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Space Shuttle- Solution To DoD Dual Access To Space

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Abstract

Now is the time to revisit the use of the Space Shuttle to implement the DoD policy of dual access to space. The Shuttle Program is in transition, improving its operational responsiveness and reducing its costs to satisfy customer requirements. Many key Shuttle Program management positions are held by people with DoD spacelift experience. NASA's way of doing business is being changed to make programs happen quicker, faster, and cheaper. Shuttle costs have been reduced by more than 25 percent since 1991. Further consolidation and streamlining of Shuttle operations can be implemented to reduce recurring costs to as low as \$2.0 billion, down over \$1.5 billion from today's operations costs. Shuttle processing has been improved to the point that the current four Orbiter fleet could easily support twelve flights per year, up four over today's flight manifest. The Shuttle provides the DoD with a backup launch capability for larger payloads which is much more reliable and less costly than the Titan IV. In addition, the Space Shuttle provides the DoD with many unique spacelift capabilities not available from the expendable launch vehicle fleet. The decision prior to the Challenger accident to move the preponderance of the payloads to Shuttle was just as incorrect as the decision after the Challenger accident to remove all DoD and commercial payloads from Shuttle. This paper will present how the Space Shuttle can become DoD's cost effective solution to dual access to space and

the benefits the DoD will accrue from utilizing the Shuttle as a spacelift asset.

Background

The DoD has played a major role in the development of the Space Shuttle. Many program requirements were DoD derived such as polar orbit, 1100 NM cross range capability for polar orbit return, and a payload bay 60 feet in length and 15 feet in diameter. Early Shuttle manifests averaged two DoD flights per year from the Eastern Test Range (ETR). A launch site was developed at the Western Test Range (WTR) to support polar launches. Shuttle Orbiter OV-103 was designated as the Vandenberg Orbiter.

However, space policy decisions led DoD to remove operational payloads from the Shuttle. The Shuttle was perceived as being expensive and complex. NASA controlled the launch process, established launch priority, and reserved final approval of crew selection. The payload manifesting cycle and integration processes were perceived as too long and complicated. The Challenger accident, and the resultant stand down demonstrated the need for dual access to space. The subsequent prohibition of Centaur upper stages on the Shuttle limited the number of DoD missions that could be flown on the Shuttle. The decision to not activate the SLC-6 complex at the WTR reduced the Shuttle's ability to satisfy DoD payload mission requirements. But even with these limitations, the Shuttle has proven its ability to support DoD and national payloads.

The Case For Shuttle

With the recent Titan IV and Atlas launch vehicle problems, and the maturing of the Shuttle system, it seems appropriate to readdress the issues that precipitated the departure of the DoD from the Shuttle. Additionally, with the severe budget constraints being placed on DoD programs, a "use what's available" philosophy provides a cost-effective alternative to a "dedicated system" approach. Just as Desert Storm demonstrated that commercial airlines and commercial GPS receivers could effectively augment dedicated DoD assets, a routinely flying Shuttle could augment DoD launch assets. With the activation of the Space Warfare Center and its focus on space applications, the Shuttle offers what no ELV can match - a space-based tactics and test lab with man-in-the-loop.

The Shuttle program is in transition, improving the operational responsiveness and reducing costs to satisfy the needs of customers. Organizational changes at each related NASA center and Headquarters are being made. Many key Shuttle program positions are filled by people with DoD space-lift experience. The way of doing business is being changed to make things happen quicker, faster and cheaper.

The Space Shuttle system provides unique capabilities as the nation's premier heavy-lift launch system. Of primary benefit are its capability to deliver up to 58 klb to low earth orbit, its ability to act as an orbital test bed for a wide variety of experiments and missions, and its capability to operate at inclinations from 28 to 63 degrees. The Shuttle can stay on orbit for up to 16 days (28 days with the Long Duration Orbiter upgrade kit) and it can be configured with several variations of laboratories for specified missions. The Hubble repair mission validated the Shuttle's capability to perform on-orbit checkout, maintenance and repair of high-value payloads. Potential Shuttle upgrades that will

enhance operations and improve mission capability include controls and displays upgrades, GPS navigation, electro-mechanical actuators, rugged thermal protection systems, standard payload interface and vehicle health management. Figure 1 shows many of the potential performance upgrades under

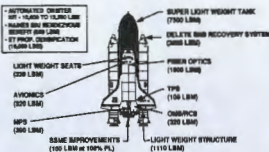


Figure 1. Potential Performance Improvements

consideration to improve the Shuttle payload capability by 15,500 pounds to deploy and service the Global Space Station at an inclination of 51.6 degrees. The Shuttle can deliver a valuable payload to orbit, check it out, make any necessary repairs and deploy the payload. Retrieved payloads can be placed into the payload bay for return to earth.

The Space Shuttle has the highest launch vehicle success rate when compared to today's operational expendable launch vehicles (Table I). The Saturn launch vehicle which used the same design approach as the Space Shuttle had a 100 percent launch success rate. Eleven of the 57 successful launches have been dedicated DoD missions, the latest being STS-53, which flew in December 1992. Numerous secondary payloads have flown in the payload bay, in the aft flight deck and as hand-held experiments operated by military-trained astronauts. Shuttle DoD experiments have included earth-surface object identification, space object tracking and various communications tests.

LAUNCH VEHICLE	%
Shuttle	98.3
Delta	94.6
Ariane	91.8
Titan 34B, II, III	91.1
Proton	88.3
Scout	87.9
Titan IV	85.7
Long March	83.3
Atlas	80.2

Table I. Shuttle Has Highest Launch Success Rate

The Shuttle has a better on-time launch record than the expendable launch vehicles (Figure 2). An attempt was made to apply the same

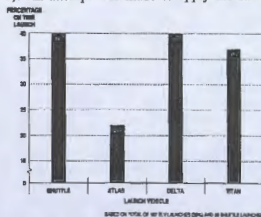


Figure 2. Shuttle Has Better On-Time Launch Record Than ELVs

definition for "launch delay"—any delay after the launch vehicle has arrived at the launch pad that prevents the launch from occurring on the scheduled day—to both ELVs and the Shuttle. Since the ELV data did not always specify when the launch date was established, all delays may not have been considered. Of the fifty-seven Shuttle flights from STS-1 through STS-51, thirty-five have been successfully launched in one launch attempt

and fourteen others in two attempts. Twenty-seven of the Shuttle launch delays to later in the same day or scrubs to another day were caused by weather. Some of the weather violations were at the world-wide abort sites necessary for the safe return of the crew. It is inappropriate to consider those weather related delays or scrubs when comparing Shuttle to ELV launch-on-time performance. Safe return of the crew and payload is a small price to pay for occasional delays or scrubs. Additionally, each Shuttle flight element contractor has reassessed and refined launch constraint redlines to improve launch probability. Furthermore, the program has minimized violations of winds aloft criteria by recently implementing a day-of-launch I-load update (DOLIU) capability which further improves launch probability. The implementation of these improvements has led to an overall launch probability consistently in excess of 90%.

The Space Shuttle provides competitive cargo cost into orbit. As indicated in Figure 3, the Shuttle cost (\$/lb.) to LEO is less than Titan IV and competitive with Atlas and Ariane.

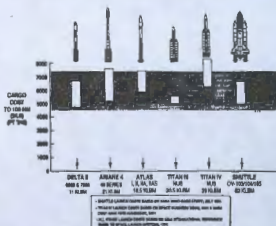


Figure 3. Shuttle Provides Competitive Cargo Cost Into Orbit

While accurate and comparable costs are difficult to determine, there is no conflict over cost trends. Shuttle costs have been coming down while Titan IV costs have increased.

The cost ranges reflect expected variations in flight rates per year of the Shuttle and variations in production runs and payload integration complexity for the ELVs. Lower flight rates result in higher cost/lb. to LEO because fixed costs are spread over fewer flights. Conversely, higher flight rates result in lower cost/lb. The fixed costs dominate at low launch rates (Figure 4). As the flight rate increases from 8 per year to 12 per year, the recurring costs increase only by \$407M (\$3,359M for 8 flights to \$3,766M for 12 flights). At the same time, the average cost per flight decreases from \$420M (for 8 flights) to \$314M (for 12 flights) and the cost per pound decreases from \$6,667M (for 8 flights) to \$4,984 (for 12 flights).

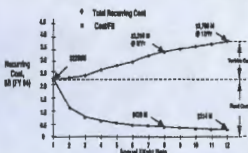


Figure 4. Fixed Infrastructure Drives Total Recurring Costs

Additional cost reductions can be achieved to make the Shuttle system even more cost effective. The Shuttle launch operations concept should be modified to initiate a long range operations cost reduction plan leading to an industrial STS operator (Figure 5): The first step is the consolidation of NASA contractor roles and the elimination of duplicate effort across all Shuttle operations contracts. The elimination of duplicate launch support services significantly reduces manpower and provides a direct link from Shuttle element processor to Shuttle element designer. It eliminates at least one layer of oversight and removes the inefficiency that goes with multiple contractor interfaces and the hand off of technical issues. Additional

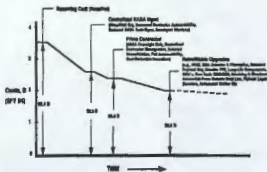


Figure 5. Shuttle Operations Cost Can Be Reduced To At Least \$2.0B

consolidation of support contracts and elimination of duplicate effort will lead to significant Shuttle operations cost reductions and still maintain hardware reliability and safety.

NASA must manage program milestones and the contractors on a mission contract basis. Shuttle management responsibilities should incrementally transition to an industrial Shuttle Operator with NASA retaining top level control and with a single contractor held accountable for Shuttle operation. Redundancies between the civil servants, element contractors, processing contractors, and support services contractors could be significantly reduced, if not eliminated. Consolidation of duplicate effort and turning day-to-day Shuttle operations over to an industrial operator could reduce Shuttle non-hardware operations costs by at least \$1.5B per year.

The NASA is significantly improving the Shuttle flight rate capability. The typical turnaround time (TAT) for a 1992 Shuttle flight (Figure 6) was 134 days (DRFC 7, OPF 83, VAB 7 and Pad 37). Several actions being implemented have improved this schedule. Landing at KSC saves 7 days. At the OPF, use of standardized and streamlined flows, expansion of fair wear-and-tear specifications, increased use of in-flight checkout, and use of manifesting techniques

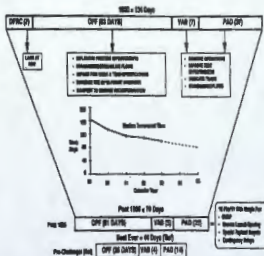


Figure 6. Turnaround Time Is Being Significantly Reduced

to minimize reconfiguration are helping reach the goal of a 51-day typical processing time by 1995. In the VAB and on the pad, combining operations, improving test effectiveness, and using dedicated teams, as well as standard flows, are helping reduce the typical time from 44 to 27 days. These actions will enable a theoretical flight rate greater than 16 per year with a four-Orbiter fleet. Even after allowing for Orbiter down-time, unequally spaced missions, weather, and other contingencies, a realistic flight rate of 12 per year is achievable, opening up at least 4 flights per year for DoD.

The Shuttle Launch-On-Need (LON) capability was required by and planned for by the DoD. Currently, the only planned LON is a Hubble Telescope repair mission which can be flown within 12 months of call-up. A payload with less complex requirements could be called up on a shorter timeline. For a payload to be classified as an LON payload, 1) its integration cycle must be complete; 2) all operational documentation must be developed and on the shelf; 3) the ground flow must be validated by pathfinder or analytically; and, 4) no configuration changes are allowed that would invalidate the safety or integration processes. If a payload can be stored at the launch site, time will be saved in

ground processing. How quickly a LON payload can be launched depends on where the Shuttle Orbiter is in its turnaround cycle. Figure 7 shows the various scenarios for inserting a LON payload. As shown, the shortest time to launch will be achieved if the call-up occurs at the start of the up-mission processing (UMPS). Under that condition, the payload can be launched in 75 days. The worst scenarios are those that occur just as the Orbiter lands, or when the Shuttle is at the pad with a payload which must be removed to accommodate the LON payload. Under those scenarios, launch could not occur for 96 days. Additional timeline improvements could be achieved for payloads with a minimum of software and hardware interfaces with the Shuttle.

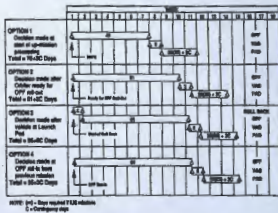


Figure 7. LON Processing Flow Options

The decision to ban payloads requiring a Centaur upper stage after the Challenger accident was a response to the inherent additional danger to the crew posed by high energy liquid propellant upper stages. The hardware system to accommodate a Centaur stage exists and was, in fact, scheduled to be installed for the next flight following the Challenger accident. The only constraint to flying a Centaur class payload is the presence of the crew. Several studies have looked at flying the Shuttle without the crew. Two types of crew-less configurations could be developed. One implements an Automated

Orbiter Kit (AOK) and the other provides a Reusable Cargo Vehicle (RCV). The AOK provides an automated mission kit in the crew module that performs normal crew functions but does not substantially change the Orbiter configuration. Payload lift capability is increased by 10,000 to 12,500 pounds by the removal of the crew and selected crew equipment. The RCV concept removes all crew unique systems thereby saving weight and improving performance by over 20,000 pounds. The RCV cost and schedule is essentially the same as a new Orbiter.

Typical of upper stages which can be used to launch DoD payloads from the Shuttle nominal parking orbit is the IRIS. IRIS was developed by Alenia Spazio for the Italian Space Agency to launch LAGEOS 2 into a 5900 Km orbit at a 52 degree inclination. The IRIS system is designed to inject a 900 kg mass payload into geostationary transfer orbit, starting from the Shuttle nominal parking orbit. Figure 8 gives the performance characteristics of the IRIS launched from a standard Shuttle orbit.

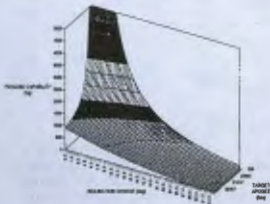


Figure 8. IRIS Payload Capability From Standard Shuttle Orbit

The cost of designing payloads for dual launch system capability has been perceived as an issue. Since the induced environments for Shuttle and Titan IV are essentially the same, with Shuttle being slightly more benign, the added cost of designing payloads

to fly on Shuttle as well as ELVs is related to physically adapting the payload and designing systems that are man-rated in terms of safety, redundancy and reliability. Some payloads are dual compatible now. DSP has flown on Shuttle and may be flown on it again. GPS was originally designed to fly on Shuttle. Some national asset payloads may be Shuttle compatible. Payloads utilizing IUS or PAM upper stages should require minimal change. The impact on new development payloads would be minimal since in-line design would avoid the high cost of redesign and recertification. A cradle can be developed which will adapt Titan IV payloads to Shuttle so that the payloads would be able to fly on either system without design change. Similar "launch vehicle simulators" might be worth investigating for Atlas and Delta class payloads.

Another perceived impediment to launching DoD payloads on Shuttle is the reduction in Shuttle security. The DoD terminated full control mode for Shuttle missions with STS-38 as a cost avoidance. Security constraints on the integration process for the flights of AFP-675, IBSS, and STP-1 on STS-39 and the flight of DSP on STS-44 were waived by the DoD. Detailed payload capabilities and test results remained classified. No security problems were encountered on those missions. Prior to STS-53, which flew the DoD-I payload, security requirements were relaxed under the DoD Secure Shuttle Operations (DSSO) concept. That flight demonstrated that economical and adequate security measures are still in place to protect national interests.

Summary

Revisiting the use of the Space Shuttle to ensure access to space for national priority payloads is worthwhile. Capability, reliability, affordability, and responsiveness are all attributes of today's Space Shuttle system. The definition of our nation's DoD priorities, coupled with the "new NASA", supports the need to re-examine the military's use of

Shuttle. Not only is the current manifest supportive of increased DoD use, but NASA's new culture better accommodates the mutual resolution of technical and programmatic issues. The current administrative policies that restrict DoD use of Shuttle need to be addressed and updated. The Shuttle is a national asset. The question is not whether the nation should have a Shuttle - it is here. The real question is how can the DoD quickly and cost effectively execute its space mission.