Small Space Launch: Origins & Challenges

Lt Col Thomas H. Freeman, USAF, thomas.freeman@kirltand.af.mil, (505)853-4750
Maj Jose Delarosa, USAF, joselito.delarosa@kirtland.af.mil, (505)846-4097
Launch Test Squadron, SMC/SDTW

Small Space Launch: Origins

The United States Space Situational Awareness capability continues to be a key element in obtaining and maintaining the high ground in space. Space Situational Awareness satellites are critical enablers for integrated air, ground and sea operations, and play an essential role in fighting and winning conflicts. The United States leads the world space community in spacecraft payload systems from the component level into spacecraft, and in the development of constellations of spacecraft. The United States' position is founded upon continued government investment in research and development in space technology [1], which is clearly reflected in the Space Situational Awareness capabilities and the longevity of these missions.

In the area of launch systems that support Space Situational Awareness, despite the recent development of small launch vehicles, the United States launch capability is dominated by an old, unresponsive and relatively expensive set of launchers [1] in the Expandable, Expendable Launch Vehicles (EELV) platforms; Delta IV and Atlas V. The EELV systems require an average of six to eight months from positioning on the launch table until liftoff [3]. Access to space requires maintaining a robust space transportation capability, founded on a rigorous industrial and technology base. The downturn of commercial space launch service use has undermined, for the time being, the ability of industry to recoup its significant investment in current launch systems. This has effectively precluded industry from sustaining a balanced robust industrial and technology base to sufficiently meet all United States Government spacelift needs [2]. The reduction of resources to the Department of Defense and the Air Force, coupled by the long launch preparation periods have further resulted in less operationally responsive spacelift capability from new launch systems.

To assure access to space, the United States directed Air Force Space Command to develop the capability for operationally responsive access to space and use of space to support national security, including the ability to provide critical space capabilities in the event of a failure of launch or on-orbit capabilities. Under the Air Force Policy Directive, the Air Force will establish, organize, employ and sustain space forces necessary to execute the mission and functions assigned including rapid response to the National Command Authorities and the conduct of military operations across the spectrum of conflict [4]. Air Force Space Command executes the majority of spacelift operations for the DoD, and other government and commercial agencies. Air Force Space Command researched and identified a course of action that has maximized operationally responsive space for Low-Earth-Orbit Space Situational Awareness assets.

On 1 Aug 06, Air Force Space Command activated the Space Development & Test Wing (SDTW) to perform development, test and evaluation of Air Force space systems and to execute advanced space deployment and demonstration projects to exploit new concepts and technologies, and rapidly migrate capabilities to the warfighter. The SDTW is organized into two groups and subordinate squadrons, as follows:

- Space Test Group
  - Space Test Squadron
  - Space Test Operations Squadron
  - Launch Test Squadron
- Space Development Group
  - Spacecraft Development Squadron
  - Responsive Satellite Command & Control
  - Responsive Space Squadron
  - Human Spaceflight Payloads Division
  - Mission Design Division

Small Space Launch: Origins (continued)

The SDTW charged the Launch Test Squadron (LTS) with the mission to develop the capability of small space launch, supporting government research and development space launches and missile defense target missions, with operationally responsive spacelift for Low-Earth-Orbit Space Situational Awareness assets as a future mission. This new mission created new challenges for LTS.

Small Space Launch: Challenges

The LTS mission tenets of developing space launches and missile defense target vehicles were an evolution from the squadron's previous mission of providing sounding rockets under the Rocket Sounding Launch Program (RSLP). The new mission tenets include shortened operational response periods criteria for the warfighter, while reducing the life-cycle development, production and launch costs of space launch systems.

Based on these criteria, Air Force Space Command determined that LTS would employ deactivated/retired Minuteman and Peacekeeper ICBM rocket motors as launch systems for space launch and missile defense target missions, to include Space Situational Awareness missions, to meet the National Space Policy operationally responsive goal [2]. The LTS created and executed a space enterprise strategy to place small payloads (1000 pounds), at low cost (less than $28M to $30M per launch), repeatable and rapidly. The squadron provides scalable launch support services including program management support, engineering support, payload integration and post-test evaluation for space systems. The space launch and missile defense targets missions bring unique technical challenges, two of which are detailed below.

Space Launch Mission

The key space launch mission challenge is founded in transitioning the Peacekeeper ICBM weapon system to perform a spacelift mission. The existing LTS Minotaur I space launch system program management and operations provided a proven and transferable basis to plan and execute all mission requirements, with one exception; mission assurance. The mission assurance employed for RSLP required additional bolstering as customer payload values rose from $3M to over $500M and acceptable mission risk went down. To address this concern, the LTS conducted an in-depth Internal Risk Review study under the guidance of the Space & Missile Systems Center. As a result of the study, the LTS increased mission assurance surveillance in the following areas:

-Guidance & Control
- Software verification
-Avionics
-Fluid mechanics
-Structures & dynamics
-Propulsion
-Flight trajectory analysis
-Field processing
-Field support
-Post flight analysis

The additional mission assurance in flight trajectory analysis identified that the Peacekeeper ICBM, now Minotaur IV, third stage gas generator produced a five to eight pound thrust vector during a mission coast phase. Modeling revealed that the vector would place the Minotaur IV into an unrecoverable trajectory and complete mission failure. The LTS co-developed a Minotaur IV, third stage gas generator "diffuser", mitigating the original thrust vector to less than .25 pounds, saving the mission. The first Minotaur IV space launch vehicle launched successfully 20 April 2010 carrying the Defense Acquisition Research Program Agency (DARPA) Hypersonic Test Vehicle, paving the way for three additional Minotaur IV missions through September 2011. Each new Minotaur IV mission will bring unique requirements which will implement the strengthened mission assurance process to increase mission success and lower mission risk.

Missile Defense Targets Mission

Like the space launch mission, the key missile defense target mission challenge in transitioning ICBM weapons systems to another mission. The missile defense target mission utilizes deactivated Minuteman ICBM weapon system rocket motors to replicate non-DoD launch vehicles in flight, either from a ground launch site or an airborne platform, e.g., a C-17 aircraft. The ground launch of missile defense targets has an outstanding 98% mission success record, however a mission critical failure occurred in an airborne mission that led to a key challenge mission that grounded four Missile Defense Agency (MDA) missions.

The MDA Failure Review Board identified that the missile defense target launch vehicle rigging and the overall launch vehicle assembly process were the root-cause of the failure. The failure occurred during launch vehicle airborne extraction from a C-17 aircraft, in which an umbilical cable bound due to inaccurate rigging, causing all power pins to ground-out; thus causing a guidance system brown-out and re-boot of on-board computers on the launch vehicle. The $33M launch vehicle was a complete loss. While the MDA did launch, nor spend its interceptor missile weapons system against the failed launch vehicle, the agency was unable to complete a program milestone at a cost of an additional $28M to conduct the mission.

The LTS utilized the in-depth Internal Risk Review study process established for Minotaur IV space launch to create a joint mission partner “return to flight program” between LTS, MDA and the launch vehicle assembly contractor. The return to flight program included the following focus areas:

-Top down detailed program plan
-Organizational re-structure
-Quality assurance
-Mission assurance
-Technical management
-Risk management
-System design
-Material & production control
-Mission readiness
-Field processing
-Field support
-Post flight analysis

The return to flight program required eight months to produce a mission ready target launch vehicle, thus reestablishing this important capability to MDA and the Air Force. This capability and effort improved multi-mission partner processing for target launch vehicles, and have re-stored the target launch manifest for four missions through Aug 2011. In addition, the lessons learned have been integrated into space launch missions to continuous improve LTS processes.

CONCLUSION: The Air Force, through the SDTW/LTS, will continue to evolve its space launch and missile defense targets launch mission by creating small, less-expensive, repeatable and operationally responsive space launch capability. In doing so, LTS’ shared processes and lessons learned with Air Force, DoD, civil and commercial space entity partnerships will contribute to cost and schedule reductions in launch vehicle and spacecraft development, production and operations.

Bibliography:

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