NATIONAL RECONNAISSANCE OFFICE

Office of Space Launch Atlas V Aft Bulkhead Carrier & Operationally Unique Technologies Satellite

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FREEDOM'S SENTINEL IN SPACE

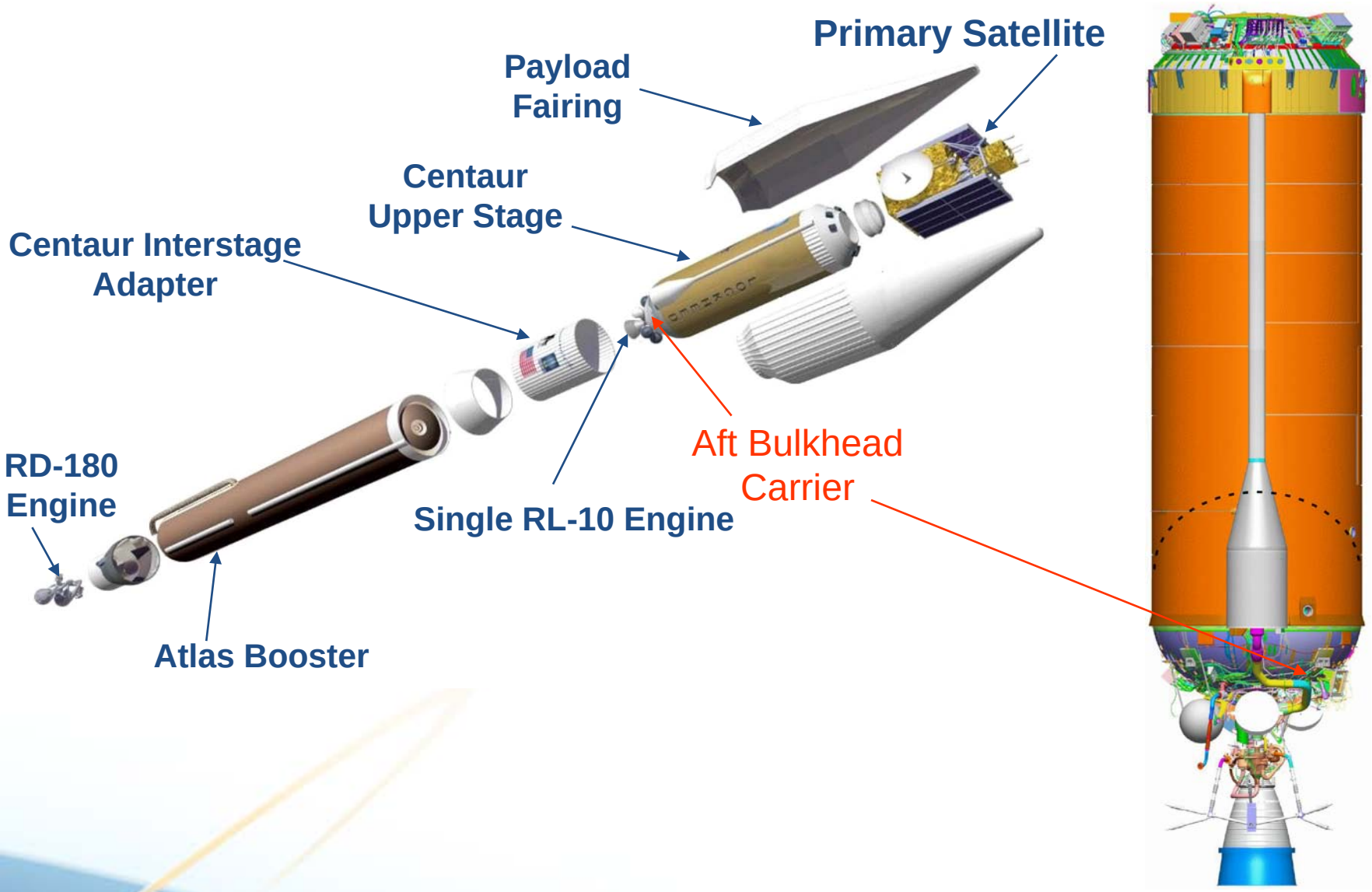
Origin of Aft Bulkhead Carrier on Atlas V

- United Launch Alliance (ULA) modified Atlas V Centaur upper stage – 3 small spherical helium tanks replaced by 2 large cylindrical tanks
  - Helium used to pressurize LOX and LH cryogenics
  - Made approximately 20”x20”x30” available for AP

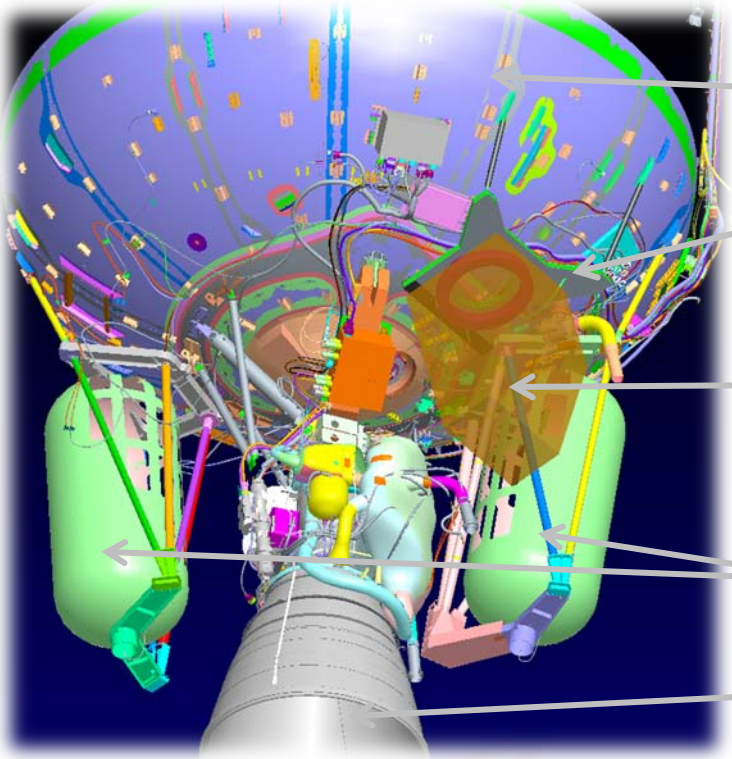
- Office of Space Launch (OSL) developed Aft Bulkhead Carrier (ABC) with ULA to use available volume to launch Auxiliary Payload (AP)

- Development requirements:
  - No/minimal impact to primary mission
    - Mission Design
    - Ground Ops
    - Environments/loads
    - EMI/EMC
    - Security
    - Mission Integration
    - Launch Ops
    - Electrical
    - etc
  - No redesign to existing Centaur upper stage or rest of vehicle
    - Identical load paths
    - Eliminates redesign, updated production paperwork, retooling, testing, etc. for the aft bulkhead

Atlas V with Aft Bulkhead Carrier



ABC Location and Volume



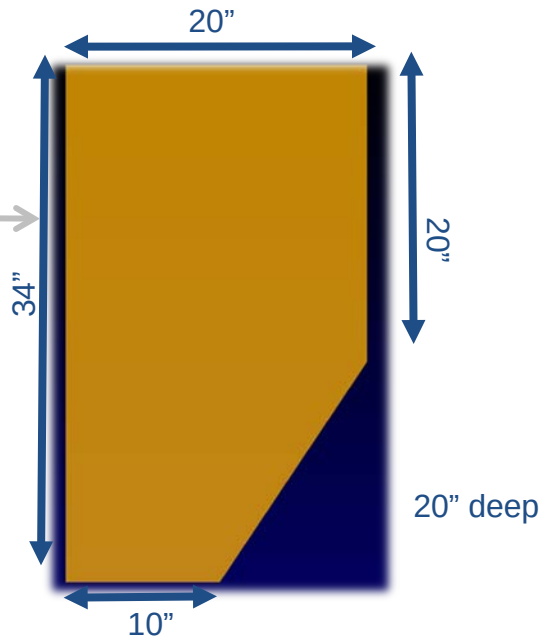
Centaur Aft Bulkhead

Aft Bulkhead Carrier

Auxiliary Payload Volume

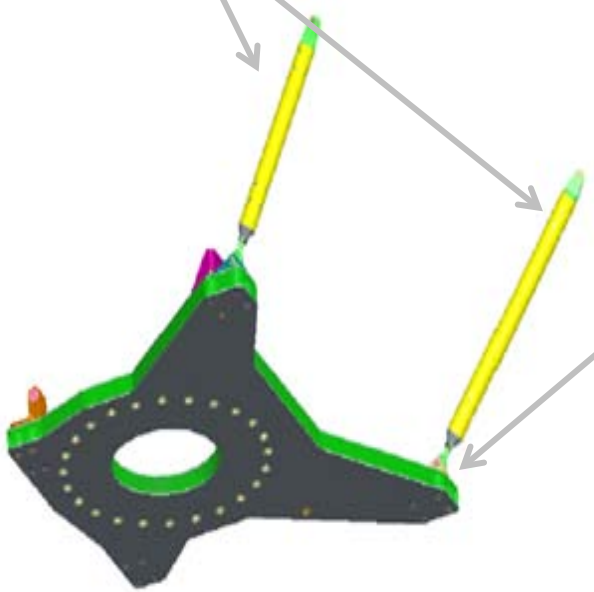
Large Helium Tanks

RL-10 Engine



ABC Details

Struts based on existing helium tank design



ABC plate is of standard Atlas V material/construction
- Aluminum facesheets with aluminum honeycomb core

Auxiliary payload maximum weight =174 lbs
- no additional structural testing
- max weight consistent with volume

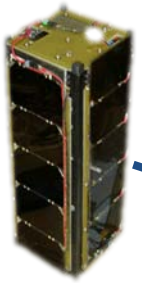
ABC Rideshare on NROL-36

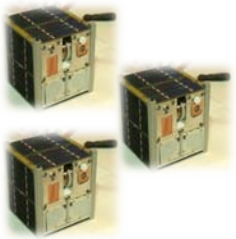
- Aug 2010 - Decision to plan for auxiliary payload NROL-36 (Aug 2012 launch)
  - Excess mission performance
  - Favorable orbital characteristics
    - Allows third burn of upper stage to place small satellites in useful LEO
    - Consistent with space debris mitigation requirement orbital life < 25 yrs (~5 yrs on orbit)
- "Operationally Unique Technologies Satellite" (OUTSat) to use Atlas V ABC to deploy cubesats
- OSL responsibilities:
  - AP manifest and integration effort
  - Program/Mission integration with NROL-36
- AP constraints for L-36:
  - Dormant/powered off until after deployment
    - Exception made for real time clocks and a 1 U data logger
  - Separated only after Primary SV is deployed
  - No propellant/propulsion/pressurized systems
  - No ordnance
  - Delayed deployable release
  - Delayed transmitter turn-on

OUTSat Auxiliary Payload

CubeSat

3U





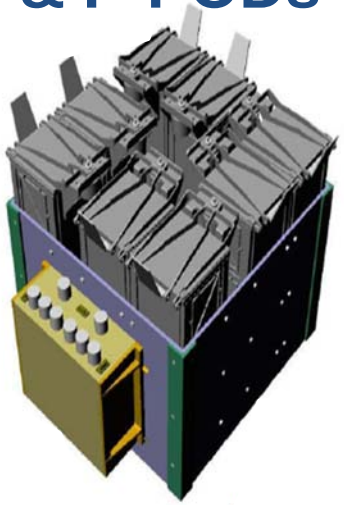
1U

Installed in P-POD

P-POD

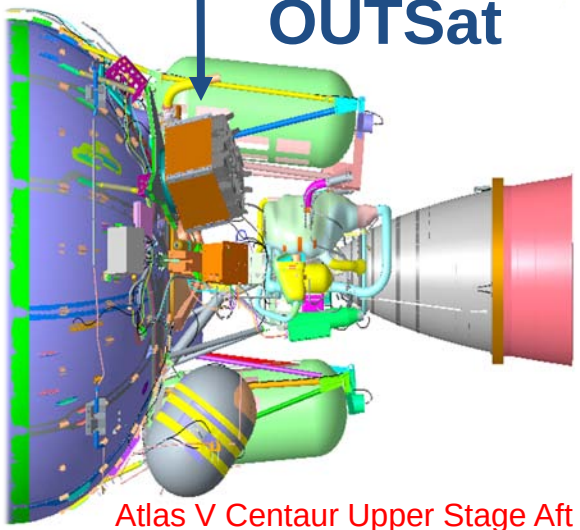
8 P-PODs installed in NPSCuL

NPSCuL & P-PODs



OUTSat installed on Centaur aft bulkhead

OUTSat

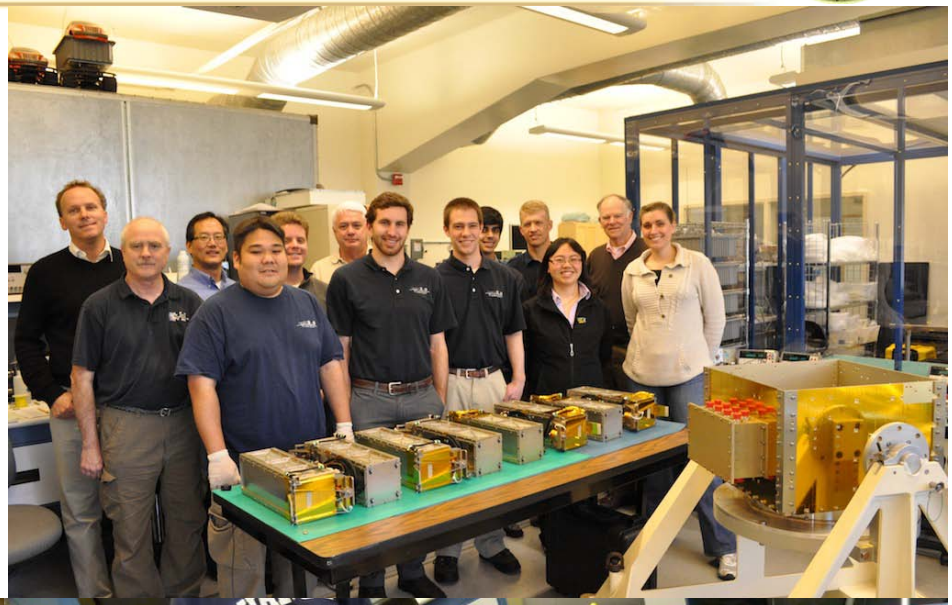


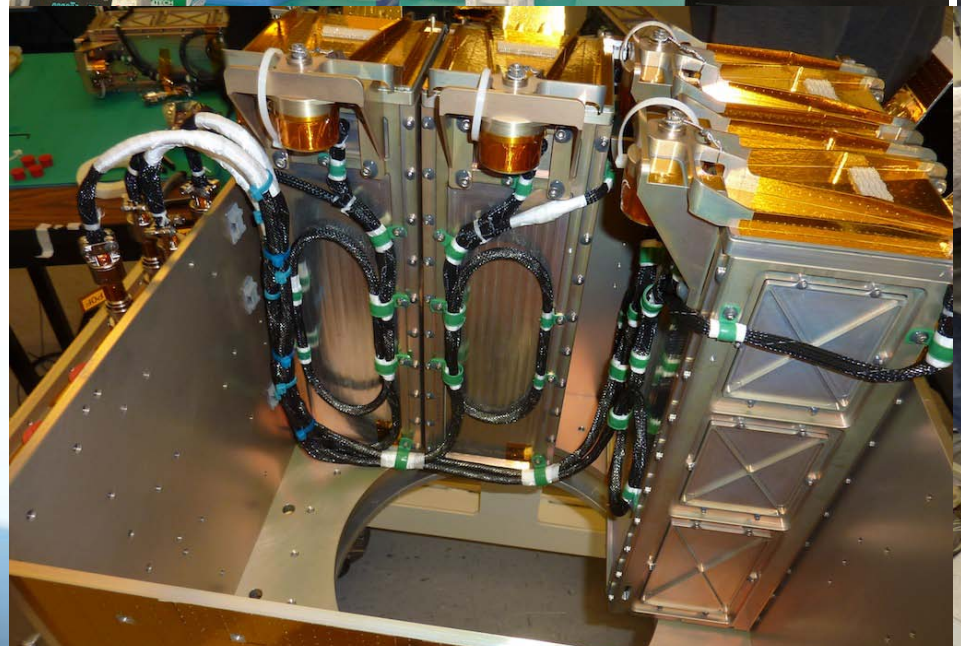
Atlas V Centaur Upper Stage Aft End

APIC (Cal Poly/SRI International) responsibilities as single integrator for Auxiliary Payload (LSIC equivalent):

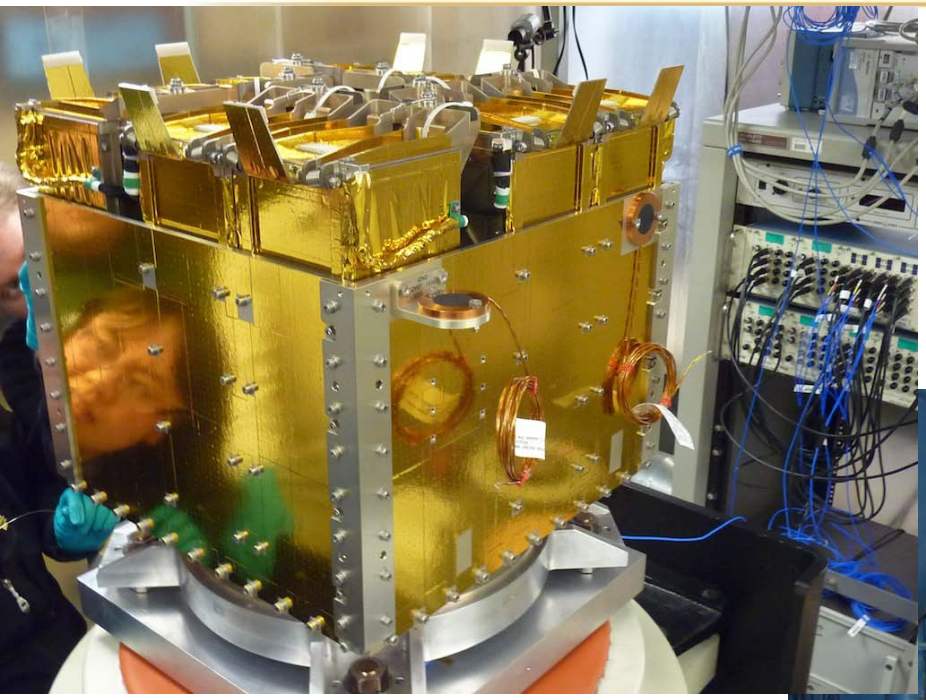
- Manage the delivery and integration of Cubesats
- Integration and test of P-PODs and OUTSat ICW NPS
- Deliverables for OUTSat mate to Atlas V ABC
  - ULA analyses/documentation
  - Safety documentation

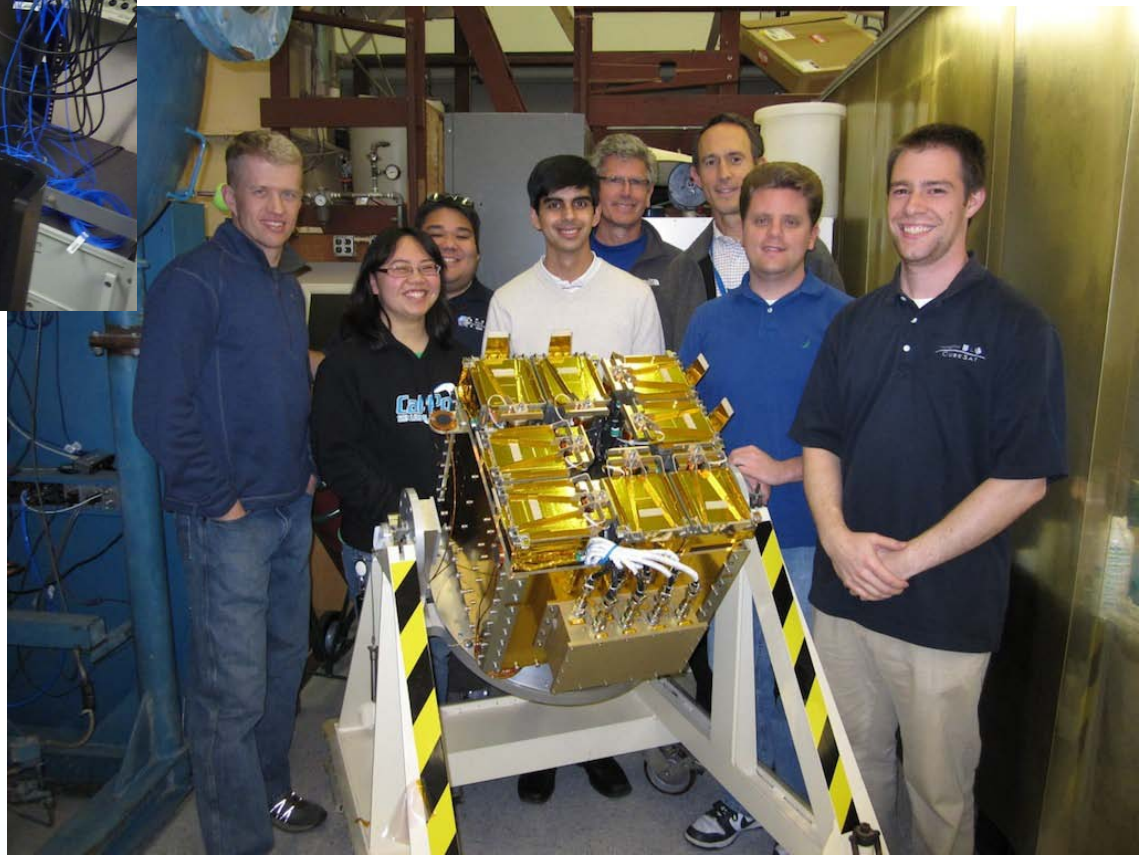
OUTSat Integration





Integrated/Tested OUTSat

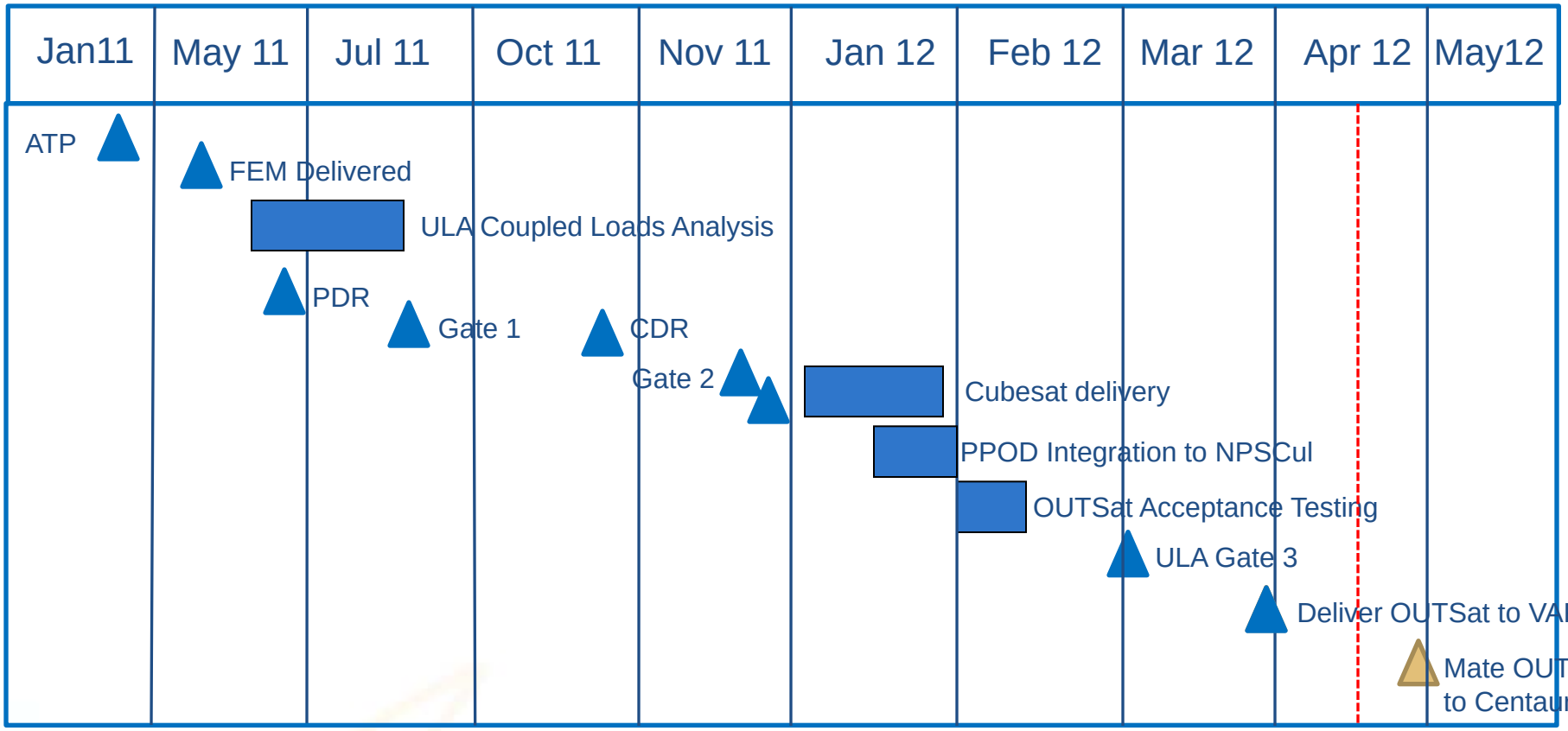




ABC OUTSat CubeSat Manifest

Sponsor	Slot	CubeSat Name	Organization	Size	Mass (kg)
NRO/MSD	1/8	ORS Enabler Sat	SMDC	3U Qty 2	4.05
NRO/MSD	2	AeroCube-4.5	Aerospace Corp	1U Qty 3	1.3 ±0.1
NRO/MSD	3	AENEAS	USC	3U	3.66
NASA/LSP	4	CSSWE	National Science Foundation	3u	3.46
NASA/LSP	5	CP5	Cal Polytechnic San Luis Obispo	1u	1.1
NASA/LSP	5	CXBN	Morehead State University and Kentucky Space	2u	2.6
NASA/LSP	6	CINEMA	National Science Foundation	3u	2.8
NRO/MSD	7	Re	LLNL	3U	3.9

OUTSat Milestone Schedule



OUTSat Development and L-36 Integration < 1.5 yrs

Nominal Auxiliary Payload Mission

Liftoff

ntaur Main
gine Start-
1

Fairing
Separation

Centaur Main
Engine
Cutoff-1

Park
Orbit
Coast

Centaur MES2

Centaur
MECO-2

SV
Separation

Centaur
CCAM

AP Deployment:
does not take place until primary mission is complete

Centaur
third burn to
adjust orbit

AP
Deployed

Pros & Cons

- Pros
  - Physically and electrically separated from primary payload and its load path
  - Can accommodate any AP configuration that meets interface requirements:
    - Standard 15 in adapter
    - 80 kg/175lb max
    - Volume restraints
    - Mission specific AP constraints
- Cons
  - Relatively severe environmental conditions
    - Vibration and thermal
  - Depending on launch site, AP must be ready to integrate 4-6 months before launch/ILC

Lessons Learned

- All CubeSats must have/fit within stringent deployment and operational boundaries to prevent case-by-case analyses
  - Physical and functional characteristics defined by L-12 mos
    - RF signature
    - Deployables
    - Power-on configuration
    - Fault tolerance
      - Multiple inhibits for premature power-on/transmission
        - Dual inhibits/single fault tolerance prevents pairing analysis
        - Triple inhibits/dual fault tolerance eliminates all interference anaylses
  - Ensure timers for power-on post deployment reset during chatter

Great flexibility, but late changes cause rework > $$$

Lessons Learned

- Back-ups:
  - At least a full compliment of back-up cubesats
    - Maintain all as primary candidates until integration
  - Mass simulator needed for each component/configuration to prevent perturbations to the mission
    - May need to fund/plan integration with AP or mass simulator
- Early auxiliary payload integrator involvement
  - Initiate documentation prep and submittal
  - Solidify design and ICD requirements
  - Both for AP satellite integration and coordination of integration with the primary SV and launch vehicle

Conclusion

- ABC designed to offer low cost, recurring launch opportunity for smallsats (80 kg/175 lb) on a vehicle with proven track record
- First use has had it's challenges, however:
  - OUTSat has been integrated, tested, delivered to VAFB and is ready for mate to the Centaur on 30 Apr
  - L-36 mission team and ULA satisfied - all "do-no-harm" requirements have been met
- Challenges definitely exist for smallsats to co-exist with high-value national security payloads – but it is doable with the right planning
- ABC location outside of primary SV volume offers distinct advantages
- OUTSat on track for first use of ABC in Aug 2012 with 8 P-POD's containing 11 cubesats of varying technologies for both the NRO and NASA
- ABC's future:
  - Take advantage of all NRO missions that meet performance criteria - L-36, L-39
  - Work with Air Force and commercial partners to establish ABC as a standard service on applicable Atlas V missions

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