National Aeronautics and Space Administration

Space Launch System Status

Briefing to NAC Space Operations Committee

8 February 2011

Background

- **In response to direction in Section 309 of the NASA Authorization Act of 2010 (P.L. 111-267) on October 11, 2010, NASA was required to deliver a preliminary report to Congress within 90 days after the date of enactment of this Act**

- **NASA submitted the preliminary report regarding NASA's plans for developing a Space Launch System (SLS) and Multi-Purpose Crew Vehicle (MPCV) on January 10, 2011**

- **Details within the report to meet the requirements of the Act**
  - NASA Administrator has established three principles for development of any future systems for exploration
    - Affordable
    - Sustainable
    - Realistic
  - *"NASA commits to obtaining independent (outside of the Agency) assessments of cost and schedule for SLS and MPCV design options as part of its decision process this Spring or Summer, and further to make these assessments public"*, **page 4 of the report**

- **NASA's interpretation is not to proceed with acquisitions until the independent assessment of cost and schedule is completed**

Source of Requirements

- **Primary driver is NASA Authorization Act of 2010**
  - **Section 302 Space Launch System as Follow-on Launch Vehicle to the Space Shuttle**

(a) POLICY — It is the policy of the United States that NASA develop a Space Launch System as a follow-on to the Space Shuttle that can access cis-lunar space and the regions of space beyond low-Earth orbit in order to enable the United States to participate in global efforts to access and develop this increasingly strategic region.

(b) INITIATION OF DEVELOPMENT

(1) IN GENERAL.—The Administrator shall, as soon as practicable after the date of the enactment of this Act, initiate development of a Space Launch System meeting the minimum capabilities requirements.

(2) MODIFICATION OF CURRENT CONTRACTS — In order to limit NASA's termination liability costs and support critical capabilities, the Administrator shall, to the extent practicable, extend or modify existing vehicle development and associated contracts.

(c) MINIMUM CAPABILITY REQUIREMENTS

(1) IN GENERAL — The Space Launch System developed shall be designed to have, at a minimum, the following:

(a) The initial capability of the core elements, **without an upper stage**, of lifting payloads weighing between **70 tons and 100 tons into low-Earth orbit** in preparation for transit for missions beyond low-Earth orbit.

(b) The capability to carry **an integrated upper Earth departure stage** bringing the total lift capability of the Space Launch System to **130 tons or more**

(c) The capability to lift the multipurpose crew vehicle

(d) The capability to serve as a **backup system** for supplying and supporting ISS cargo requirements or crew delivery requirements not otherwise met by available commercial or partner-supplied vehicles.

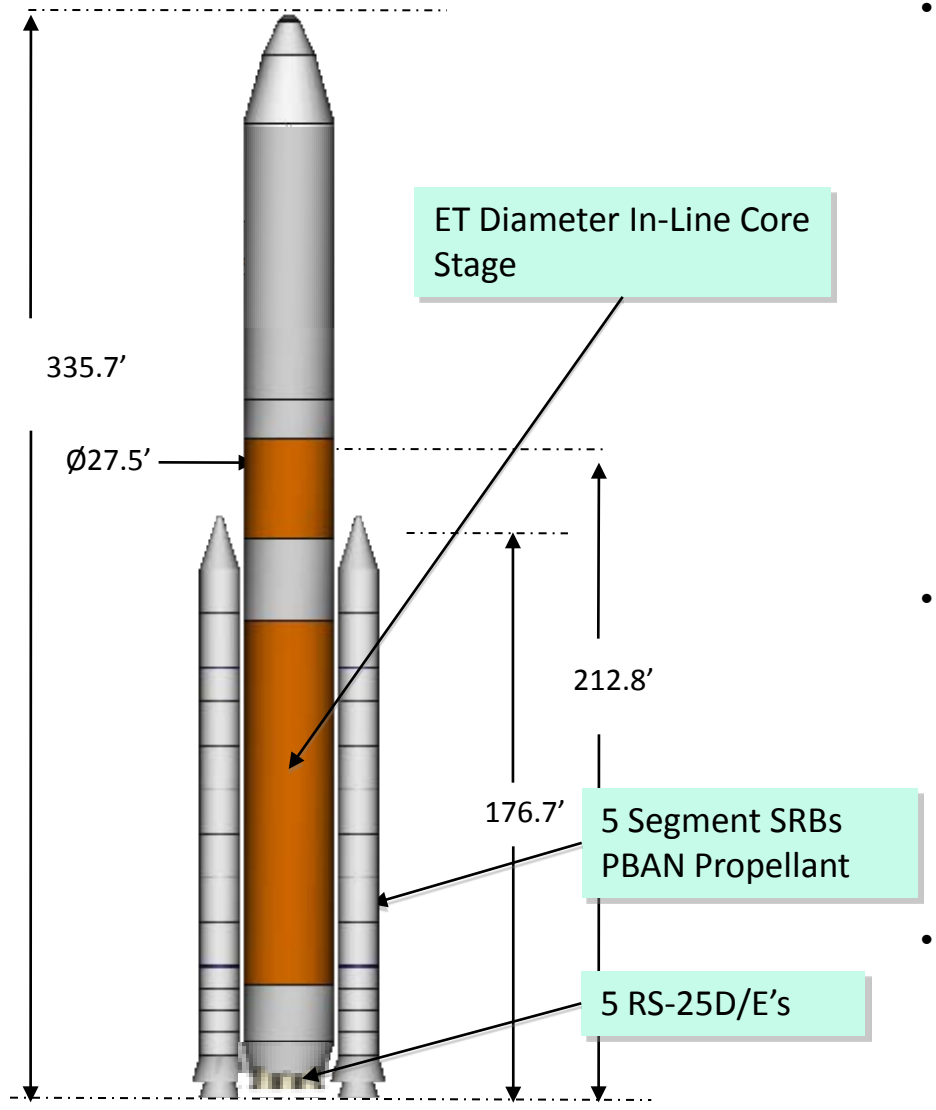
(2) FLEXIBILITY — The Space Launch System shall be designed from inception as a fully-integrated vehicle capable of carrying a total payload of 130 tons or more into low-Earth orbit in preparation for transit for missions beyond low-Earth orbit. Developmental work and testing of the core elements and the upper stage should proceed in parallel subject to appropriations. Priority should be placed on the core elements with the goal for operational capability for the core elements not later than **December 31, 2016**.

(3) TRANSITION NEEDS — The Administrator shall ensure critical skills and capabilities are retained, modified, and developed, as appropriate.

(4) The capacity for efficient and timely evolution, including the incorporation of new technologies, competition of sub-elements, and commercial operations.

SLS Reference Vehicle Design

Baseline SLS Path: Ares/Shuttle-derived System



- **Key Auth Act Direction**
  - The Administrator shall, to the extent practicable, extend or modify existing vehicle development and associated contracts
  - The initial capability of the core elements, without an upper stage, of lifting payloads weighing between 70 tons and 100 tons into low-Earth orbit
  - The capability to lift the multipurpose crew vehicle
  - The capability to serve as a backup system for supplying and supporting ISS cargo requirements or crew delivery requirements not otherwise met by available commercial or partner-supplied vehicles

- **SLS Reference Vehicle Design**
  - 27.5’ Diameter LOX/LH2 Core Stage
  - Five RS25 based engines using Shuttle assets then RS25E expendable derivative
  - Two 5-Segment Ares derived SRBs
  - Delivers 108.6t to 30x130 nmi

- **Evolved System to 130mT**
  - Upper stage with one or two J-2X upper stage engines (trades pending)

SLS Approach

SLS Near-term Activities

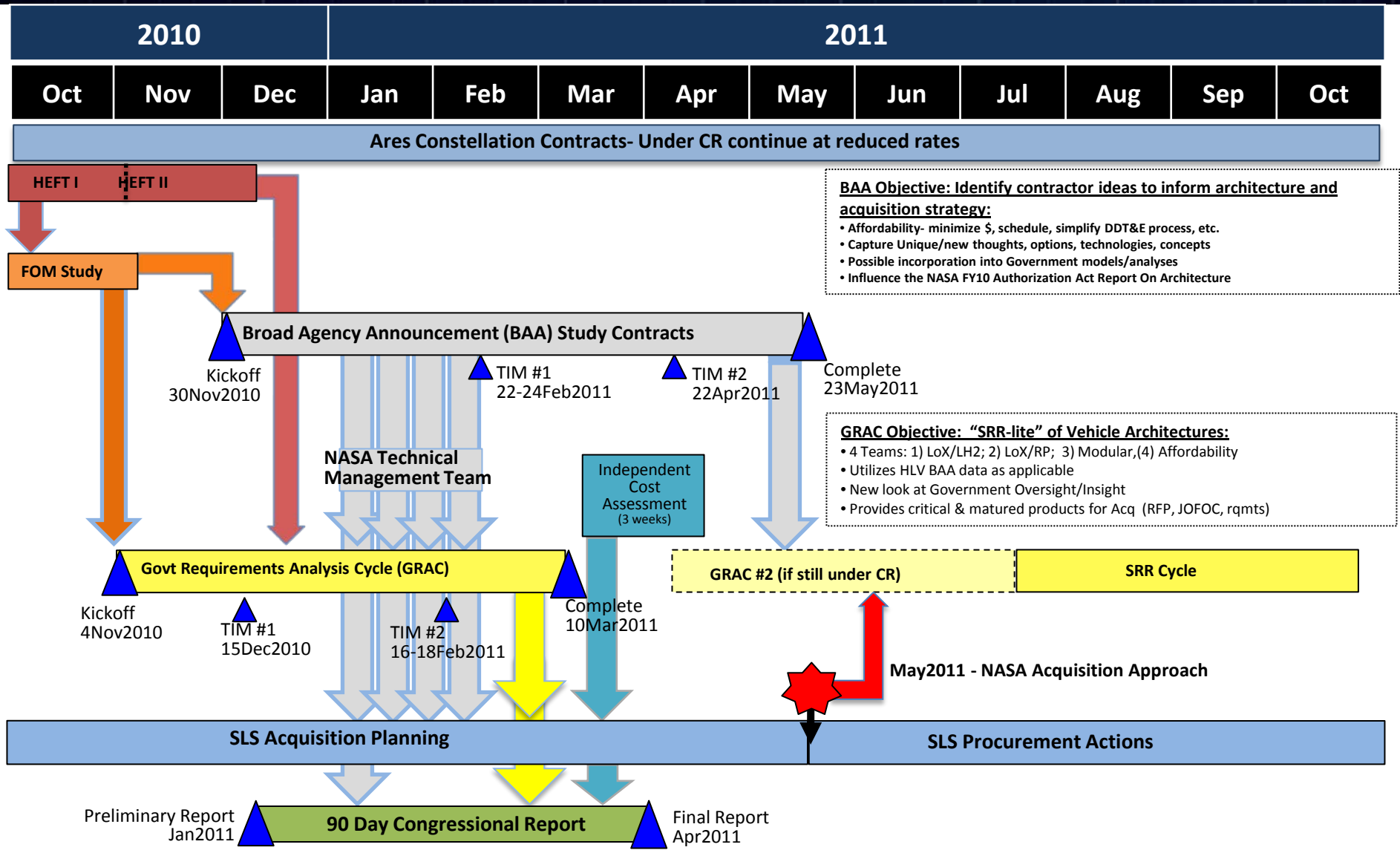
- **NASA pursuing two approaches for a more cost effective SLS solution**
  - NASA's Reference Vehicle Design for SLS is an Ares/Shuttle-derived LOX/LH2 solution
    - This vehicle comes closest to meeting schedule FOM with opportunities for affordability that could bring costs down to acceptable levels
    - Closely aligns with NASA Authorization Act of 2010
  - NASA will use data from Industry and Internal Government Analysis to make a final decision on SLS acquisition and development approach
  - Final Agency Decision on SLS will culminate in mid 2011

- **Approach 1: SLS Study Contracts (HLV BAA)**
  - In November 2010, NASA awarded 13 study contracts for a 6-month period of performance
    - Maximum award $625K
    - Total cost $7.5M
  - Working with industry on multiple affordability options for various heavy lift launch vehicle architectures
    - Technical Interchange Meeting (TIM) 1: 22-24 February 2011
    - TIM 2: 22 April 2011
  - Final Reports from each Industry partner due late May 2011

- **Approach 2: Government Requirements Analysis Cycle (RAC)**
  - Validate decisions through rigorous technical and acquisition process
  - Develop and validate vehicle-level requirements and provide a concept that meets the requirements
  - Demonstrate approach for incorporating "affordability" into design and analysis cycles

- **In parallel with SLS acquisition activities, the Constellation Ares contracts will continue through FY11 until the SLS contracts are awarded to minimize workforce disruptions**

SLS Near-term Activities



BAA Study Contract Participants

- **Awarded to 13 Teams**
  - Maximum award $625K
  - Total cost $7.5M

- **Mix of large aerospace firms, engine developers, academia**
  - Aerojet General Corp., Rancho Cordova, Calif.
  - Analytical Mechanics Associates, Huntsville, Ala.
  - Andrews Space, Tukwila, Wash.
  - Alliant Techsystems, Huntsville, Ala.
  - The Boeing Co., Huntsville, Ala.
  - Lockheed Martin Corp., Huntsville, Ala.
  - Northrop Grumman Systems Corp., Huntsville, Ala.
  - Orbital Sciences Corp., Chandler, Ariz.
  - Pratt & Whitney Rocketdyne, Canoga Park, Calif.
  - Science Applications International Corp., Huntsville, Ala.
  - Space Exploration Technologies Corp., Hawthorne, Calif.
  - United Launch Alliance, Centennial, Colo.
  - United Space Alliance, Huntsville, Ala

- **Majority of contracts involve teaming arrangements with academia and labs (e.g., University of Huntsville, Draper)**

- **Period of performance is six months**

Requirements Analysis Cycle (RAC)

Overview

- **Objective**
  - Develop and validate vehicle-level requirements and provide a concept that meets the requirements.
  - Demonstrate approach for incorporating “affordability” into design and analysis cycles
  - Execute the RAC process and the Organizational Management Model
- **Four Teams**
  - Team 1: LOX/LH2/SRB Core
  - Team 2: LOX/RP Core
  - Team 3: LOX/RP Modular Core
  - Affordability Team (e.g. Insight/Oversight Models, Design, Construction & Workmanship Standards, etc)
- **Timeline**
  - TIM 1: 15 December 2010 – Complete: Presented initial study approach and preliminary architectures
  - TIM 2: 16-18 February 2011
  - Red Team Review: 10 March 2011
- **Products**
  - Concept of Operations
  - Functional Analysis Document
  - Systems Requirements Document (preliminary)

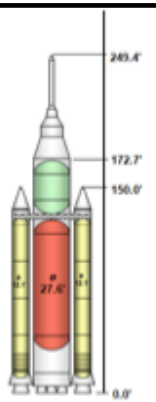
Requirements Analysis Cycle (RAC)

Team 1 Architecture Options: Ares/Shuttle-Derived

- **Team 1 is addressing a "Family" of Ares/Shuttle –derived vehicles**

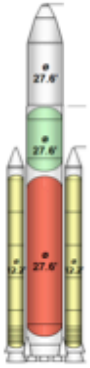
Block 0-2016

- **Core**
  - Size 27.5' diameter (ET pedigree)
  - RS-25D/E x 3
- **Booster**
  - RSRMV-1 x 2
- **Payload Shroud**
  - 27.5' x 52' Aluminum//Composite
- **Payload Capacity**
  - MPCV – 70mT
  - MPCV to LEO with engine out capability



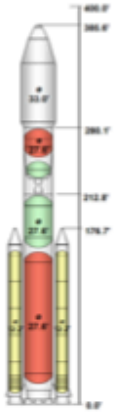
Block I-2019

- **Core**
  - Size 27.5' diameter
  - RS-25E x 5
  - Length extended to increase propellant load
- **Booster**
  - RSRMV x 2
- **Payload Shroud**
  - 27.5' x 52' Aluminum/Composite
- **Payload Capacity**
  - 100 mT



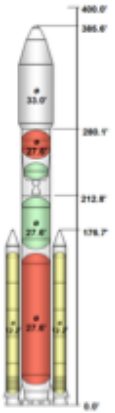
Block III-2026

- **Core (unchanged)**
  - Size 27.5' diameter
  - RS-25E x 5
- **Booster**
  - Upgraded RSRMV x 2 (HTPB)
  - Upgraded booster can be pulled forward
- **Upper Stage (unchanged)**
  - Size 27.5' diameter
  - RS-25E x 1
- **Payload Shroud**
  - 33' x 60' Aluminum/Composite
- **Payload Capacity**
  - 150 mT



Block II-2022

- **Core (unchanged)**
  - Size 27.5' diameter
  - RS-25E x 5
- **Booster (unchanged)**
  - RSRMV x 2
- **Upper Stage**
  - Size 27.5' diameter
  - RS-25E x 1
- **Payload Shroud**
  - 27.5' x 52' Aluminum/Composite
  - 33' x 60' Aluminum/Composite
- **Payload Capacity**
  - 130 mT



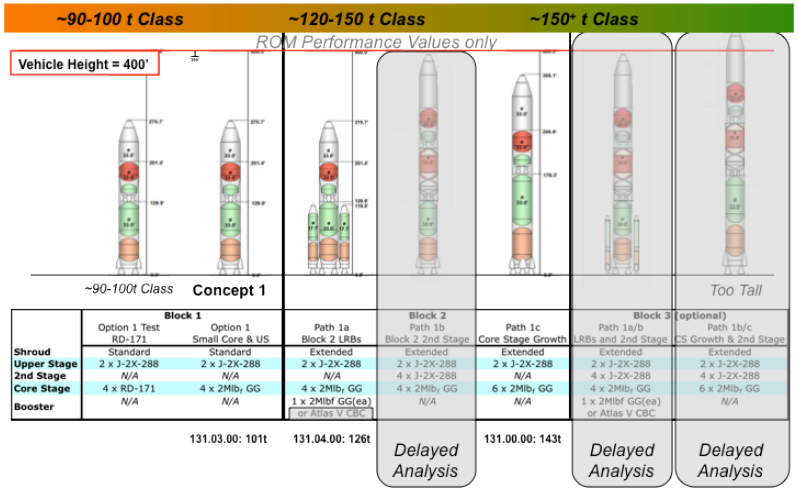
Point of Departure Architecture Selected After Considering Multiple Evolution Paths

Requirements Analysis Cycle (RAC)

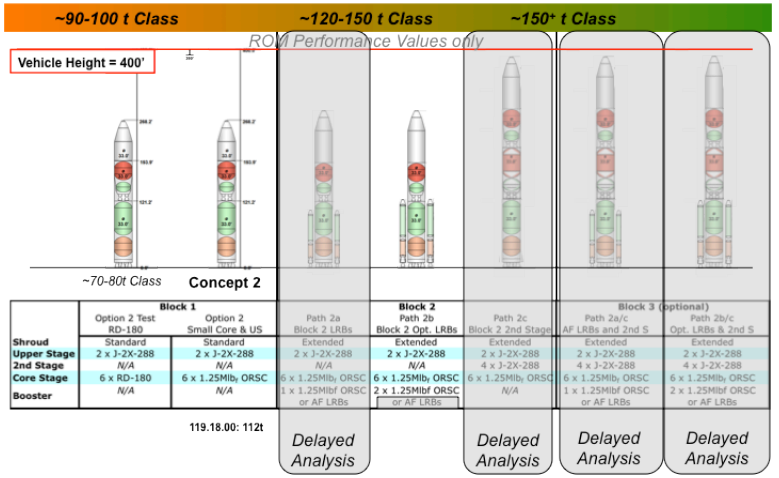
Team 2 Architecture Options: LOX/RP

- **Team 2 is addressing four Concept Development Paths**

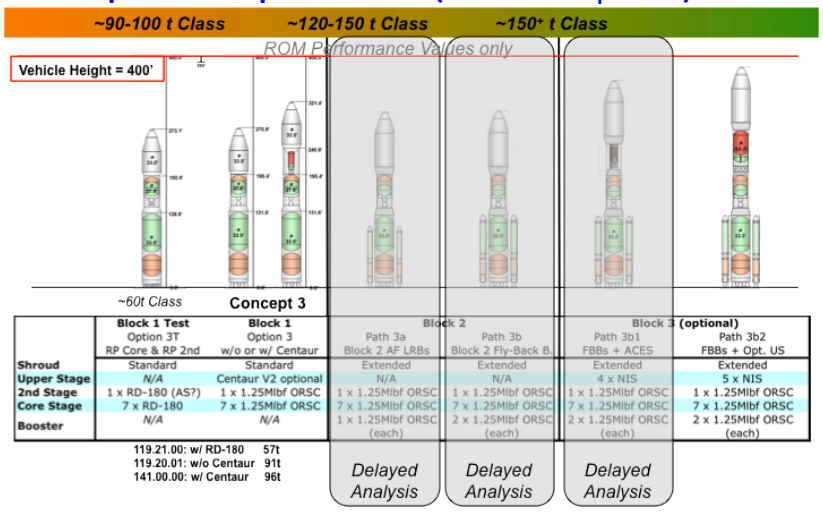
Concept 1 Development Paths (2Mlb$_f$ GG CS)



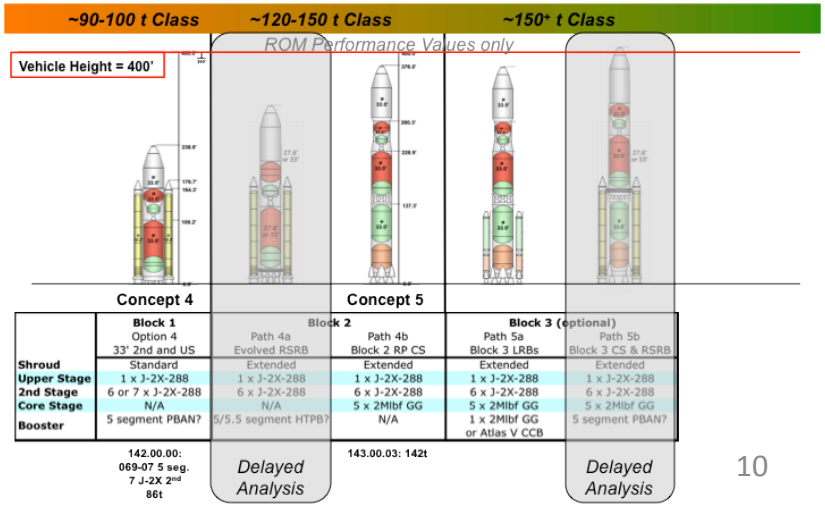
Concept 2 Development Paths (1.25Mlb$_f$ ORSC CS)



Concept 3 Development Paths (All 1.25Mlb$_f$ ORSC)



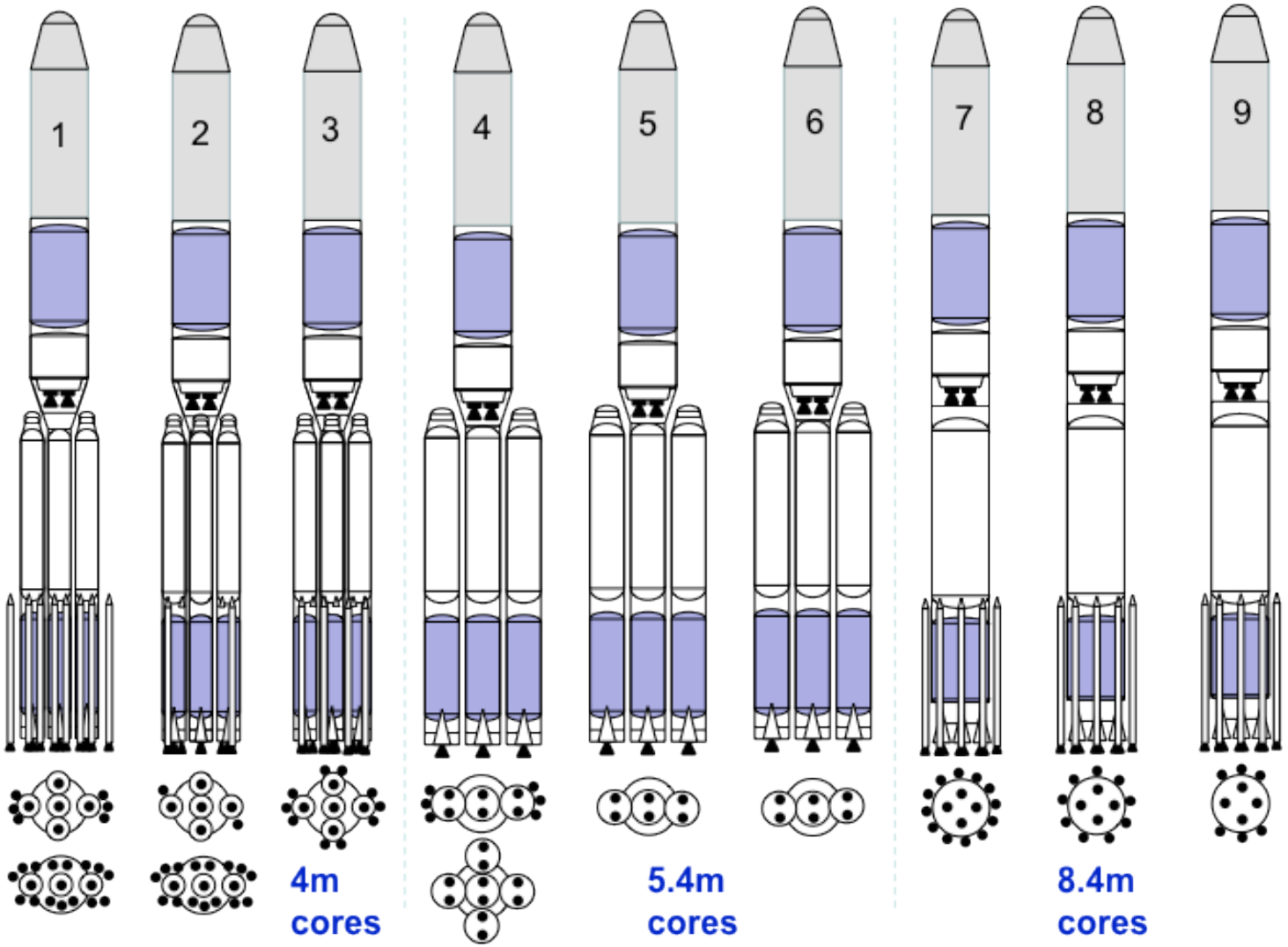
Concept 4 - 5 Development Paths



Requirements Analysis Cycle (RAC)

Team 3 Architecture Options: Modular

- **Team 3 is addressing Modular (common-core diameter) vehicles**



Requirements Analysis Cycle (RAC)

Team 4 Affordability

- **Affordability is a key consideration in the development of the Con-Ops, Functional Flow derivation and requirement development**

- **Key strategies :**
  - Leverage current Infrastructure assets
  - Enable Competition
  - Leverage existing Government workforce to reduce risk
  - Design to avoid development and operation cost
  - Reduce Requirements to bare minimum needed to obtain performance
    - Requirements drive verification, paperwork, and personnel costs
  - Reduce or combine functions
    - Functions and verification of function drive cost
    - Reducing the number of functions to the minimum required to launch a vehicle minimizes cost
  - Right size insight
    - Engagement model
    - Risk-driven activities
  - Allocate cost and measure cost
    - Activity-driven cost accounting
    - Coupling of development activities with production cost control
  - Excellence in execution
    - Take care of your pennies and your dollars will take care of themselves

SLS Forward Work

- **NASA will continue with its current FY11 Near-term SLS plan**
  - Continue on with Constellation Ares contracts through FY11
  - Continue to execute the HLV BAA study contracts - focus of on achieving affordability, operability, reliability, and commonality with multiple users at the system and subsystem levels
  - Continue with government Requirements Analysis Cycle (RAC) teams process for defining system-level requirements, with a target completion early March 2011
  - Obtain an Independent Cost and Schedule estimate by an external entity and submit report to OMB/OSTP
  - Submit a final report to Congress by April 2011 outlining detailed development plans for SLS

- **NASA will continue identifying and addressing the Affordability strategies**
  - NASA has reviewed affordability initiatives by Industry for existing hardware elements
    - PWR Infrastructure Consolidation, Manufacturing and Supply Chain Approach
    - ATK Infrastructure and Cost Reduction Initiatives
    - Current NASA estimates incorporate these potential savings
  - Continue to cull additional affordability strategies identified through the RAC and BAA study Contracts to achieve an affordable, sustainable, and realistic SLS development approach

- **NASA understands that improvements in its cost estimating capability are needed**
  - NASA is working closely with industry to validate cost estimates for the existing hardware elements/systems
  - Cost models are only outputs
    - Model output is DDTE estimates for total value then phased by year
    - Affordability and implementation approaches drive actual costs
    - Current estimates are outputs of models on historical data – approach to drive affordability to optimize actual cost is underway
  - Need to understand how to take affordability initiative “credit” on cost estimating