[1]ORBITAL SPACE PLANE (OSP) PROGRAM AT LOCKHEED MARTIN

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ABSTRACT-B

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 2002 to focus the overall theme of safer, more affordable space transportation along two paths—the Orbital Space Plane (OSP) 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 or earlier and transfer capability for crew (and contingency 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 design level of maturity by December 2003. This paper and presentation will update the aerospace 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-B

The Orbital Space Plane 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 or earlier and a full crew transfer OSP by 2012. NASA updated these dates in July 2003 from the original requirements of 2010 for rescue and 2012 for transfer in recognition (reinforced by the Columbia accident) of the urgent need to provide a safer means of transportation to and from ISS for our astronaut corps. The Lockheed Martin system will meet NASA's requirements to 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 competitively developing conceptual designs of the OSP system that best balance customer needs as reflected in the high-level requirements. A major shift in emphasis, driven by the earlier need date for the OSP, has occurred in that NASA desires little or no advanced technology should be 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 Headquarters in February 2003 as a means to provide system concept guidelines to the OSP program. 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 contingence cargo to and from ISS by replacing some or all crewmembers with 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.

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*AIAA member grade, job title.

- The OSP transfer vehicle shall transport no fewer than four crew to/from ISS for crew rotation and ISS maintenance.

The OSP system shall have increased on-orbit maneuverability compared to the Space Shuttle.

Lockheed Martin's concept fulfills all these Level 1 requirements from NASA and uses a system design approach innovative in its implementation to ensure that all the "wants and needs" of the system are supplied by the design. Figure 1 shows the elements of the OSP operational system.

STATUS-B

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) and associated systems requirements document. Originally planned for October-November 2003, a technical directive was provided to all three prime contractors that moved the SRR to September 2003. The contractors are still performing system trades and analyses to refine their concepts to be ready for a system design review (SDR) (now slated for December 2003 due to the accelerated plan). There is reason to believe that NASA plans a competitive downselect to a single contractor for the OSP with a request for proposal due out in November 2003, proposal submission by March 2004 and authorization to proceed by August 2004.

In addition to the main system concept design contracts, there are three major flight demonstration 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. Lockheed Martin is the prime contractor.
- The X-37 program is to validate thermal effects during approach and 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 U.S. launch systems would clearly benefit from the opportunity to launch the OSP while providing alternate access to space. Figure 2 shows candidate launch systems for the Lockheed Martin OSP. Early crew rescue capability is critical to realizing full science capability of the ISS.

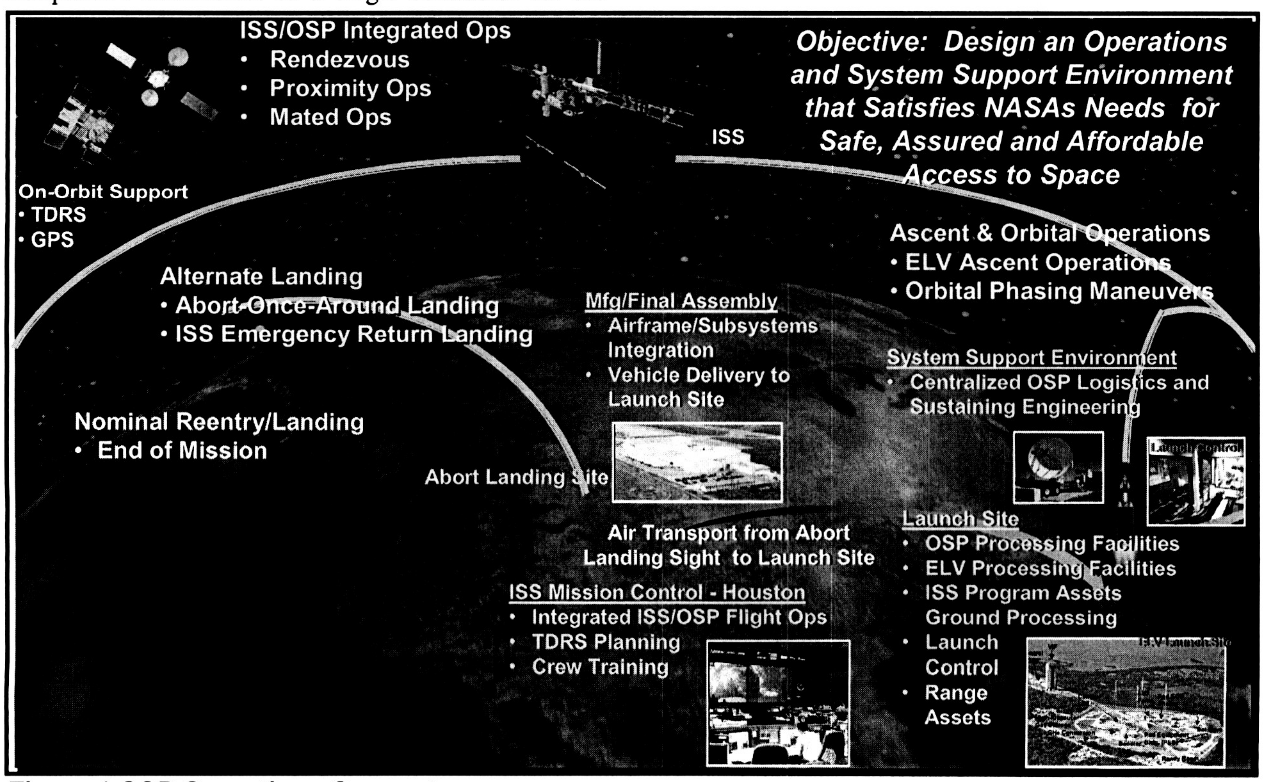

Figure 1 OSP Operations Concept

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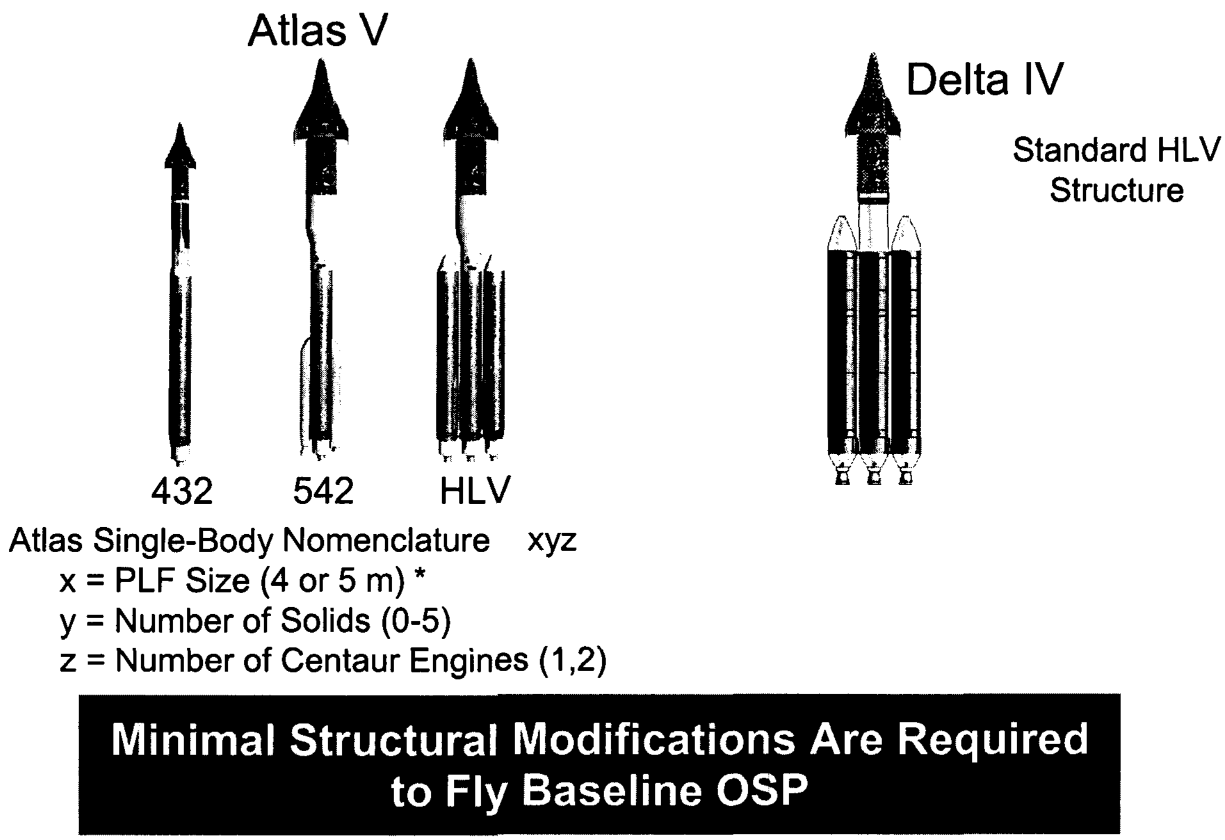

Figure 2 Baseline LV Configurations

Since the Space Shuttle Columbia accident in February 2003, there has been increasing pressure on NASA to accelerate plans for providing a complementary vehicle to the Shuttle to ensure access to the ISS. As a result, NASA has released 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 or earlier, and while challenging, believes it can be accomplished.

OSP ACCELERATION CHALLENGES-B

Lockheed Martin has determined that a combined OSP crew rescue/transfer capability is possible even earlier than 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, an SDR is scheduled to take place in December 2003. The work necessary to accomplish a preliminary design review (PDR) and a critical design review (CDR) must be well understood. Our assessment of the accelerated program results in shortened time periods between key program milestones.

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

Our accelerated schedule reduces the period of time between CDR and IOC compared to NASA's original baseline schedule. To successfully meet the compressed schedule while still maintaining a low-risk approach, Lockheed Martin emphasis is to choose to develop a single rescue/transfer vehicle design rather than evolving a rescue design to a transfer design. This would eliminate one 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 before 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.

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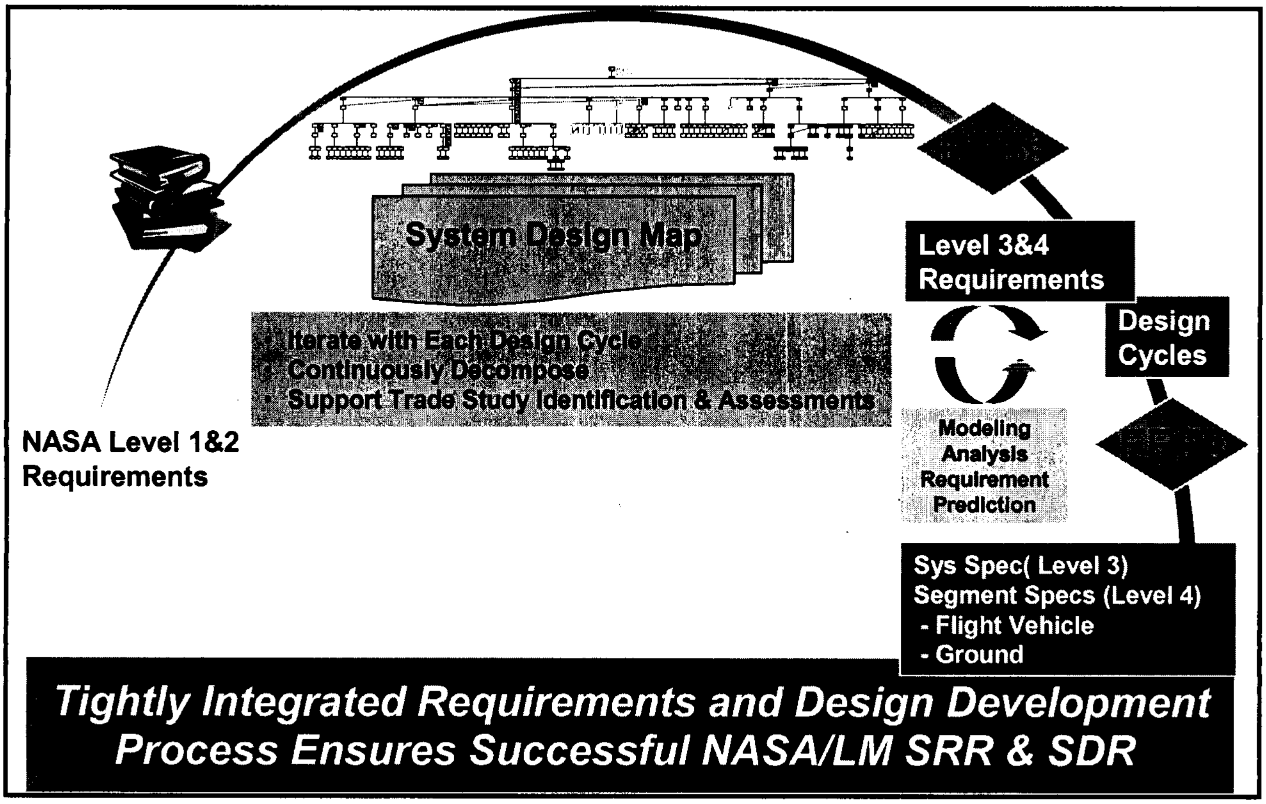

Figure 3 Requirements Development Process

One of the biggest challenges for both Lockheed Martin and NASA will be 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. Lockheed Martin will use experience gained in recent programs in the space and aeronautic sectors, which it has fielded systems to, and reduced schedules to meet the nation's need. An efficient, innovative, collaborative management approach (Figure 3) illustrates the flow of requirement development that helps focus on the system's 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-B

Lockheed Martin Space Systems Company is committed to being a preferred provider of human and reusable space transportation systems and services. We have a long heritage—more than 45 years—of providing space transportation services, including the Mercury, Gemini, Space Shuttle, and ISS 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). Figure 4 shows the concepts under study.

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- OSP 202 Airplane
  - Fully Reusable Airplane Configuration
- OSP 302
  - Small Reusable Airplane/Service Module Configuration
- OSP 402
  - Capsule/Service Module Configuration
  - Max Reusable Capsule/min Expendable Service Module
- OSP 502
  - Capsule/Service Module Configuration
  - Min Reusable Capsule/max Expendable Service Module
- X-38
  - Maintain Size to Take Advantage of Parafoil, Aero Work and V201
- HL-20
  - LaRC Database

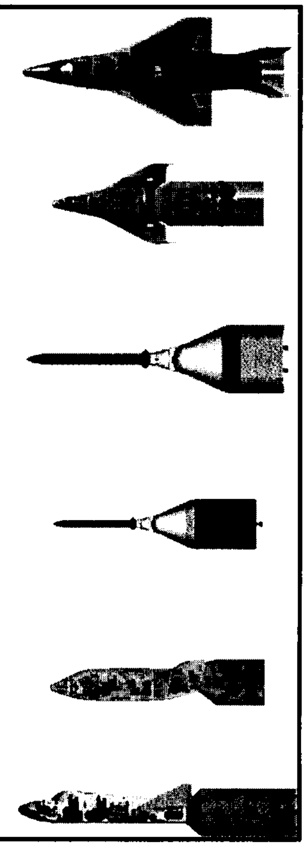

Figure 4 Concept Trade Study

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 may not provide the evolvability 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°, the risk of an abort that would result in a landing in the Alps.

Some concepts look at landing under parachutes—robust and reliable and negating the need for wheel well doors in the thermal shield.

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.

ISSUES-B

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 the 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. Lockheed martin is actively investigating methods with NASA on the OSP program to address the expected concerns of the CAIB report.

Budget concerns remain one of the most daunting issues facing the OSP program. Current NASA budget

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requests for OSP were based on the old 2010/2012 target dates and were considered by many as inadequate—particularly in the first 2 or 3 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."

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 Design 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-B

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 Lockheed Martin 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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