United Launch Alliance

Presentation To

2010 AIAA/USU Conference on Small Satellites

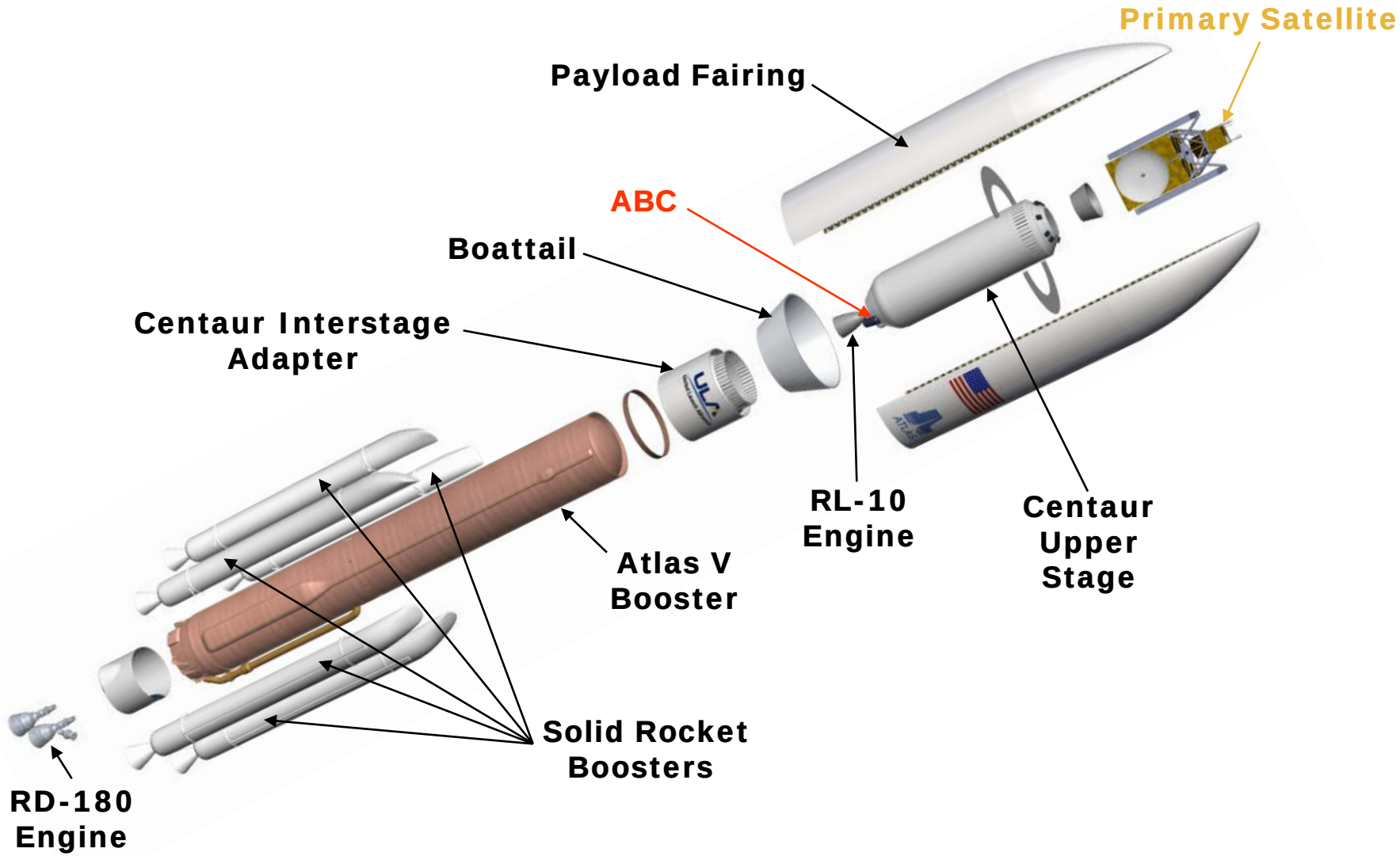
August 9-12, 2010

George Budris
Customer Program Office

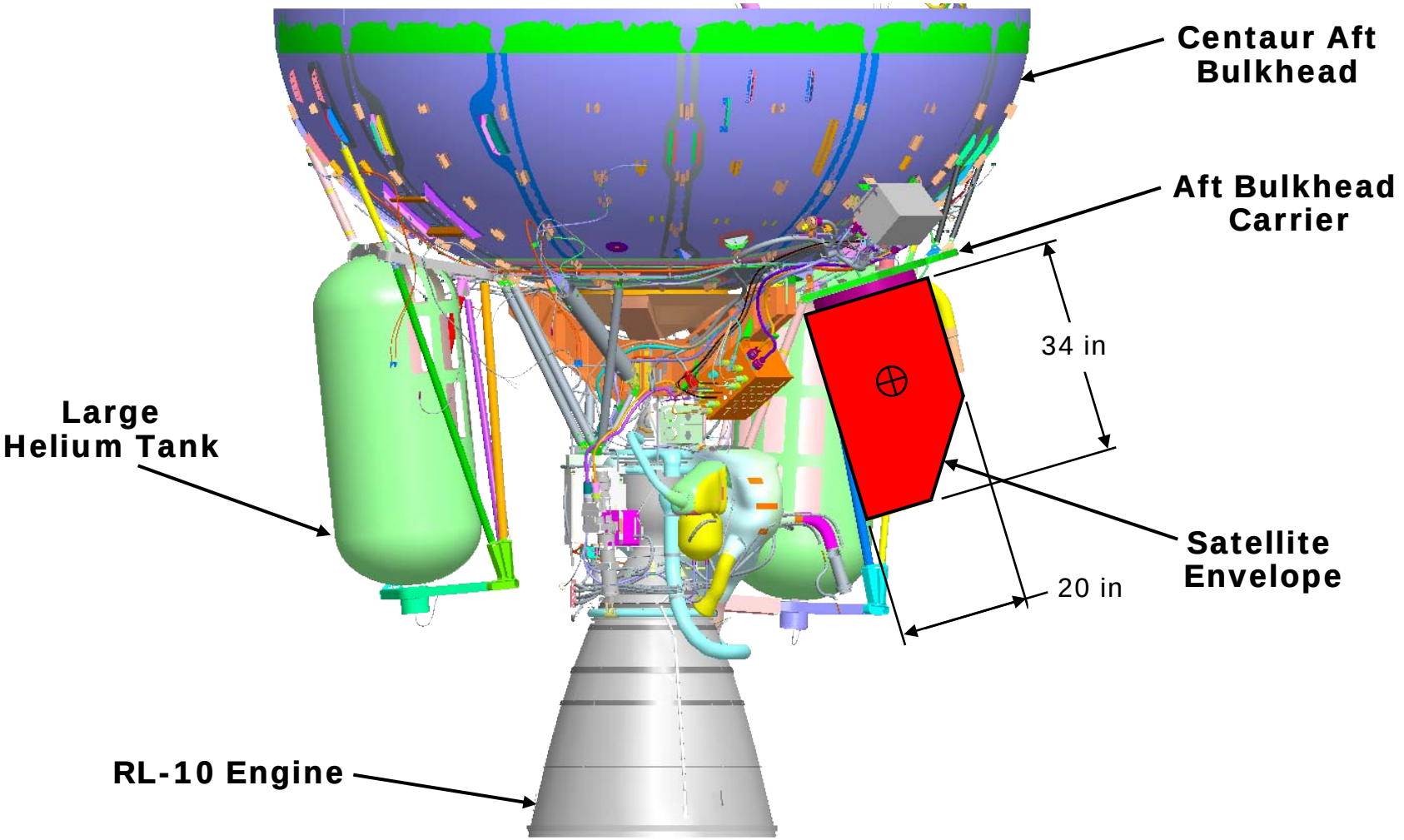
Aft Bulkhead Carrier (ABC) Overview

- ULA has developed the Aft Bulkhead Carrier (ABC) system for mounting small satellites onto the Atlas V launch vehicle
  - Located at the aft end of the Centaur upper stage
  - Accommodates small payloads up to 80 kg (170 lb) within a 51 x 51 x 86 cm (20 x 20 x 34 in) envelope
- Advantages of ABC
  - Located in an area separate from the primary payload
  - Space will be available on every mission, after flyout of He bottle missions
  - Able to fly on any mission with performance margin
- Program Activity
  - PDR completed in late 2008, CDR completed August 2009
  - ABC safety documentation reviewed by the Western Range
- ABC Users Guide in development
  - Initial release scheduled for September 2010
- Flight hardware built and available for launch

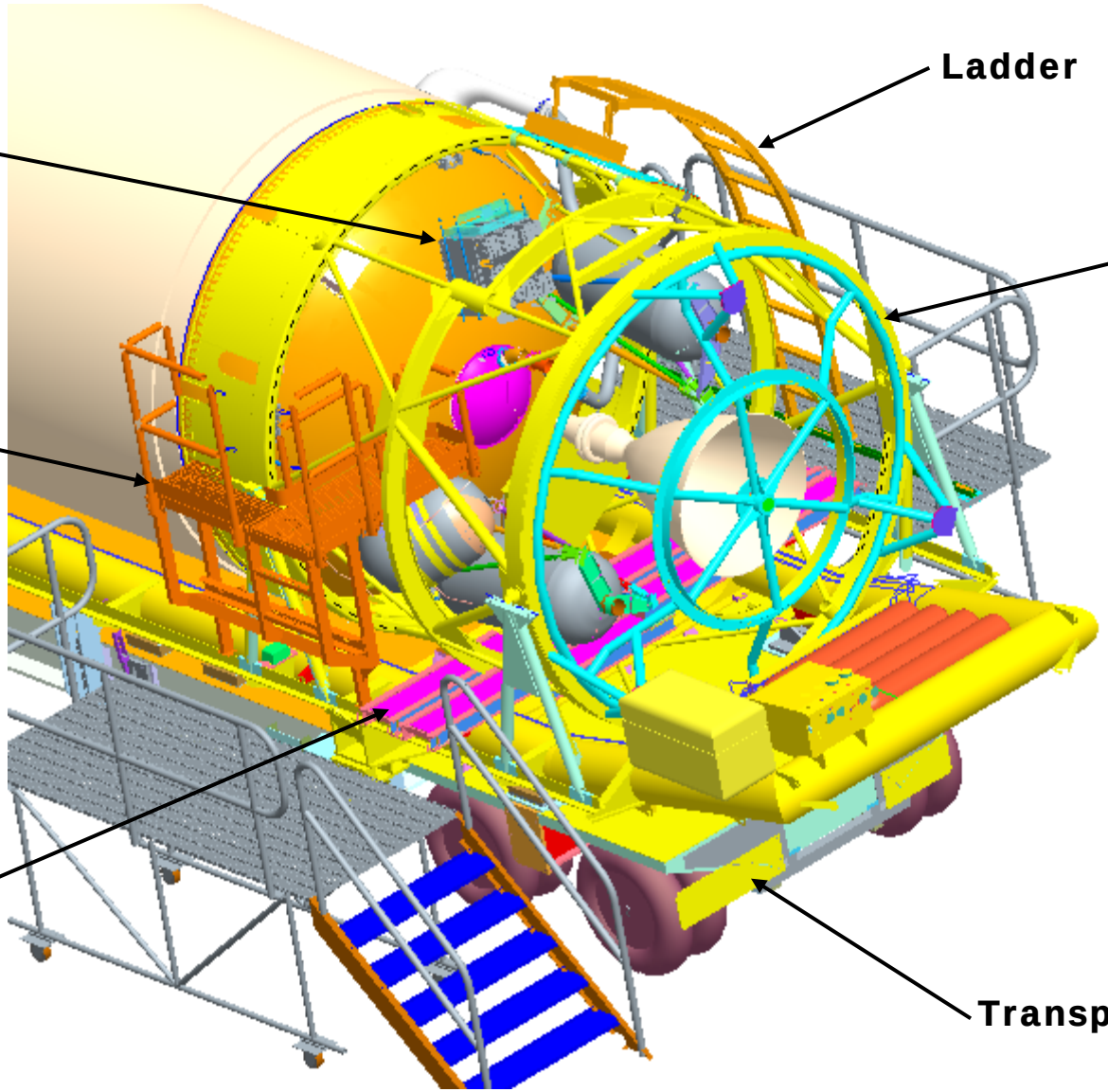
ABC Location (Atlas V 500 Series)



ABC Flight Configuration

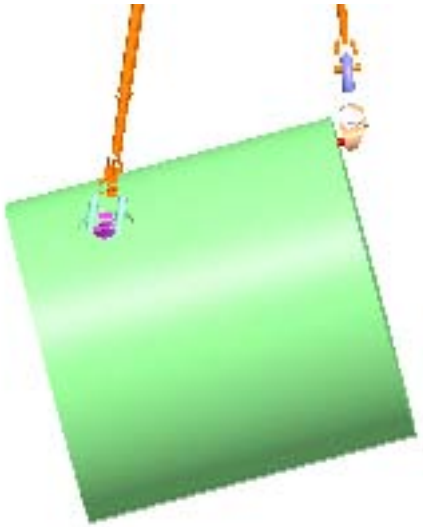


ABC - Access Platforms



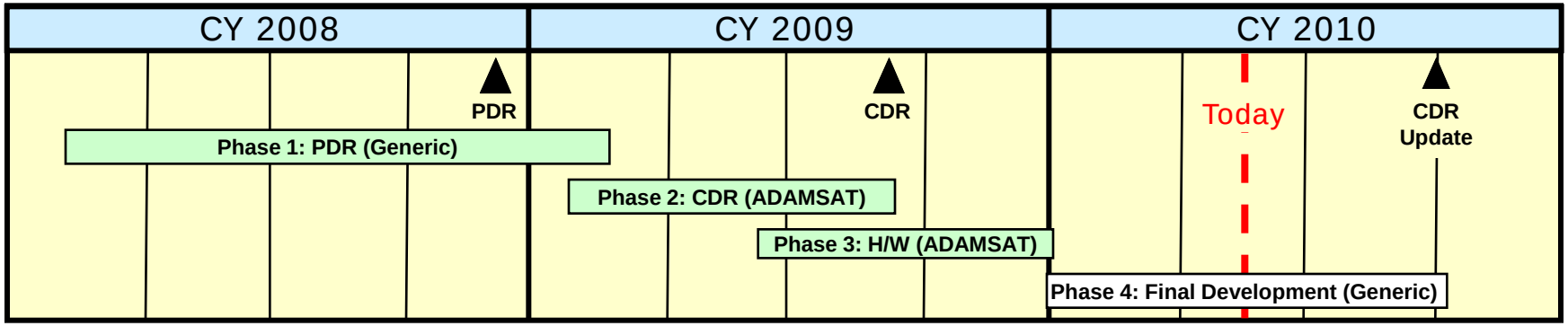
Mass Simulator Requirement

- The mass simulator will be a necessary deliverable from the secondary payload team, providing a mass and center of gravity substitute
  - If the satellite can't make its integration milestone, the mass simulator will be used
  - This allows the launch vehicle/primary payload integration to continue without rerunning analyses
- Arrives at launch site in time to support processing schedule



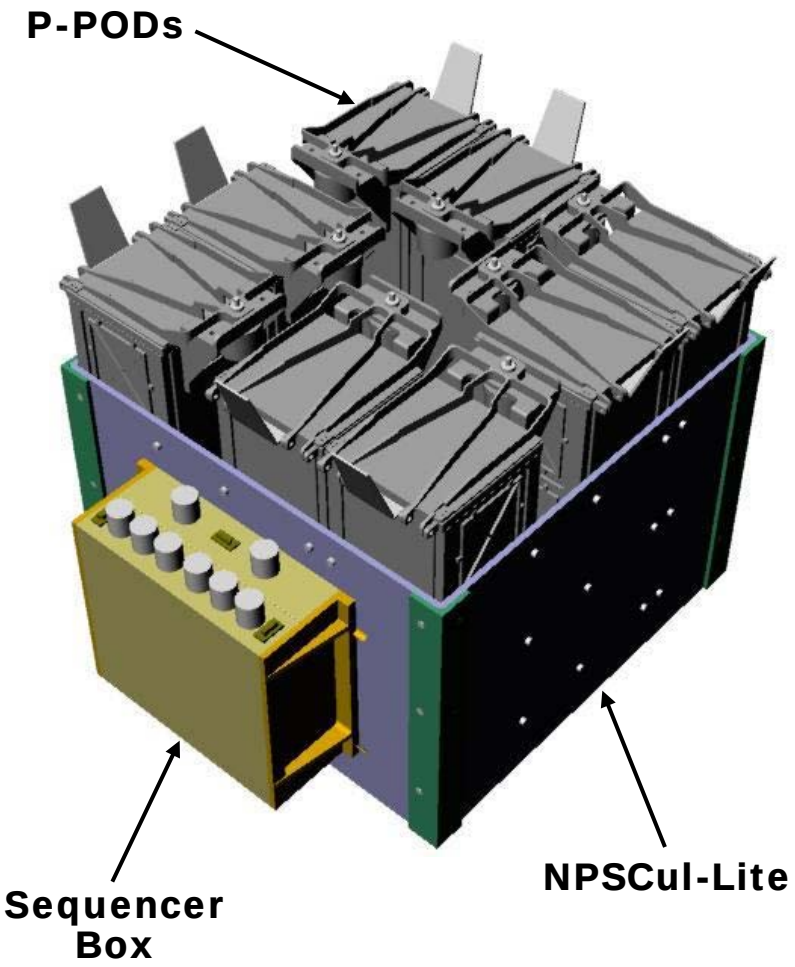
ABC Implementation Approach

- Customer Objectives
  - Establish low cost secondary capability on Atlas V, using existing space and capability on Centaur Aft Bulkhead
  - Continue generic capability to include separation system, T-0 umbilical, Users Guide
- Contract Implementation
  - Phase 1: Conceptual "generic" study developing preliminary design, culminating in PDR
    - Develop draft Users Guide
  - Phase 2: Develop ABC design to CDR level:
    - Point design for ADAMSAT Cubesat Deployer
    - Develop ABC ICD for ADAMSAT to Atlas V launch vehicle
  - Phase 3: Complete design release, hardware build, GSE build, & integration to Centaur
  - Phase 4: Complete generic ABC capability, release Users Guide

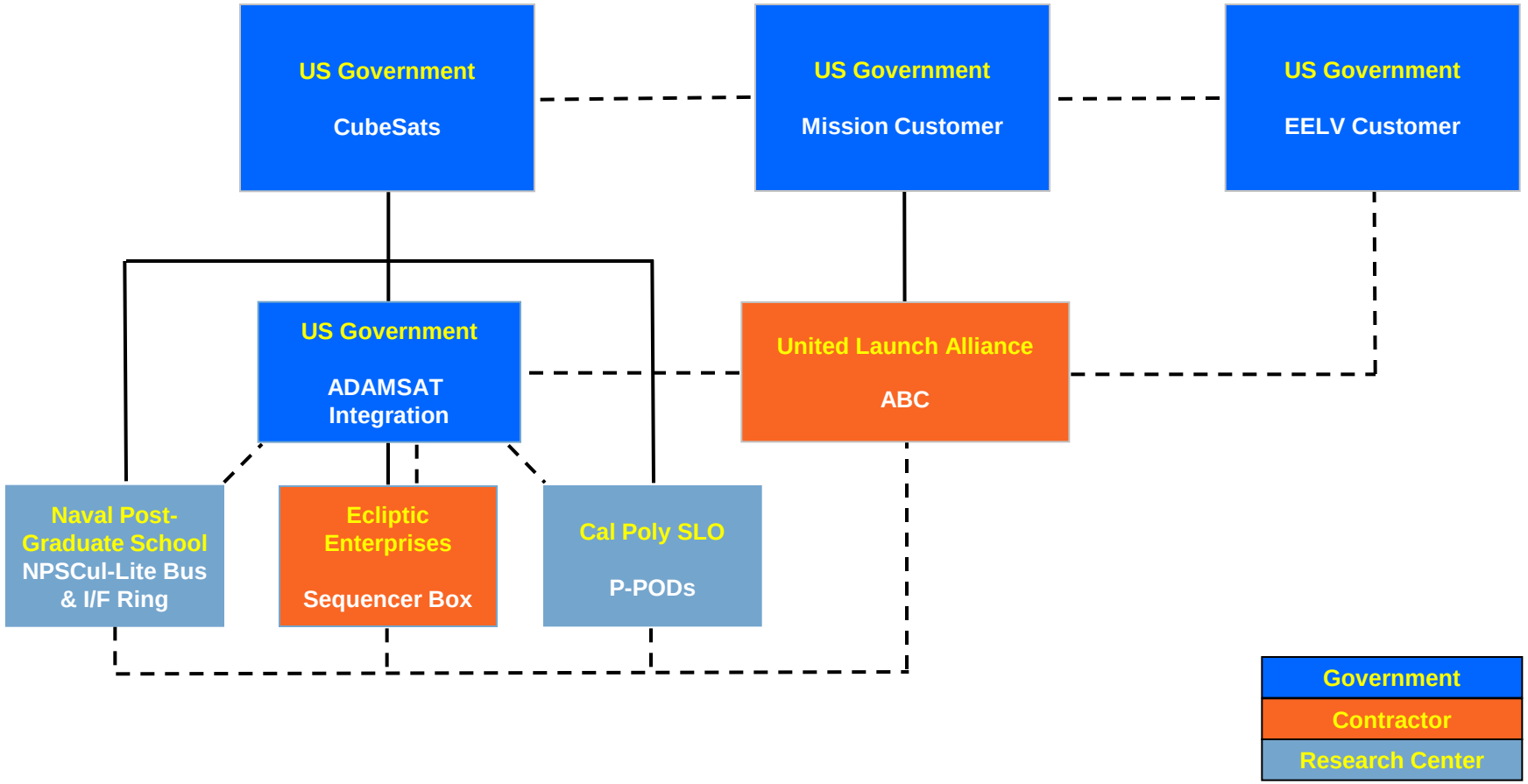


ADAMSAT

- ADAMSAT
  - NPSCul-Lite box structure provided by Naval Postgraduate School
  - Sequencer Box provided by Ecliptic Enteprises
  - P-PODs provided by Cal Poly San Luis Obispo



ABC / ADAMSAT Responsible Organizations



Solid lines denote contractual relationship

Dotted lines denote cross-coordination across major team members

ABC Lessons Learned Overview

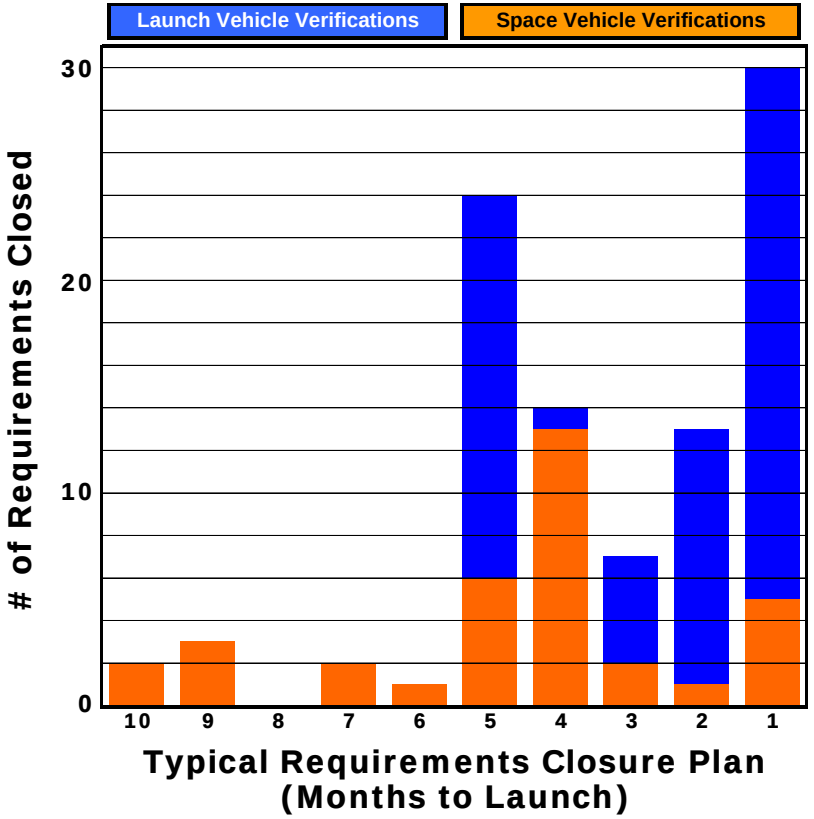
- During the ABC/ADAMSAT integration effort, various issues came up that eventually derailed the launch opportunity
  - Had the process been more rigorously followed, the impacts could have been mitigated
- When working with the rideshare community, primary payload mission managers expect the small satellite programs to meet the same high standards for requirements, management, and closeout during integration on their mission
- Successful integration of small satellites onto the ABC can be accomplished by following a disciplined approach to meeting and verifying mission requirements
- It is vital that the community comprehend what these requirements are and follow an established process to meet them

"Launch reliability is my top priority. Our constellations for any of our missions cannot tolerate a launch failure."

Gary Payton, Deputy Under Secretary of the Air Force for Space Programs

Requirements To Be Addressed By the Secondary Payload Customer

- Mission
  - Orbit Insertion and Accuracy
  - Launch Window
  - Separation Control
    - Satellite Mass Properties
    - Centaur Control Capabilities
  - Separation Requirements
- Interface
  - Satellite to Launch Vehicle Interfaces
    - Coordinate System
    - Volume, Mechanical Interface
    - Stiffness
  - Avionics Interfaces
    - Ground Interfaces
    - Separation Indication
  - Range and System Safety Interfaces, Facilities and Processing

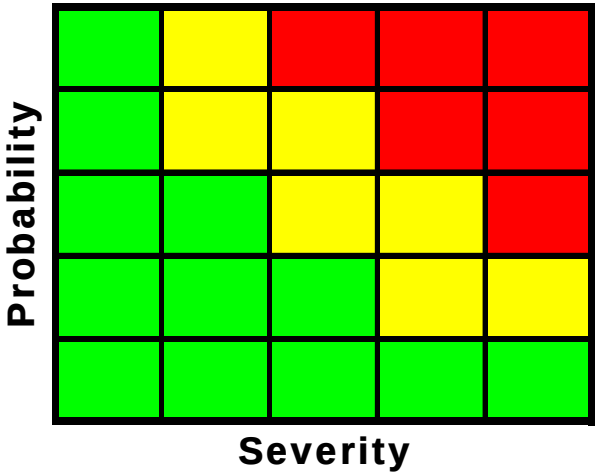


Requirements To Be Addressed (Cont.)

- Environments
  - Prelaunch
    - Thermal – Processing, Transport and Mate, Prelaunch
    - Electromagnetic Compatibility (EMC)
    - Contamination Control and Cleanliness - Contamination and Helium Environment
    - Transport Loads
  - Launch and Flight Environments
    - Spacecraft Design Load Factors
    - Vibration, Shock and Acoustics
    - Thermal - Ambient Temperature and Convection, Solar Heating, Thruster Plume
    - Static Pressure
    - Contamination Control, including Molecular and Particulate
    - Radiation and EMC
  - Satellite Compatibility Test Requirements
    - Dynamic Compatibility Test Requirements
    - Thermal Test Requirements
    - EMI/EMC Test Requirements

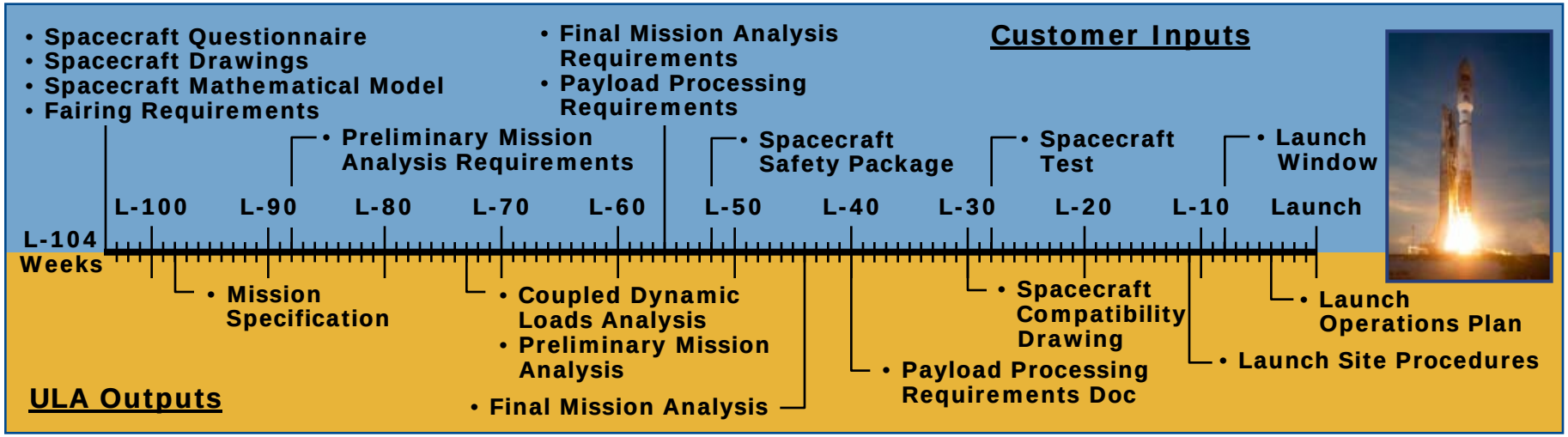
Safety Lessons Learned

- Understand Satellite Functions
  - Not only understand how your hardware functions, but also how it might malfunction, and what conditions or circumstances could induce a malfunction
- Safety Documentation - The MSPSP
  - A Missile System Prelaunch Safety Package (MSPSP) is the primary "price of admission" onto the launch vehicle and launch range



- Early Range Coordination
  - The Range needs to know what the hazards may be with the satellite
  - Coordination must occur as early as possible in the integration cycle
  - Late ADAMSAT coordination stressed the range safety team
- Small satellites do not necessarily present "small" hazards
  - Appropriate levels of fault tolerance features must be incorporated into the design

Schedule Lessons Learned



- Milestone Schedule
  - Small satellites customers must prepare a schedule with milestones that support the launch vehicle and primary payload integration schedules
- Understand the Launch Vehicle Timeline
  - Small satellite developers need to understand launch vehicle timeline and the cost and program impacts if they do not submit or change mass properties, orbit parameters, etc
- ADAMSAT Example
  - The ADAMSAT design team developed an electrical harness that interfered with lifting operations. The launch vehicle development team specifically went over what could & could not be done, yet several months later they did it anyway, causing redesign

Program Lessons Learned

- Integration Contractor
  - Need a strong third party integration contractor from the beginning to coordinate requirements with the satellite
- Small satellite program support and plan
  - LV and primary payload mission team will need to have assurance that there is a commitment of funding and resources
- Launch vehicle & primary payload mission managers expect regular small satellite status
- Integration schedule milestones
  - Includes regular technical interchange meetings (TIMs)
  - Key meetings PDR, CDR

Program Lessons Learned

- Rigorous design and manufacturing processes
  - Verifications are evaluated by launch vehicle teams as ICD requirements are met
- Understanding requirements
  - Small satellite program must have thorough understanding of technical and programmatic requirements.
  - Must also have an understanding of the verification information that is required to be provided
  - The integration contractor will be central to this effort
- Can't over emphasize the phrase "do no harm to the primary payload"
  - Small satellites need to understand the extent that they are going to have to prove to all that they have the proper inhibits, design margins, etc.
  - Mission success is of paramount importance

Summary

- To the Small Satellite community:
  - Meet the requirements
  - Complete high-quality verifications
  - Implement lessons learned
- No secondary payload has ever caused a mission to fail
- All missions must be successful to support the warfighter

Aft Bulkhead Carrier is ready!