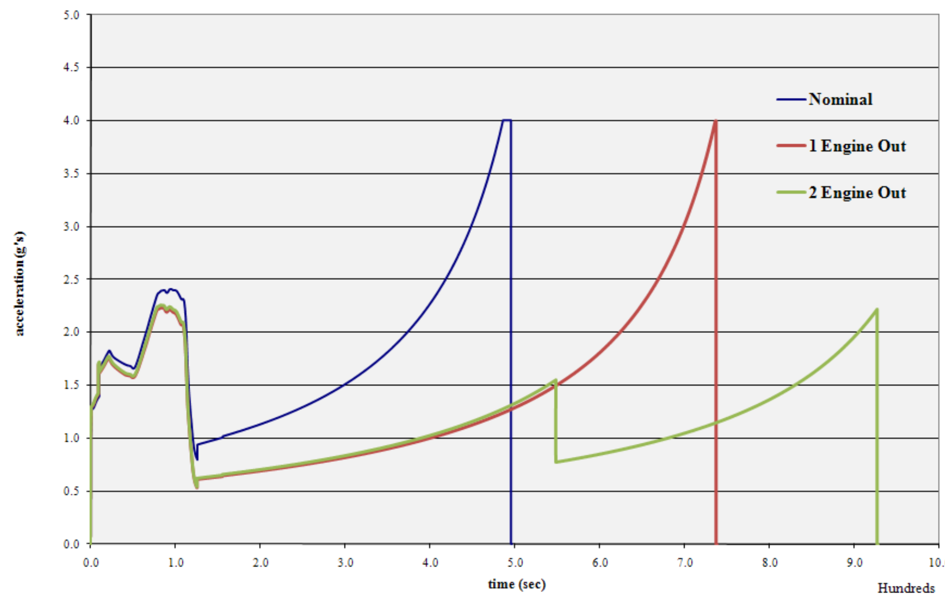


Vehicle ID	107.03.05	107.03.06
# RS-25D	3	3
Booster	4-seg PBAN SRB	4-seg PBAN SRB
Payload Element	MPCV	Cargo Shroud
GLOW (M-lbf)	4.53	4.54
Propellant Offload	-	-
Payload (t)	73.1	74.5
Insertion Orbit	-11x100nmi @ 51.6˚	30x130nmi @ 29.0˚

Engine Out Analysis

- **MPCV payload**
- **-11x100 nmi @ 51.6˚**
- **Scenario One**
  - Ground start
  - One engine out at 1 sec after liftoff
  - 33.5 t to LEO (-11x100 @ 51.6)
- **Scenario Two**
  - Ground start
  - One engine out at 1 sec after liftoff
  - Determined earliest time on ascent which 2nd LOE could occur and still achieve 25t delivery (548 sec)





Evolutionary Path

Conclusions

- **Early demonstrator concepts provide advantages**
  - Minimize development schedule and initial monetary investment
    - STS resources, high structural margins, lower pad interference with air start
  - Serve as a working test platform
    - MPCV, MPS, GN&C
  - Can provide 67 t of LEO payload
- **Operational version of demonstrator**
  - Optimize structures, ground start main engines
  - Can provide 75 t of LEO payload
  - Marginal increase over demonstrator may dictate moving directly to 5-seg, 5-eng
    - Utilize demo vehicle in interim
- **Engine out analysis**
  - Payload margin available for 1 and 2 engine out scenarios
- **Evolutionary pathway**
  - Depending on funding, scheduling and ultimate goals, shuttle-derived inline can eventually provide LEO payload in the 140 t range

Thanks

Questions?