

Multi-Payload Integration Lessons Learned from STP-S26

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- Launch Date: 19 Nov 2010 1625 AKST
- Launch Site: Kodiak Launch Complex, AK
- LV: Minotaur IV with HAPS
- Two Mission Orbits:
 - 72° 650 km (all payloads deploy)
 - 72° 1200km (ballasts deploy)
- Payload complement:
 - STPSat-2 (SMC/SD)
 - FalconSAT-5 (USAFA)
 - FASTRAC (AFRL)
 - FASTSAT w/internal P-POD (NASA)
 - NanoSail-D (NASA)
 - Two P-PODS on Stage 4 (NASA & NSF)
 - O/OREOS (NASA)
 - RAX (NSF)



16 Experiments on 7 Payloads







Objectives

- 1) Provide access to space for STPSat-2
- 2) Demonstrate dual orbit capability of the Minotaur IV using the Hydrazine Auxiliary Propulsion System (HAPS)
- 3) Demonstrate multiple payload capability of the Minotaur IV
- 4) Fly maximum number of SERB experiments

<u>Firsts</u>

- First flight of STP SIV satellite
- First use of MMSOC GSA
- First flight of Minotaur IV Multipayload Adapter (MPA)
- First use of HAPS to obtain dual orbit on Minotaur IV
- First Minotaur IV CubeSat deployment
- First CubeSat deployed from free flying ESPA satellite
- First Minotaur launch from KLC











Lessons Learned Process

<u>Development</u>

>Lessons learned captured throughout program

Lessons solicited from all mission partners &

contractors

<u>Review</u>

Working Group review – clarification, consolidation, additions

Reviewed internally in small teams

>Further evaluation, consolidation, and categorization

Reporting

Lessons briefed up chain of command
 Recorded into STP database

Implementation

Review with ongoing/new missions
 Incorporate recommendations into STP processes





Efficient & Timely Communication

Lesson: Effective communication is a must for a successful program.

- STP Program Office was the communication node between all teams
 - Made sure appropriate information was routed correctly
- Web-based file sharing system is essential
 - Should be accessible and maintainable
 - Must be controlled by integrating organization





Interface Control Documents

Actual:

- SV-LV ICD included:
 - 4 ESPA-class Satellites
 - DSS/Ballast on the HAPS
- CubeSat/P-POD ICD (O/OREOS)
- CubeSat/P-POD ICD (RAX)

Recommended:

Separate ICD for each LV interface is recommended







Lesson: Fit checks are vital to risk reduction for multi-payload missions.

- 2 Initial fit checks held prior to mate
 - MPA SV mass models
 - P-PODS mass models
- Final fit check with MPA SV's and DSS/Ballasts
- Check for hardware interference
 - Harnesses, integration equipment & tool access
- Verify attachment points, proper connections, cable lengths and bend radii of flight hardware
- The process used during fit check should be the process used at integration







Lesson: Mate procedures need to be practiced, scrutinized, and edited to ensure there are no issues.

- RBF and all excursions need to be properly identified ahead of time, in a CAD drawing if possible
- Need continuity between personnel performing fit check and SV mate procedures at the launch site
- Hold a Pre-mate Readiness Review for personnel working at the launch site
 - Describe roles and responsibilities
 - Describe launch site specific items i.e. safety & security
 - Describe operations tempo





Payload Processing Logistics

- **Lesson:** Satellite processing and integration should be scheduled in detail ahead of time.
 - Launch site required integration space for 7 satellites, 1 technology demo, & the launch vehicle
 - Satellites were scheduled to enter the PPF on a staggered schedule
 - Not optimal for each SV, but optimal for the mission
 - Manning restrictions
 - 2 person minimum rule
 - Area constraints for SV activities
 - 4 ESPA-class SVs, 2 P-PODS, DSS/Ballasts, HAPS, Payload Fairing & LV Stage 4 all needed to fit in the PPF
 - De-conflict processing
 - Hazardous Ops needed to be de-conflicted
 - All tasks were tracked on the Daily Activity Schedule





Lesson: Guidelines/requirements for mass properties and FEM correlation need to be set early.

- Mass property testing and reporting expectations
 - Model correlation guidelines/requirements
 - Mass properties testing and reporting
- Mass properties are particularly important for a multipayload mission, they are integral to:
 - Tip-off
 - Separation/Re-contact analysis
 - LV mass margin
- Both analyses are factors in determining deployment sequence and attitude of stack during deployment
- Analysis requires accurate mass properties for LV software prior to testing



Integrated Tip-off and Separation Analysis



Lesson: Separation & tip-off analysis on a multi-payload mission is complex.

- SVs were < 4" apart on the MPA
- Very detailed tip-off analysis required close coordination w/PSC (sep system provider)
 - Tip-off analysis confirmed no contact and did not drive any deployment order decisions
 - SV w/highest tip-off happened to be last to separate
- Separation analysis also required close coordination w/PSC
 - LV maneuvers used to keep in-track components of SV
 \Delta V > 5cm/sec apart to account for all uncertainty
- Post-launch evaluation of data shows the greatest unknown in the analysis is the behavior of the LV Stage 4
 - In the future, work harder to get LV data







Lesson: Collision Avoidance products need to be understood before rehearsals and expectations set for identifying objects.

- Worked with the JSpOC for conjunction assessments
 - Ensured SVs and LV did not encounter known objects
- RCO and MD had different requiements for the launch COLA products
 - Based COLA decisions on different criteria
 - Both the JSpOC COLA and an Aerospace-provided COLA products were utilized for launch
- TLEs could take up to 3 days after launch to sort out
 - Mass, size, & deployment sequence all affect cross tagging issues
 - Sharing data helps sort out cross tagging issues





- Fit Checks were vital to the mission
- Payload processing should be worked well ahead of time, especially for a remote location
- A Pre-Mate Readiness Review is very beneficial
- Mass Properties should be accurately determined well ahead of time
- Collision Avoidance products to be used should be determined ahead of time





QUESTIONS?