

ORBITAL SPACE PLANE (OSP) PROGRAM

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ABSTRACT

Lockheed Martin has been an active participant in NASA's Space Launch Initiative (SLI) programs over the past several years. SLI, part of NASA's Integrated Space Transportation Plan (ISTP), was restructured in November of 2002 to focus the overall theme of safer, more afford-able space transportation along two paths – the Orbital Space Plane Program and the Next Generation Launch Technology programs.

The Orbital Space Plane Program has the goal of providing rescue capability from the International Space Station by 2008 and transfer capability for crew (and limited cargo) by 2012. The Next Generation Launch Technology program is combining research and development efforts from the 2nd Generation Reusable Launch Vehicle (2GRLV) program with cutting-edge, advanced space transportation programs (previously designated 3rd Generation) into one program aimed at enabling safe, reliable, cost-

effective reusable launch systems by the middle of the next decade.

Lockheed Martin is one of three prime contractors working to bring Orbital Space Plane system concepts to a system definition level of maturity by December of 2003. This paper and presentation will update the international community on the progress of the OSP program, from an industry perspective, and provide insights into Lockheed Martin's role in enabling the vision of a safer, more affordable means of taking people to and from space.

OVERVIEW

The Orbital Space Plane (OSP) program is part of NASA's revamped Integrated Space Transportation Plan (ISTP). It calls for an early Crew rescue capability OSP launched on an expendable launch vehicle (ELV) by 2008 and a full crew Transfer OSP by September 2012. NASA updated these dates in July of 2003 from the original requirements of 2010 for rescue and 2012 for transfer in recognition (reinforced by the

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Columbia disaster) of the urgent need to provide a safer means of transportation to and from ISS for our astronaut corps. The system will transport a crew of four astronauts, be less expensive and more flexible to operate than Shuttle, and most importantly, provide higher levels of safety when compared to Shuttle and Soyuz. Industry is currently developing conceptual designs of the OSP system that best balance the customer needs as reflected in the high level requirements. A major shift in emphasis has occurred in that NASA desires little or no advanced technology included in the critical path of an OSP system while the earlier 2GRLV program included funding of significant technology advancement projects. High-level requirements (referred to as "Level 1") were published by NASA in early 2003 as a means to provide system concept guidelines to the prime contractors. Some of the key needs expressed in these requirements included:

- The OSP System design shall provide a crew transfer capability to/from ISS as soon as practical but no later than 2012.
- The OSP System shall provide the capability for crew rescue from ISS as soon as practical but no later than 2010.
- The OSP System shall provide the capability of transporting

cargo to and from ISS by replacing some or all crew members with contingency cargo/logistics equipment.

- The OSP System shall be designed for minimum life cycle costs.
- The OSP System shall be operated through at least the year 2020.
- Probability of loss of crew and vehicle for a rescue mission shall be better than Soyuz.
- Probability of loss of crew and vehicle during a transfer mission shall be better than Shuttle.
- The OSP System shall meet all applicable ISS requirements for visiting and attached vehicles.
- The OSP transfer vehicle shall transport no fewer than 4 crew to/from ISS for crew rotation and ISS maintenance.
- The OSP System shall have increased on-orbit maneuverability compared to the Space Shuttle.

STATUS

NASA awarded three study contracts in April 2003 totaling \$135 million: \$45 million each to Lockheed Martin, Boeing, and the Northrop Grumman/Orbital Sciences team. They were asked to assist in the requirements refinement process that will result in a System Requirements Review (SRR),

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and associated Systems Requirements Document. Originally planned for October-November of 2003, a technical directive was provided to all three prime contractors that moved the SRR to September of 2003. The contractors are still performing system trades and technical engineering to refine their concepts to be ready for a System Definition Review (now slated for December of 2003 due to the accelerated plan). There is reason to believe that NASA plans a competitive downselect to a single contractor for Orbital Space Plane (OSP) with a request for proposal due out in November of 2003, proposal submission by March 2004 and authorization to proceed by August 2004. (NOTE: As of this writing, NASA's final acquisition strategy had still not been officially released.)

In addition to the main system concept design contracts, there are three major flight demo projects being worked as a part of the Orbital Space Plane program:

- The Pad Abort Demonstration program will develop the fundamental capability to test crew escape technologies in a pad abort situation. LM is the prime contractor.
- The X-37 program is to validate thermal effects during approach & landing and autonomous

approach technology. Boeing is the prime contractor.

- The Demonstration of Autonomous Rendezvous Technology (DART) program is to develop and demonstrate autonomous rendezvous and proximity operations and is being worked by Orbital Sciences Corporation.

Commercial expendable launch would clearly benefit from the opportunity to launch the OSP while providing alternate access to space. NASA, the nation, and the scientific community would benefit from enhanced crew rescue in 2008 by enabling a fully crewed ISS (7-persons) and the increased science capability that would result.

Since the Space Shuttle Columbia accident in Feb. 2003, there has been increasing pressure on NASA to accelerate plans for providing a complementary vehicle to the Shuttle to assure access to the ISS. As a result, NASA is in the process of finalizing plans to accelerate the OSP schedule. In parallel, Lockheed Martin assessed the impact of meeting a schedule for an OSP Initial Operating Capability (IOC) by 2008, and while challenging, believes it can be accomplished.

OSP ACCELERATION CHALLENGES

Lockheed Martin has determined that a combined OSP crew rescue/transfer

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capability is possible as early as 2008. This determination is based on some critical assumptions and commitments by both Lockheed Martin and NASA. Under Lockheed Martin's current contract with NASA to develop OSP design concepts, a System Definition Review (SDR) is scheduled to take place in December 2003. If the OSP IOC is to be accomplished by late 2008, the span of time between SDR and IOC is 60 months. The work necessary to accomplish preliminary design review (PDR) and critical design review (CDR) must be well understood. Our assessment of the accelerated program results in the following time periods between key program milestones:

SDR → PDR = 11 months

PDR → CDR = 15 months

CDR → IOC = 36 months

Although aggressive, we believe this schedule is achievable and will yield a safe, low risk technical solution assuming certain critical steps are taken.

In order to accomplish PDR 11 months after SDR, it will be necessary to ramp up design and development activities in Jan. 2004. It is assumed that NASA will not be able to make their downselection and award the OSP FSD contract until Summer 2004. This would make it necessary for NASA to provide funding to enable the more detailed

design leading to PDR prior to FSD contract award.

Our accelerated schedule reduces the period of time between CDR and IOC by 16 months compared to NASA's original baseline schedule. In order to successfully meet the compressed schedule while still maintaining a low-risk approach, Lockheed Martin could choose to develop a single rescue/transfer vehicle design rather than evolving a rescue design to a transfer design. This would eliminate one entire flight test demonstration program to qualify production hardware. Development flight tests could be used to reduce flight risks while providing valuable launch operations experience, reducing site integration time prior to the qualification flight by as much as 5 months.

Another time-consuming activity on the critical path to IOC is the software design, development, and test program. Since software integrates the functions of all other subsystems, software development is highly dependent on full understanding of the functional characteristics of the subsystems. Early funding to mature the subsystem designs could reduce the software development schedule by 8 months.

One of the biggest challenges for both Lockheed Martin and NASA will be

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determining and implementing a management approach that meets the critical need for government insight/oversight while at the same time executing the program in a more commercial-like manner. An efficient, innovative, collaborative management approach when combined with a determined and unwavering technical focus on a simple, safe, low-risk solution provides the best opportunity for an OSP by 2008 to become a reality.

LOCKHEED MARTIN AND OSP

Lockheed Martin Space Systems Company is committed to being the world's preferred provider of human and reusable space transportation systems and services. We have a long heritage – over 45 years – as the nation's leading provider of space transportation, including the Mercury and Gemini human space flight programs.

Under the current SLI contract to develop a design concept for the OSP, Lockheed Martin has conducted a series of trade studies to optimize key technical and programmatic elements considered to be of greatest value to NASA. The primary criteria that were considered in the trade studies were safety, affordability, risk, and evolvability to mission capabilities beyond ISS support. Configurations that were assessed as part of the trade

studies included a winged vehicle (e.g., Shuttle and X-37), a lifting body (e.g., X-38 and HL-20), and a pure capsule (e.g., Apollo and Soyuz).

A winged vehicle and a lifting body vehicle have several disadvantages: they include wheels and wheel well doors requiring fragile thermal barriers/seals during reentry; they are considerably heavier than capsule-like systems; they do not easily incorporate a crew escape system; and they are not as evolvable into vehicles capable of carrying out NASA's missions of exploration (Moon, Mars, L1, L2, etc.).

A pure capsule is inherently more robust, and therefore safer, in the three critical areas of flight control, thermal protection, and structures. But a pure capsule has the disadvantages of excessive g's during a launch abort (NASA has a 14 g limit spec) and, for the space station inclination of 51.6 deg, the risk of an abort that would result in a landing in the Alps.

Some concepts look at landing under parachutes which are robust and reliable and negate the need for wheel well doors in the thermal shield. An expendable service module behind capsule concepts could be tailored to take us to the ISS or beyond Earth orbit to L1, L2, the Moon or even to Mars.

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Under any circumstance, NASA would prefer the new OSP to be capable of launching on both the Atlas V and the Delta IV, and eventually a next generation Reusable Launch Vehicle (RLV). Winged vehicles and lifting bodies do not provide the kind of evolvability that can significantly help to meet NASA's needs beyond ISS.

INTERNATIONAL COOPERATION ON OSP

Lockheed Martin has been at the forefront of seeking ways to leverage European aerospace technology and engineering expertise to help advance next generation space transportation. Significant sub-contract relationships with European companies were in Lockheed Martin's plan for the Crew Return Vehicle (CRV) program (Astrium, Snecma, MAN, Alenia to name a few). Although NASA subsequently canceled the program, those relationships form the basis for a continued desire to seek cooperation opportunities on OSP. Contracts were executed with Astrium (supported by IRAD and Alternate Access) in early 2002 to gain information regarding advanced space transportation efforts and ATV proximity operations in Europe. LM conducted a survey in the fall of 2002 to determine European interest and capabilities for potential teaming/subcontracting to LM on 2GRLV.

Follow-up tours of several sites were conducted in September of 2002 (Snecma in Bordeaux and Vernon; Alenia in Turin, Italy; Astrium in Toulouse; EADS in Les Mureaux; and the European Space Agency in Noordwijk, Netherlands).

A renewed discussion with European companies is anticipated in the fall of 2003 as the LM plan for OSP becomes more mature and the NASA procurement plan is finalized.

ISSUES

The final report of the Columbia Accident Investigation Board (CAIB) is due to be released by the end of August and its findings will have an important impact on the Orbital Space Plane program. It is anticipated that in addition to the need to correct technical issues (such as foam insulation falling from the external tank) there will be strong recommendations to revamp NASA management processes and/or culture. It will be critical for the Lockheed Martin and NASA OSP team to ensure recommendations from the CAIB are fully implemented while maintaining a streamlined, commercial approach to getting this job done. A "business as usual" approach cannot succeed within the time and budget constraints that this important national program will be developed.

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Budget concerns remain one of the most daunting issues facing the OSP program. Current NASA budget requests for OSP were based on the old 2010 / 2012 target dates and were considered by many as inadequate – particularly in the first two or three years of the program. Now that NASA is looking to accelerate the program, the funding issue becomes even more critical. In conjunction with a recent revision of the Integrated Space Transportation Plan, NASA is preparing an amended budget request that Congress will be asked to act upon in the fall of 2003. A substantial addition to the OSP budget line for the next several years will be needed in order to make the OSP program feasible.

The United States Congress is rightly asking for strong rationale for how the Orbital Space Plane system will meet the near-term ISS rescue and transfer needs while providing building blocks for “what comes next”. Unless this rationale is clearly communicated and “sold” to both the Congress and the general public, it is unlikely that the funds needed to development this system by 2008 will be provided.

A final and most important issue to be addressed is the need to establish the final set of OSP requirements by this

fall so that the solutions developed for the System Definition Review and for the full-scale development proposals can be based on a true foundation of need versus “this is what we think you want”. Once established and approved, the entire NASA / contractor community must rally behind them and work to resist the requirements “creep” that invariably leads to schedule slips and budget overruns. The NASA / contractor team that builds the OSP must prove that it can execute to the schedule and budget proposed or the program could very well meet the same fate as many other ambitious NASA programs in the last decade (cancellation). We owe our astronauts better.

SUMMARY

Lockheed Martin fully supports NASA’s effort to provide crew rescue and crew transfer support to ISS by 2008. We will bring the best experience from across the Corporation and from industry teammates to provide the best OSP total system solution. We believe that our baseline configuration for the OSP provides the best balance between safety, affordability, risk, and evolvability to meet future human space transportation needs.

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