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## Paper Session I-A - Space Shuttle, Human Space Transportation for the Next Thirty Years

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**Space Shuttle  
Human Space Transportation for the Next Thirty Years**

**Presented to  
Launch Vehicles Session  
38<sup>th</sup> Space Congress**

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## Introduction

NASA's Integrated Space Transportation Plan (ISTP) is focused on increasing safety and reliability, reducing cost, and meeting NASA's mission requirements while making maximum use of the aerospace industry capabilities and commercial market leverage. In addition, the ISTP will ensure continued safe access to space through Space Shuttle safety and supportability upgrades until a replacement alternative has been demonstrated. To implement the ISTP, Congress has funded the Space Launch Initiative (SLI). The goal of the SLI is for NASA to meet its future space flight needs, including human access to space, using commercial launch vehicles that reduce cost and improve safety and reliability. The premise of the SLI is that the private sector can define a business environment, including a sufficiently large commercial launch market, to close the business case and justify the corporate investment required by building and operating a commercial replacement for the Shuttle. Significant changes in the launch market have reduced the opportunity to leverage off the commercial market. NASA's SLI is funding technology maturation projects to drive down the technical risk but the launch market growth projections remain elusive. If the full convergence between government and commercial mission needs can not be achieved and the market analysis and business modeling will not predict business case closure for a commercial RLV development start, a Shuttle Evolved Vehicle (SEV), supported by the ELV fleet, will use the mature technologies from the SLI to ensure that our national launch and spaceflight requirements are met. Boeing is defining an SEV architecture that will maintain the Space Shuttle System viable through 2030; provide safe, reliable, robust transportation to and from earth orbit; and meet the emerging needs of expanded missions and customers.

## Key to the Future of Human Space Flight

The Space Shuttle is the key to human exploitation of space. The Space Shuttle provides the only reusable human access to space. It is the world's most reliable launch vehicle (Figure 1); truly an

Launch Vehicle	Successful Launch Percentage
Shuttle	99.0
Soyuz / Molinya	94.4
Delta II	94.3
Ariane	94.9
Titan 34B, II, III	91.6
Proton	89.6
Scout	88.1
Long March	87.5
Titan IV	86.7
Atlas	83.7

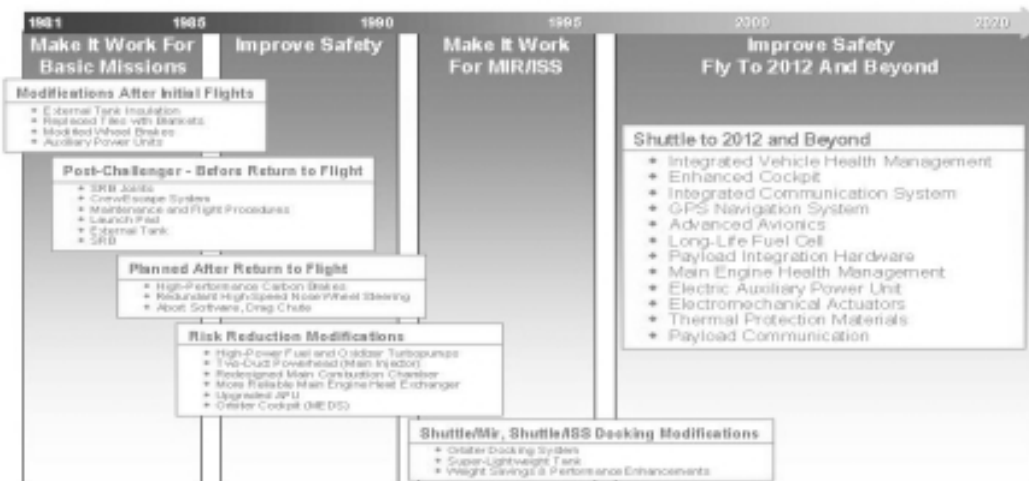
*\* Current as of 16 January 2001*

**Figure 1. Space Shuttle Is World's Most Reliable Launch Vehicle**



**Figure 2. Space Shuttle Is Key To Human Space Exploitation**

international asset. The International Space Station (ISS) can not be assembled and can not be fully utilized without the unique capabilities that the Space Shuttle provides. The Space Shuttle is the only launch system that can verify payload integrity before on orbit deployment and repair and retrieve high value space assets. The Space Shuttle has proven itself as a cost effective, on orbit testbed for new technology. As a proven asset with well-understood performance characteristics, the Space Shuttle is the logical choice to form the basis for the future of human space flight (Figure 2). With over 75 percent of its fleet life remaining, the Space Shuttle can fly safe and affordably to 2030 and beyond enabling the infrastructure that will take humans again beyond earth orbit and eventually on to the planets. The Space Shuttle provides the very unique opportunity to improve the existing system while breaking ground for

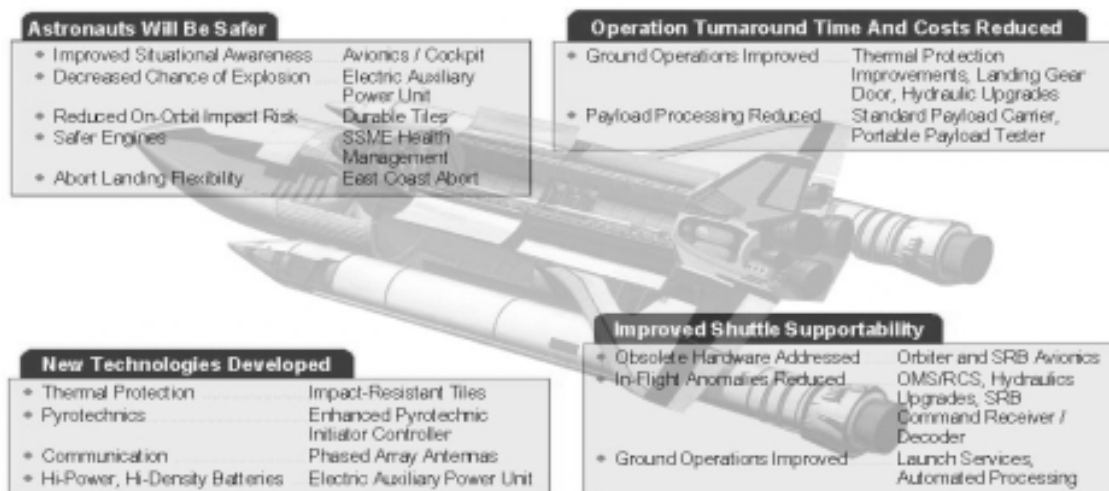


**Figure 3. Space Shuttle Has Been Continually Upgraded**

the next generation launch systems. NASA currently has an upgrades program in place that began by addressing the performance improvements required to assemble and operate the ISS and has continued to improve Shuttle System safety and supportability (Figure 3). Following the completion of the ISS assembly, it will be time for the Shuttle Program to go beyond safety and supportability improvements and significantly reduce operations costs as well as address emerging missions, such as human exploration, and new customers.

## Space Shuttle Upgrades

The Space Shuttle Program has five “upgrade” initiatives that are addressing all aspects of the Shuttle Program and infrastructure. The safety and supportability upgrades initiative addresses flight system safety upgrades including facility and ground support equipment upgrades needed to implement approved flight system changes. Supportability upgrades focus on major flight system upgrades driven by obsolescence/supportability concerns. Operations costs are also addressed at a lower priority than safety and supportability upgrades (Figure 4). NASA’s planned safety upgrades will significantly improve



**Figure 4. Space Shuttle Upgrades Address Safety, Supportability, and Cost**

ascent and mission loss of vehicle risk (Figure 5) and will seamlessly continuing to support the completion of ISS assembly in 2006.

The second of the five upgrade initiatives is Industrial Engineering for Safety which applies industrial engineering assessment and optimization techniques to Space Shuttle processing to reduce risk to the work force, reduce risk of collateral hardware damage, increase maintainability, and improve overall processing of hardware and vehicle systems. Third is the Infrastructure Revitalization/ Augmentation initiative which includes revitalization of facilities, systems, equipment and tooling that are required to manufacture, test, process, launch and land the Space Shuttle over the life of the program. Space Shuttle Program Process Reinvention, the fourth initiative, seeks to streamline requirement integration, engineering, and documentation. Finally, the Space Shuttle Program Environmental Assurance initiative focuses on ensuring continued environmental compliance of Space Shuttle Program



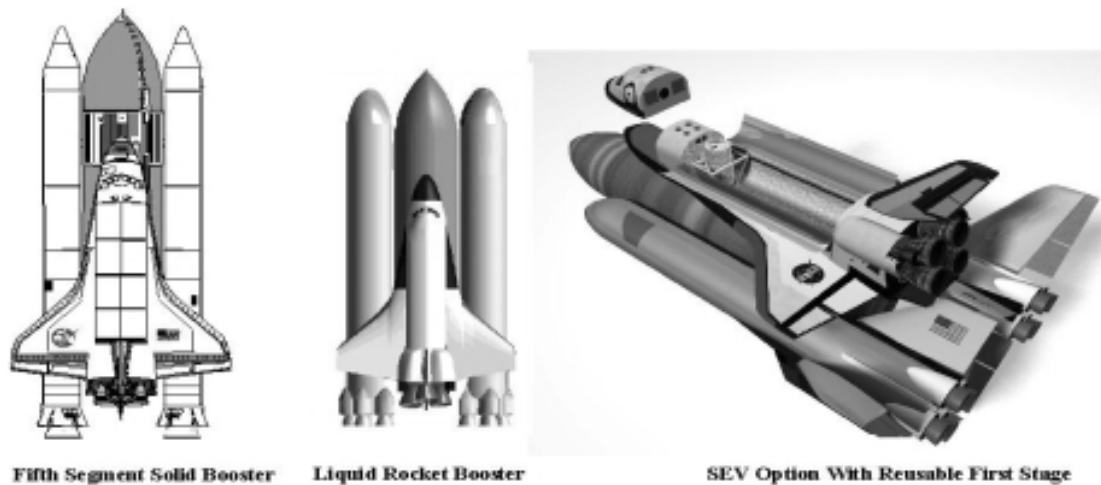
**Figure 5. Shuttle Upgrades Significantly Improve Loss Of Vehicle Risk**

elements through awareness, communication, and resolution of environmental, materials obsolescence and materials replacement technology issues including resource allocation management.

### Shuttle Evolved Vehicle Architecture

With over 75 percent of the Space Shuttle’s useful life remaining and a validated infrastructure in place, the best value solution to the future national human space flight needs is an evolved Space Shuttle. Proven during ISS assembly as a platform for on orbit structural assembly, the Space Shuttle can be the focal point for assembling the next generation telescope, human exploration transportation systems, and servicing and assembly platforms. Proven during Hubble servicing and maintenance missions as a viable on orbit servicing platform, the Space Shuttle can enable the upgrading and life extension of high value space assets. Proven as the world’s most reliable launch vehicle on over 100 missions, the Space Shuttle stands ready to launch, checkout, and release or return if required the high value payloads of not only the NASA but other government and commercial entities, both domestic and international. The Shuttle Evolved Vehicle (SEV) Architecture will meet these future human space flight needs with increased safety and reliability and with significantly reduced operating costs.

Three of the SEV design options for evolving the Space Shuttle to fly until 2030 and beyond are in Figure 6. From an external perspective the dominant design change under consideration is the booster. The objectives are increased safety and reduced cost. Both the “Return To Launch Site” and “Trans Atlantic” abort options during the ascent portion of the Shuttle mission increase risk and cost. Booster options that provide the increased performance to eliminate or reduce the potential occurrence of these two ascent abort options are being considered as a part of defining the SEV architecture. A less externally visible change under consideration is a crew escape system that would involve the separation of the crew cabin from the rest of the SEV and returning the crew safely to earth if the SEV could not safely return intact. How best to provide crew safety is a key trade in the definition of the SEV. At issue is providing extensive escape systems versus increasing the over all reliability of the Space Shuttle.



**Figure 6. Options For Evolving The Space Shuttle**

The definition of the Shuttle Orbiter systems and subsystems is using the current Shuttle Safety and Supportability Upgrades Initiative as the departure point. It is cost effective to take full advantage of the system improvements funded under that program. SEV system options are being identified using approaches such as the analysis of current system performance, identification of improvement opportunities from current cost, problem, and performance data, and assessment of previous and current related work such as the NASA Space Launch Initiative. Special consideration is being given to the evaluation of crew escape systems, abort options, performance enhancements such as canards, booster options, extended mission times, uncrewed flight, and safety enhancements. Subsystem changes that improve existing system safety, reliability, and maintainability as well as reducing costs are being evaluated. Each of the SEV system options is being analyzed against critical design parameters and operational requirements.

### **Conclusion**

The Space Shuttle represents a very significant portion of the national investment in space infrastructure. The Space Shuttle has proven itself as a safe, reliable system capable of performing many of the functions required to enable the future of human space flight and exploration. The best value solution to human space flight mission requirements is the SEV; not a new system that is less affordable and perhaps even less capable. The Space Shuttle can be evolved to increase safety and significantly reduce operations costs. Now is the time to make a national commitment to fly this national asset until 2030 and beyond.