Alternate Trajectories

Options for Competitive Sourcing of the Space Shuttle Program

Report of the Space Shuttle Competitive Sourcing Task Force

FINAL REPORT

This report of the Space Shuttle Competitive Sourcing Task Force was supported by the Science and Technology Policy Institute at RAND and sponsored by NASA's Office of Space Flight (OSA) under contract ENG-9812731. It was written by the Space Shuttle Competitive Sourcing Task Force. Copies of the report may also be obtained via the internet at: http://www.rand.org/scitech/stpi/NASA/index.html.

About the Science & Technology Policy Institute

Originally created by Congress in 1991 as the Critical Technologies Institute and renamed in 1998, the *Science and Technology Policy Institute* is a federally funded research and development center sponsored by the National Science Foundation and managed by RAND. The Institute's mission is to help improve public policy by conducting objective, independent research and analysis on policy issues that involve science and technology. To this end, the Institute:

- Supports the Office of Science and Technology Policy and other Executive Branch agencies, offices, and councils
- Helps science and technology decisionmakers understand the likely consequences of their decisions and choose among alternative policies
- Helps improve understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives.

In carrying out its mission, the Institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

Alternate Trajectories

Options for Competitive Sourcing of the Space Shuttle Program

Report of the
Space Shuttle Competitive
Sourcing Task Force

December 2002

Final Report

PREFACE

The National Aeronautics and Space Administration (NASA) has operated the Space Shuttle for more than two decades. The program has reached the point at which many within the aerospace community believe the Shuttle is ready for a shift away from the government and toward private sector control. In the past, such scenarios were addressed by the terms "privatization" and "commercialization." Today, the term "competitive sourcing" is used to suggest a broader set of options for management and operational changes to the Shuttle program. This report by the Space Shuttle Competitive Sourcing Task Force examines the future of the Space Shuttle Program (SSP) from the perspective of placing a larger share of responsibility for the system into private sector hands.

The study reviews the history of the Space Shuttle, the current and future demands for services, the level of investment made in people and infrastructure, and, most importantly, the need to maintain safety and stability as touchstones of the system. Wherever possible the study has focused on a quantitative assessment based on data supplied by NASA, the Space Shuttle contractor community, and other sources. The report focuses on NASA's Space Shuttle missions to support the International Space Station (ISS). Other potential markets are addressed and the analysis reviews the potential impact that a competitive sourcing decision could have in a broad sense.

The Space Shuttle is a critical element of the nation's space architecture. The system is the only current means of completing assembly and providing crucial services to the ISS, a highly visible program in which the United States is partnered with several foreign governments. The Task Force recognized the great importance of wise choices in regard to the Shuttle program. Task Force members were drawn from a diverse community of leaders and each was completely aware of the magnitude of decisions to be made regarding the future of the Space Shuttle. Competitive sourcing is but one issue that NASA managers must evaluate. It cannot be properly addressed without considering the larger context of an integrated space activities plan involving the ISS, the evolution of follow-on space transportation systems, the future goals of human space flight, and future government requirements.

The insights presented in this Task Force report are related to many elements of current civil and military space policy and should be of interest not only to NASA's senior leadership, but also to the Office of

Science and Technology Policy, the Office of Management and Budget, and congressional leaders in oversight and policy positions. Additionally, it is hoped that the report will form an analytical basis for pending decisions on the shape and direction of the civil space program.

This Task Force study and report were supported by RAND's Science and Technology Policy Institute (S&TPI) and sponsored by the Office of Space Flight (OSF) at NASA. S&TPI is a federally funded research and development center (FFRDC) for studies and analysis, established by Congress and administered by the National Science Foundation (NSF). The research presented in the document was completed August 2002.

Inquiries regarding the Task Force report may be directed to:

Helga E. Rippen, Ph.D., M.D., M.P.H.
Director
Science and Technology Policy Institute
RAND
1200 South Hayes Street
Arlington, VA 22202-5050
Tel: 703.413.1100, ext. 5574

CONTENTS

SYNOPSIS

Throughout the past decade there has been considerable interest in examining ways to commercialize or privatize the Space Shuttle. Numerous studies have been commissioned to examine mechanisms that would place the Shuttle system in private hands. These efforts each have reflected an awareness that, as the Shuttle matures, it is natural to examine the possible transfer of responsibility to commercial operators. The Space Shuttle was intended from the outset to be commercially operated, so the attention paid to the subject is not surprising. The loss of the *Challenger* caused a profound reassessment of the Shuttle program leading to decisions that would leave the leadership of the program within NASA, thereby delaying any decision to move toward privatization.

The Space Shuttle Competitive Sourcing Task Force was commissioned to reexamine the role that NASA and the contractor community play in operating the Space Shuttle. The Shuttle, though it remains a risky and complex system, has reached a stage of relative stability in technological and operational terms. NASA and the contractor community have worked hard to build a robust system that can reliably carry humans to orbit. Procedures have been set in place that maintain the highest degree of performance and reliability feasible and a set of planned improvements has been funded to ensure continued safe operations.

NASA is currently concentrating its attention on future launch systems, vehicles capable of transporting humans to space with less risk and for less money. These systems remain at least a decade away, but the agency is clearly contemplating something beyond Shuttle that will move closer to the ideal of routine transit to low-Earth orbit (LEO). It is hoped that the private sector will operate these future systems. Accelerating this trend of divesting NASA from the demands of operating the Shuttle flight system is an important goal. Put simply, there is a strong desire to return NASA to its roots as a premier Space Flight Research and Development organization. Realizing these goals drives initiatives to explore ways to increase the role that the private sector plays in operating the Space Shuttle. The job of this Task Force was to conduct an unbiased assessment of various options for achieving this outcome for the Shuttle program.

A desire for cultural change is one of the principal driving forces behind the concept of competitive sourcing. NASA was established as an aerospace R&D organization and the agency has met many milestones associated with establishing American leadership in aeronautics and

space. Keeping NASA at the leading edge requires an ongoing review of agency roles and missions to ensure that more routine functions are transferred to the private sector. This classic form of outsourcing ensures that NASA scientists and engineers are free to focus on R&D activities while encouraging the private sector to assume leadership roles in new business sectors.

SUMMARY

OVERVIEW OF THE TASK FORCE

The Space Shuttle Competitive Sourcing Task Force was supported by RAND's Science and Technology Policy Institute (S&TPI) in response to a request by NASA. A list of Task Force members is presented in Figure 1. Task Force members were selected in consultation with, and subject to the approval of, NASA. NASA directed the Task Force to:

1. Identify options for competitive sourcing of the Space Shuttle Program (SSP).
2. Evaluate the comparative strengths and weaknesses of these options.

The reader should appreciate that the Task Force was specifically enjoined from selecting an option or expressing a preference for one option over another. The study was designed to lead to a set of options that NASA would evaluate and choose among. The related topics of Shuttle privatization or commercialization had been extensively studied and several reports are available for public review. The purpose of this review was to provide NASA with an unquestionably "independent" evaluation.[1] To avoid any question of bias, participants were selected who had no vested interest in the outcome.

To attract private sector participation in competitive sourcing, it was imperative that commercial business needs and requirements be incorporated during deliberations. Many of the Task Force members had senior private sector backgrounds. Understanding the development and operations of aerospace systems was also vital and members were included who had extensive experience with space flight systems. The concerns of NASA's workforce were reflected on the Task Force by the participation of a senior member of the federal human resources community. Most important, an understanding of flight safety and

[1]The reader's attention is drawn to the fact that near the midpoint of the review NASA selected two members of the Task Force for senior positions within the agency. These members are noted in Figure 1. Because of their unique expertise, and because the review was at a critical point, the Chairman elected to allow their continued participation. At the conclusion of Task Force activities, the Chairman also accepted a position with NASA.

operations of the Shuttle itself was assured by selecting Task Force members who flew onboard and directed the operations of the system.

The Task Force was supported by a cadre of RAND senior researchers. To facilitate the many detailed assessments needed, the Task Force and the RAND support groups were assigned to discipline-oriented teams, shown in Figure 1. These teams performed analyses of Shuttle program costs, personnel, and facilities. Throughout the study, the RAND support team worked closely with the Shuttle program's NASA and contractor staff to prepare quantitative and qualitative reports at the request of Task Force members. The Task Force also solicited information from a broad sector of the Shuttle community, including potential future customers. The Task Force believes that this review represents the most comprehensive analysis of potential private sector operation of the Shuttle yet conducted.

Name	Title	Affiliation	Team	RAND Staff
George Baker (NASA Cognizant)	Senior Advisor for Space Access	NASA		
Bretton Alexander (OSTP Cognizant)	Assistant for Aeronautics and Space	OSTP		
Liam Sarsfield, CHAIRMAN [1]	Senior Analyst	RAND	Strategy	Peter Wilson, Steve Berner
Owen Barwell [1]	Principal Consultant	PricewaterhouseCoopers		
Jack Donahue	Raymond Vernon Lecturer in Public Policy	Harvard University/Kennedy School of Government		
Robert Sieck	Shuttle Launch Director (former)	NASA (Retired)	Safety	Dave Ortiz, Skip Williams, Julia Warner
Pierre Thuot	Executive Vice President/COO	HawkEye Systems		
Francis DiBello	President/CEO	Florida Space Finance Corporation	Market/ Finance	Steve Berner, Jim Dryden
	General Partner	SpaceVest Fund, LP		
Michael Miller [2]	Managing Director	BV Group Vetures, LLC		
Patrick Ciganer [1]	Chief Financial Officer	Mobileway Inc.	Cost	Liam Sarsfield, Thor Hogan, Jeff Drezner
Steven Cohen	Acting Director (former)	OPM (Retired)	Human Resources	John Ausink, Joe Guzman
John Vinter	President	International Space Brokers	Liability	Liam Sarsfield
Daniel Heimerdinger	Executive Vice President	Valador, Inc.	Operations	Dave Ortiz, Liam Sarsfield, Skip Williams
Michael Lembeck	Group Vice President	Team Encounter, LLC		

[1] - At the time of this report these members have joined NASA's senior staff.
[2] - Currently Managing Director, ComSpace Development, LLC.

Figure 1—Task Force Members and Assignments

A SNAPSHOT OF THE SHUTTLE PROGRAM

The concept of a reusable space plane began to emerge at the very beginning of the space program. Throughout the '60s and '70s, the platform for what was to become the Space Shuttle took shape. The current Space Shuttle is a compromise vehicle, with the most important compromise being a retreat from the goal of full reusability. Today, hardware purchases represent approximately 44 percent of the Shuttle's annual budget, making it more a refurbishable system than a reusable one.

The Space Shuttle is NASA's largest single program and the foundation of NASA's Human Exploration and Development of Space (HEDS) enterprise.[2] It is a vital element of NASA's near-term human space program from the perspective that it is the only system currently configured to complete assembly of the International Space Station (ISS). In the longer term, ISS operations critically depend upon reliable Shuttle service (or an effective replacement) for both human and cargo transportation.

Flying the Space Shuttle is an enormous undertaking and the scale of the program can only be called gargantuan. The flight elements of what is called the Space Transportation System (STS) are shown in Figure 2. Primary propulsion is provided by three Boeing/Rocketdyne Space Shuttle Main Engines (SSMEs) each producing 393,800 pounds of thrust (at sea level, 104 percent). These engines are fed from a non-recoverable External Tank (ET) containing a combined 535,000 gallons of liquid oxygen and liquid hydrogen. Additional thrust is supplied by two solid rocket boosters (SRBs), 150 feet long and generating 3,300,000 pounds of thrust (at sea level) each. The orbiter itself weighs 180,000 pounds (empty) and, at 122 feet long, is the size of a small airliner.[3,4]

---

[2]NASA maintains five principal enterprises. In addition to HEDS, they are: Space Science, Biological and Physical Research, Aerospace Technology, and Earth Science.

[3]There are currently four orbiters in the fleet (*Columbia, Atlantis, Endeavour*, and *Discovery*) and the performance of each one varies due to ongoing modifications. Of the four vehicles, *Columbia* is the oldest and heaviest in the fleet. It has less performance since it has not had many of the enhancements made to the other three orbiters.

[4]The STS was originally designed as a system that included cargo variants. The Shuttle-C and Shuttle-Z configurations, capable of lifting a projected 125,000 pounds and 300,000 pounds respectively, replaced the orbiter with a shrouded cargo container to which SSME elements were attached. The variants were never built due to a combination of funding constraints and insufficient demand; see Jenkins, D., *Space Shuttle: The History of the National Space Transportation System*, Stillwater, MN: Voyageur Press, 2001, p. 456.

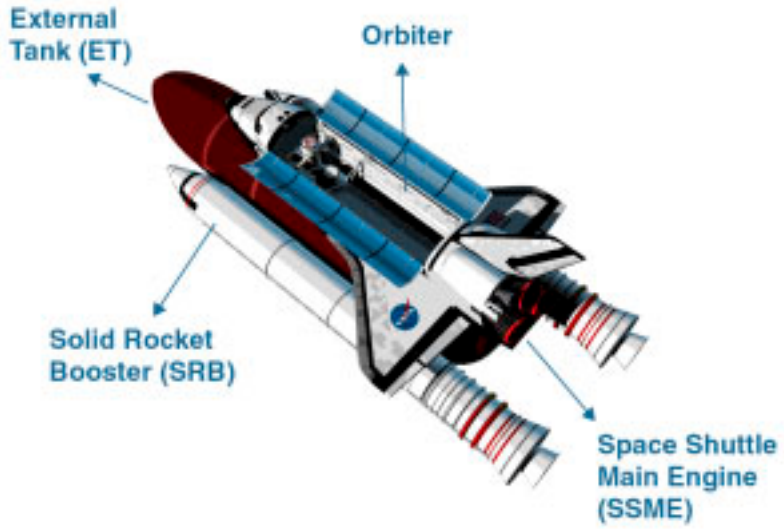

Figure 2—The Space Transportation System

The size of the Space Shuttle Program (SSP) includes an impressive array of flying elements; in many respects the ground infrastructure is even larger. From a full-cost perspective the SSP represents a $3.8 billion annual investment—the largest single activity within NASA, comprising several thousand civil servants and more than 20,000 contractor employees.[5] Over $4 billion in government ground assets are required to integrate and operate the Shuttle, and virtually every NASA field center plays a role in the program.[6] To recover the SRBs and to transport the ET from its assembly plant in Michoud, Louisiana, NASA maintains a small number of barges and surface ships. Special rail cars are needed to transport the reusable solid rocket motor (RSRM) segments, later assembled to complete an SRB, from the ATK/Thiokol manufacturing facility in Magna, Utah. Communications to and from the orbiter are provided by a unique, NASA-operated space-based tracking and data relay satellite system in addition to specialized ground-based communications systems. These

[5]The term "full cost" implies that the cost of civil service labor, travel, and associated support costs are included. Using this definition, the full cost of programs within NASA's five enterprises would, when summed, equal the agency's budget authority in a given year. The numbers used in this report for full cost and personnel are *estimates* generated by the Task Force.

[6]This figure represents the current replacement value (CRV) of the ground assets.

many pieces of infrastructure have been operating for more than 20 years.[7]

Though a regular event, the launch of a Space Shuttle continues to generate media interest. The Shuttle and the astronauts who fly the vehicle remain NASA's most visible ambassadors and the media monitor Shuttle program events closely. The loss of the *Challenger* in 1986 did not diminish public support for human space flight and NASA has restructured the program to yield a highly reliable and capable launch platform. The Space Shuttle in fact has the best long-term reliability record of any launcher in the U.S. inventory.

Generally, people associate the Space Shuttle with NASA, despite the fact that 92 percent of its funding is directed externally to a network of contractors. That association is not misplaced. Although NASA *outsources* most of the Shuttle program to the private sector, agency managers remain very much in charge. In essence, NASA runs the Shuttle program. The agency procures hardware, defines requirements, and is responsible for approving readiness for launch.

THE MEANING OF COMPETITIVE SOURCING

Competitive sourcing is a central element of government policy and a major theme of the President's Management Agenda.[8] The term "competitive sourcing" has a specific meaning in government circles and the definition is quite narrow:

> **Competitive Sourcing—**is the act of exposing government activities to competition with the private sector. The process of competition provides an imperative for the public sector to focus on continuous improvement and removing roadblocks to better performance and greater efficiency. The objective is to focus on the most effective and efficient way of accomplishing the agency's mission regardless of whether it is done by civil servants or contractors.[9]

Competitive sourcing is a management device for lowering the cost and/or improving the performance of public tasks by exposing those tasks to the discipline of commercial competition. Requiring public

---

[7]The Space Shuttle also relies on pieces of infrastructure inherited from the Apollo program, such as the crawler/transporters that move the integrated vehicle to the launch pad.

[8]The White House, *The President's Management Agenda*, Washington, D.C., January, 2002.

[9]Lentz, L., "Competitive Sourcing: the FAIR Act and OMB Circular A-76," briefing the NASA HQ staff, March, 2002.

employees who perform commercially available tasks to compete for the right to continue the work can improve efficiency. This is done either by replacing public incumbents with commercial alternatives or by motivating the public incumbents to attain or exceed the efficiency standards of the competitive private sector. A consistent pattern of competition produces a better value for the government and the infusion of innovation.[10]

Implied in this definition is a degree of overlap in the experiences and capabilities of comparable workers in the government and private sector. However, within the SSP, a program already heavily outsourced, there is actually little functional overlap between government and contractor managers and employees. Within the context of the Space Shuttle, competitive sourcing must be defined in a broader sense, with an emphasis on preserving safe operations. To adequately frame the analysis, the Task Force reviewed many sources of guidance to synthesize the following goals for changes in the structure, management, or governance of the Shuttle program that advance the broad goals of the President's Management Agenda and competitive sourcing:

> **Ensure the safe transport of humans to and from orbit**—operating with the highest priority on crew and operator safety must be the principal goal of a competitive sourcing initiative; the goal should be to exceed current levels of safety. The private sector should continue to assume greater responsibility for safety so that NASA can confidently acquire transportation services when next-generation Reusable Launch Vehicles (RLVs) come on-line.
>
> **Enable NASA to exit the business of operating human space assets—**with 20 years of experience, and as routine servicing of the ISS becomes the mainstay of the Shuttle's mission, Shuttle launches are as "operational" as they are going to get.[11] There will not be a better time to relieve NASA of the burden of running transport services.
>
> **Enhance the competitive environment—**to the greatest extent practical, a competitive sourcing initiative should serve as a catalyst for competition to ensure that the government gets best value. Competition drives not just operational efficiency and cost control but also innovation and the development of enterprises focused on space-based commerce.

---

[10]Styles, A., "The Administration's Competitive Sourcing Initiative," Administrator, Office of Federal Procurement Policy, in testimony before the House Subcommittee on Technology and Procurement Policy, June 28, 2001.

[11]The Task Force recognized that upcoming Space Station assembly flights are, in many respects, the most challenging flights the Shuttle program has ever faced.

Open up a cost wedge for reinvestment—competitive sourcing should offer NASA options for savings and efficiencies that both improve safety and reduce costs, freeing up resources for reinvestment in the Shuttle and other NASA programs.

Reinvigorate NASA as an R&D organization—a competitive sourcing strategy should view NASA as a premier R&D agency that is at its best when pursuing high-risk, high-reward science and technology. Relieving NASA of transport burdens, in other words, is not just a means to advance other goals but a goal in its own right.

A desire for cultural change is one of the principal driving forces behind the concept of competitive sourcing. NASA was established as an R&D organization and the agency has met many milestones associated with establishing American leadership in aeronautics and space. Arguably, NASA is at its best when tasked with achieving scientific and technological objectives that truly challenge its abilities. Keeping NASA at the leading edge requires an ongoing review of agency roles and missions to ensure that more routine functions are transferred to the private sector.

Shuttle competitive sourcing seeks to encourage this stepwise migration of functions into commercial hands. The private sector has assumed a leadership role in the launch of Expendable Launch Vehicles (ELVs).[12] In the future, it is likely that the launch of humans into space will also be left largely to commercial operators. In this way, the Shuttle system can once again be a pathfinder, allowing the private sector to acquire the skills, disciplines, and practices that are necessary to safely transport humans into space.

MARKETS AND COMPETITIVE FACTORS

When the Space Shuttle was first conceived, NASA projections for the launch rate for the Shuttle estimated an average of close to 50 flights per year.[13] The projected demand model for the Shuttle included the deployment of scientific spacecraft, military and intelligence-gathering payloads, commercial systems including communication satellites, and

[12]It is important to note that although U.S. ELV launches are viewed largely as a commercial operation, in practice the government provides substantial support. Private firms launching from Cape Canaveral, for example, enjoy the benefits of facilities and support made available at the Kennedy Space Center (KSC). An appreciable amount of KSC resources support ELV operations.

[13]Dennis R. Jenkins, "Broken in Mid-Stride: Space Shuttle as a Launch Vehicle," in Roger Launius and Dennis Jenkins, eds., *To Reach the High Frontier*, Lexington, KY: University of Kentucky Press, 2002, p. 376.

foreign payloads. The Shuttle was to be the primary means of building and operating the Space Station, NASA's next large program designed to follow when the Shuttle was declared operational. Interestingly, early plans for the Space Shuttle were based on turning the system over to contractor control once five initial operational test flights were successfully completed. The Shuttle proved, however, to be far more complex an operational system than first conceived. Though the Shuttle quickly began carrying payloads, NASA found itself in a protracted period of learning, battling a myriad of teething problems with the system. Confidence in the Shuttle developed steadily until the destruction of the *Challenger* and the loss of seven crew members in 1986.

The loss of the *Challenger* crippled the Shuttle program for nearly three years. Flights were stopped until the cause of the *Challenger* loss could be ascertained and the safety of the system improved. The failure mode, leakage of hot propellant gases through a joint in the solid rocket motor (SRM) segments, was corrected by both a redesign of the SRBs and new flight rules that restricted Shuttle operations.[14] By the time the Shuttle returned to flight, however, demand for the Shuttle had withered. The launch hiatus, new flight rules, and a reformulated national space policy combined to drive customers off what was then perceived to be a fragile system.[15] Most damaging was the decision by the Department of Defense (DoD) to abandon the STS as the primary means of military space transportation.

In the years since *Challenger*, NASA and the contractor community have proved that the Shuttle is a robust system. Though there have been serious incidents, and a few close calls, the resiliency of the system has been aptly demonstrated and its ability to complete missions proven. Carrying the Spacelab and Spacehab modules in its payload bay, the Shuttle proved its worth as a research platform. The ability to service the Hubble Space Telescope allowed one of NASA's most successful spacecraft to continue operations. Today, the Shuttle is engaged in the building of the ISS and

---

[14]"Flight rules" are codified practices, procedures, limitations, and restrictions that govern operation of the Shuttle to ensure safety.

[15]The modified space policy restricted use of the Space Shuttle from flying commercial communication satellites. DoD decided that the Shuttle represented excessive risk to military platforms that required assured access to space. NASA's scientific offices also reformulated their plans, preferring from this point forward to use expendable launch vehicles (ELVs) to launch spacecraft into orbit or into deep-space trajectories.

will service that laboratory for at least the next 12 years.[16] Yet, despite the system's resiliency, demand for Shuttle services has not risen.

Today, SSP's dominant customer is NASA itself, and the primary use of the Shuttle is building and servicing ISS.[17] The broadening of this customer base would greatly improve the prospects for a market-based Shuttle system, fed by revenues beyond NASA's and disciplined by customers beyond NASA. The Task Force examined the potential emergence of other demands for the Shuttle. The results were not encouraging.

Commercial markets, such as satellite servicing and the development of commercial space stations are immature and unlikely to build a substantial revenue stream in the near- to mid-term. Space tourism, much touted by many in the space community as a large source of revenue, is also unlikely to demand Shuttle services. Space tourism is a small market consisting of an unknown number of very wealthy individuals who can afford a ride into space. Though an unsubsidized price for a ticket on the Shuttle would remain affordable to the very wealthy, the use of government equipment for such purposes is also problematic.

The deployment of commercial communication satellites, even if the national space policy restrictions were removed, would not reestablish a viable source of demand for Shuttle services. Satellites have to be designed to be launched from the Shuttle due to the different way that structural loads are imparted to the satellite from its mounting within the orbiter's payload bay. Also, the Shuttle's low orbit requires that the satellite must carry an upper stage to boost it to a higher geosynchronous orbit; these booster stages are no longer in production. Finally, the failure of the low-Earth orbit (LEO) communications market and the longer-life and greater performance of modern communication satellites has reduced the number of satellites being launched, causing excess capacity, and therefore competitive pricing, in the ELV market. The market price for satellite launches, in short, has fallen to well below the cost of providing such services on the Shuttle.

Military users, too, are unlikely to place significant demands on the Shuttle. Both DoD and the intelligence community have no long-term requirement for "humans-in-the-loop" to deploy or operate their

---

[16]Replacing the Shuttle is a much discussed and politically charged subject. There are several options available, but all are costly. If the choice is made to replace the Shuttle, however, the earliest possible replacement date is likely to be 2014.

[17]NASA's Space Science Enterprise projects a need for one Shuttle flight every three years; the remainder of the Shuttle manifest is completely dominated by the ISS.

payloads. DoD has also invested heavily in the development of the new Evolved Expendable Launch Vehicle (EELV), a fleet of new high performance, high reliability launchers. The Task Force was only able to identify a limited DoD interest in the Shuttle, mainly for the occasional deployment of small technology demonstrator type satellites.

The primary reason for the lack of interest in the Shuttle is the cost and complexity of using the system. At a full annual cost of $3.8 billion and a launch rate of four to six missions per year, the average cost is very high. The nature of a Shuttle launch varies widely, making it very difficult to calculate the marginal cost of a launch—that is, the costs that are solely attributable to one additional launch, excluding all fixed costs. The marginal cost is generally thought of as the benchmark for pricing a service. Previous studies have placed the Shuttle's marginal cost between $100 million and $150 million per launch.[18] This is above the cost of all but the largest of expendable launchers. So even if the government meets all costs other than those strictly due to the extra launch, the Shuttle's economics compare unfavorably with ELVs. Processing the Shuttle is also necessarily complex. Although NASA has made substantial investment in fleet modernization, and has streamlined procedures in many areas, flying the Shuttle is an exceedingly time-consuming task—a further deterrent to commercial demand for its services.

Beyond the demand for Shuttle in the external market is consideration of the internal market, the supplier base, and competition for the current $3.2 billion in NASA extramural spending. The Shuttle program is served directly by nearly 200 companies.[19] The majority of these contracts are less than $500,000. Many of the largest contracts are sole-source supply contracts to procure the Space Shuttle flight elements. The largest contract, the Space Flight Operations Contract (SFOC), is approximately $1.5 billion, which equals 47 percent of program extramural spending. Although this contract is designed for periodic recompetition, there are daunting barriers to the entry of serious rivals to the incumbent contractor. Together, these factors create a situation in which there are very few bidding opportunities for contracts of substantial size.

Changing contract structures does not necessarily improve competition. SFOC is currently serviced by United Space Alliance (USA), a joint venture of Boeing and Lockheed Martin. The creation of USA, essentially

---

[18]National Academy of Public Administration, *A Review of Space Shuttle Costs, Reductions Goals and Procedures*, Washington, D.C., 1994.

[19]These are companies with Shuttle contracts managed by NASA. Hundreds of other firms are involved in the Shuttle program as subcontractors to the prime contract firms.

reflecting a cartel agreement between America's two largest aerospace firms, puts in place a firm with tremendous market leverage. The net result of the current structure is that Boeing and Lockheed Martin together secure two-thirds of SSP's $3.2 billion extramural budget. Incumbent contractors with high award fees and a long-term relationship with NASA are the trademarks that constrain outsider firms from bidding. Additionally, many of the larger firms that currently support the Shuttle program are subcontractors or teammates of Boeing or Lockheed Martin on other programs. It is not clear whether a situation of strategic interdependence exists in relation to the Shuttle program, but the limited number of aerospace firms available to bid on Shuttle contracts makes it difficult to generate significant improvements in the competitive environment.

NASA can raise the stakes on competition by extending the duration of base contracts. The Task Force examined the potential for new, and possibly non-aerospace, firms to be attracted to the SSP through the mechanism of long-term (10+ year) contracts and found some degree of interest if such procurement options were considered. However, long-term contracting itself acts as a limit to competition, a reversal of the intended goal. Long-term contracting could also lead to a commercial resistance to evolving to a new launch system, since contractors will be inclined to maintain an alliance to a known source of funding. Considering the reduced size of the pool of private firms interested in and capable of bidding on Shuttle activities (mostly due to mergers and acquisitions), the complex nature of the work (with a paramount focus on safety), and the size of the individual contracts, it will likely prove very difficult to engender a more competitive environment for the SSP.

PLACING THE SHUTTLE IN NON-NASA HANDS

One of the most limiting factors to competitive sourcing is NASA's reticence when it comes to relinquishing control of the Shuttle program. This reticence has both practical and cultural dimensions.

On the practical side, proponents of maintaining NASA ownership and leadership argue that the Shuttle is hardly an operational vehicle. The Space Shuttle was not designed to operate like commercial equipment, for example, an airliner. Indeed there are few similarities between Shuttle operations and commercial airline operations. The Shuttle is launched like a rocket with complex checklists and a countdown that harkens back to

the early days of chemical rockets.[20] There is also substantial variability in the Shuttle system. Besides the significant variation among the orbiters themselves, there are many changes that must be made to the hardware and software between flights. Some of this is due to the changing nature of the payloads carried within the Shuttle. Differences in the type and mass of equipment being placed in the orbiter's payload bay, for example, require rebalancing of the vehicle and often changes to the flight software. While "maintainability" was considered early in the Shuttle design, accelerated development schedules and budget reductions led to a vehicle that is difficult to maintain and repair. An orbiter is a densely packaged system with little room for technicians to perform work in critical areas. Post-*Challenger* procedures require far more maintenance and inspection than was originally planned, and the system was not designed to accommodate these activities.

From a cultural perspective, NASA's research staff resists efforts to make the system more operational. NASA, an agency chartered to develop advanced technology, continues to use the Space Shuttle as a test platform. The Shuttle is the only operational RLV in the world and is, therefore, an obvious research platform for NASA experimenters. Changes to Shuttle systems are constant, and some of these changes are extremely complex and costly. Many changes to flight and ground elements of the Shuttle system are conducted in the name of safety, but, in some cases, it is likely that improvements yield only marginal safety benefits.

Competitive sourcing faces other hurdles as well. A significant complicating factor is the indeterminate length of the Shuttle program. Today, NASA cannot tell a company tasked with assuming Shuttle operations the length of time the Shuttle will remain in service. NASA continues to officially state that the STS is slated to remain operational only until 2012.[21] In practice, however, the operational lifetime of the Shuttle could be much longer. The Shuttle's operational lifetime does affect how a private firm would approach operating the system. The longer the potential operating period, the greater private sector interest will be in becoming involved in operating it. Of course, the Shuttle will not fly forever, so taking on the risk and responsibility of operating the Shuttle requires potential commercial operators to develop a financially viable "exit strategy." This barrier to entry can be lowered by redefining

---

[20]Dornberger, W. Gen., *V-2: The Nazi Rocket Weapon*, New York: Ballantine Books, 1952, p. 33.

[21]NASA, "Marshall Space Flight Center, Narrowing Down The Future," Press Release, Huntsville, AL, July 18, 2002.

the objective of competitive sourcing to be "human spaceflight transportation" as opposed to "Shuttle operations." Private sector interest in operating human spaceflight assets over the very long-term would likely be higher, possibly broadening the base of competition.[22] Such an approach would provide business planners with an "entry strategy" and long-term profit potential.

Aging of the fleet and the supporting infrastructure is another factor. First launched in 1981, the Shuttle is showing its age. Reductions in the number of launches have meant that the system has not reached structural limits at the speed originally envisioned, but obsolescence is becoming a major factor in sustaining Shuttle operations. A reduced flight rate has led to a reduction in the demand for Shuttle components. Smaller vendors, some with a business base largely reliant on SSP purchase orders, have either gone out of business or sought other markets. This has led to a constant need to recertify new vendors for parts and components and the careful stockpiling of spares and critical components. It has also led to the need to often pay more for certain parts and components than would normally be necessary in order to encourage vendors to remain in business.

Aging takes its toll on both flight and ground infrastructure. The flight elements of the STS (mainly the orbiter and its engines, but also the ET and SRB) are slated for significant upgrades and improvements. The Task Force estimated that, in the out-years, the SSP will face a steady-state cost of approximately $300 million per year for depot maintenance of the flight elements and base maintenance of the ground facilities, even at the reduced flight rate. This steady-state number is roughly double what is now allocated. In the near term, it is unlikely that the planned budget for upgrades and obsolescence (approximately $1.1 billion during the five-year period FY03 to FY07) will be sufficient to sustain Shuttle operations, even to 2012. The level of additional investment required will be significantly affected by the schedule for a Shuttle follow-on system.

The ground infrastructure is also in need of urgent repair. The official estimate for the backlog of maintenance and repair (BMAR) is approximately $420 million, but the Task Force found that this estimate is low. The Task Force found that the actual cost to address needed facility maintenance and improvements could be nearly twice the current estimate. The list of BMAR includes some big ticket items, such as

---

[22]This strategy requires a clear message from NASA that future launch systems are intended from the outset to be designed technically and programmatically for operation by private firms.

replacing the roof on the Vehicle Assembly Building (VAB) at KSC, which will likely cost $100 million.

In summary, a competitive sourcing initiative faces an array of challenges ranging from reticence on the part of NASA to the difficulty of dealing with an aging system. The Task Force concluded that these challenges, though significant, could be successfully overcome. For competitive sourcing to succeed, however, other steps are needed. The Task Force applied the term "right-sizing" to a set of management reforms needed as a precursor to competitive sourcing. The term right-sizing describes the process of restructuring the SSP along the lines of a private enterprise, as well as matching the scope of the program to its expected market base. While right-sizing does imply savings to the program, the Task Force did not conclude that such an initiative would lead to a significant net reduction in the full cost of the Shuttle program. *This is because savings, when realized, will be needed to offset cost growth the Task Force expects in other, currently unbudgeted, areas*. The Task Force concluded that an appropriate target for right-sizing would be to reduce annual SSP operating costs by approximately $500 million.[23]

The STS was originally designed for much higher utilization. Prior to initial operations, NASA configured the production system for a flight rate of 48 flights per year.[24] Once operations started, however, it became clear that such a flight rate could never be attained in practice. Shuttle facilities and staffing were reduced to meet a flight rate of 12 to 14 per year, but even this flight rate has never been achieved.[25] Without a significant strategic discontinuity, one that leads to a dramatic boost in demand for Shuttle flights, it is likely that the Shuttle will continue to fly

---

[23]This would translate into a reduction of the annual full-cost budget of the SSP from $3.8 to $3.3 billion; achieved over a five-year period (reduction of $100 million per year). In the professional judgment of Task Force members, this is a reasonable target. The Task Force did perform first-order estimates of some options for producing savings. These analyses provided sufficient evidence that cost savings are available within the program. However, the Task Force did not have sufficient time to evaluate the political or program risk ramifications of certain actions. As described earlier, the Task Force expects that costs will rise in areas such as facility maintenance and orbiter upgrades. While the net financial effect of right-sizing might not be significant, attention to cost savings is important if NASA is to avoid overall cost growth in the Shuttle program.

[24]Williamson, R., "Developing the Space Shuttle," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, Logsdon, J., et al. (editors), NASA SP-4407, Washington, D.C., 1996, p. 179.

[25]The largest number of flights flown by the Shuttle in a given year was nine in 1985.

between four and six times per year.[26] Implied in this assessment is the existence of some degree of remaining excess capacity within the Shuttle system. When the assembly of the ISS is complete in the middle of this decade, the Shuttle program will enter a period of fairly routine operations in support of logistics. This should provide additional opportunities for personnel and infrastructure redeployment.

Realigning the SSP management structure is an important element of change and an enabling step to competitive sourcing. At present, the Program Manager (PM) resides at the Johnson Space Center (JSC) in Houston, Texas. The Shuttle PM has the lead responsibility for the program, overseeing the performance of a workforce that includes many workers resident at KSC.[27] However, the Marshall Space Flight Center (MSFC) in Huntsville, Alabama, an R&D center that took the lead in developing ascent propulsion elements of the Shuttle, continues to procure major hardware elements, spending nearly one-third of the $3.2 billion annual extramural budget. This appears inconsistent with typical business management principles. An important step in moving toward competitive sourcing would be reorienting the SSP to reflect a focus on more centralized management and procurement. Put simply, there is a need to realign the Shuttle management along programmatic lines. This will require centralizing all management activities to the program office at JSC, a move that will signal an end to field center–dominated matrix management.

The Task Force found that right-sizing of the Shuttle program should begin now as a prelude to competitive sourcing. When the timelines for competitive sourcing options are examined, it will likely take up to two years before a competitive sourcing initiative can begin in earnest. In the meantime, NASA can begin to right-size Shuttle management systems and organization and create initiatives to streamline infrastructure.

Should the private sector assume a greater leadership role in the Shuttle program, the size and complexion of the Shuttle workforce will change. A

---

[26]It is difficult to envision an event that would lead to a sharp rise in demand for Shuttle services. Scenarios that the Task Force examined included: (1) a need to conduct emergency repairs to the ISS, (2) a military event that requires the placement of large payloads into space (possibly requiring the construction of STS cargo variants), and (3) a discovery on the ISS that leads to the need for expanded space-based production. The Task Force found these to be possible but unlikely scenarios.

[27]The SSP PM currently resides at JSC, but NASA is in the process of making this position a Headquarters function. The PM would likely continue to reside at JSC, but the line of reporting would be directly to NASA Headquarters instead of through the Johnson Space Center Director.

major challenge associated with competitive sourcing relates to human resource issues. The Task Force found that more than 3,100 full-time equivalent (FTE) civil service employee positions are supporting the Shuttle program; the staff distribution by function is shown in Figure 3. The fact that these are FTE positions and not employees complicates the topic of transition. Of the more than 3,100 Shuttle FTE positions, fewer than 900 are filled by people working 100 percent on the Shuttle program. The remaining approximately 2,200 FTE positions are filled by personnel working on other programs in addition to Shuttle.

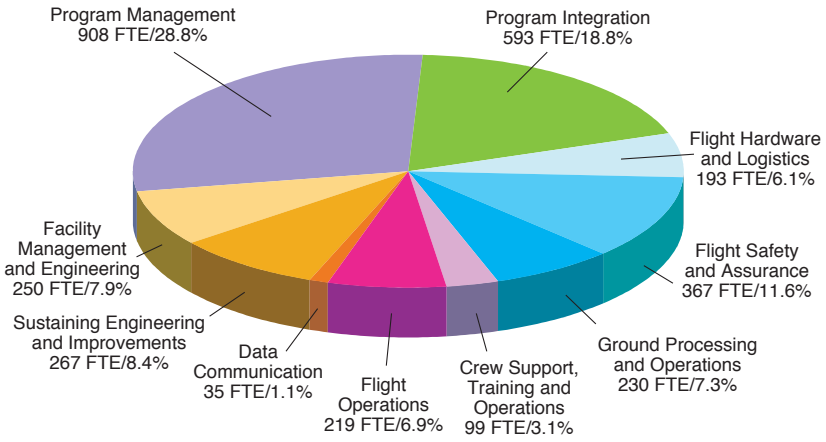

Figure 3—Distribution of SSP Civil Service Staff

The Task Force discovered that fewer than one-third of the Shuttle program's FTE positions are represented by individuals eligible for immediate retirement; the remaining two-thirds are ineligible for immediate retirement, though their benefits are "portable" under the Federal Employees Retirement System (FERS).[28] By far the largest proportion of employees eligible for regular or early-out retirement are in the Civil Service Retirement System (CSRS). These factors greatly complicate the task of Shuttle program transition to the private sector. Buyouts are unlikely to be of significant assistance, since the vast majority

[28]FERS replaced the earlier CSRS in 1987. Under FERS, employee retirement benefits are retained in periods of job transition and are "portable," akin to private sector benefit plans. CSRS regulations are far less open, however, and therefore employees operating within this plan are less likely to leave government service, especially when they are further along in their career path. A comprehensive comparison of the two plans can be found in Asch, B., and J. Warner, *Separation and Retirement Incentives in the Federal Civil Service: A Comparison of the Federal Employees Retirement System*, RAND MR-986-OSD, Santa Monica, CA, 1999.

of employees that wanted to leave NASA took buyouts on prior offerings. For employees who are close to eligible retirement age, the current limitation on the value of buyouts is far below the level required to provide an adequate incentive.

There are many decisions that NASA must make if a competitive sourcing strategy is pursued. Many of these actions are strategic and will have a profound influence on the NASA and contract employees that constitute the Shuttle program. At the core of competitive sourcing is a willingness to transfer much more responsibility, authority, and leadership of the Shuttle program to operators (private or public) outside NASA. If NASA implements this strategy, agency managers must lay the groundwork by minimizing changes to the current system configuration, right-sizing elements of the program to support the anticipated flight rate, and ensuring that supporting infrastructure can sustain operations. Clearly, competitive sourcing will place NASA in a new role in terms of Shuttle operations, a shift that will have a significant impact on NASA's culture and personnel.

A NEW ROLE FOR NASA

It is natural to question whether NASA and the contractor community are ready to proceed with what the Task Force considers to be competitive sourcing options. From the contractor perspective, added responsibility for operating the Space Shuttle is not automatically welcomed. Flying the Shuttle is a dangerous and risky undertaking. The potential for loss is calculated to be on the order of 1/250, a factor not usually associated with commercial operations. Today, NASA's leadership role includes responsibility for the Certification of Flight Readiness (CoFR) process. The contractor community assists with this process, but NASA assumes the risks and liability associated with launching the Shuttle.[29] If the private sector were to take more responsibility for Shuttle launch operations, the assumption of risk and liability may grow proportionately.

NASA recognized several years ago that the contractor community was capable of assuming a greater role in Shuttle operations. NASA created SFOC to consolidate functions and allow a private firm to take on many of

[29]Contractor personnel play a significant role in assuring safety and providing information that supports the signing of the CoFR. Some elements of the CoFR document are actually signed by contractor personnel and private firms follow a process that in many ways mirrors NASA's. However, the contractors implement processes that are largely designed and controlled by NASA. The final decision to launch remains solely with NASA, and the government indemnifies the launch.

the management and engineering jobs previously held exclusively by NASA personnel. SFOC was to proceed in two phases. The Phase I effort involved the initial consolidation of contracts under a lead operational contract. Phase II was to involve additional consolidation resulting in what would essentially be a single prime contractor managing the Shuttle. When Rockwell International (subsequently acquired by Boeing) and Lockheed Martin joined forces to create USA to bid for, and eventually win, SFOC (there were no other bidders), the contractor quickly grew to more than 10,000 employees that handle most day-to-day Shuttle operations.[30] Interestingly, NASA did not allow the Phase II consolidation to occur and SFOC has not yet evolved to single-prime status.[31]

In creating SFOC and transferring certain operational responsibilities to the private sector, NASA has found itself in a position of retaining management jobs and an aging workforce, while being restricted in its ability to attract, train, and retain younger engineers. Creating USA and transferring key jobs has made it difficult for NASA to bring an engineer "up through the ranks." Some senior NASA program officials are concerned that their employees will lose the skills necessary to exercise adequate safety oversight of the contractor and see this as a major reason for competitive sourcing.

The Task Force found that although the NASA Shuttle workforce is not being fully replenished, the current age distribution is not unusual when compared with that in other programs. It is possible that a steady loss of skills will erode the SSP's ability to maintain oversight of the program. However, the Task Force also found that there are ways to acquire the necessary skills. For example, NASA should be able to maintain adequate oversight capabilities through key staff hiring, rotational assignments both within NASA and with existing contractors, knowledge-management systems, and other strategies. Potential loss of skill base is not in and of itself a compelling argument in favor of competitive sourcing.

The Task Force found that the private sector has the capacity to assume a larger role in Shuttle operations and in the development of equipment (such as the external tank and the solid rocket motors). What the Task

---

[30]The SFOC contract also includes some support to the ISS Program.

[31]The Task Force found that the primary reason for NASA's caution in this regard is the feeling that USA, the SFOC contractor, has not secured the senior managers and engineers needed to assure the leadership that a single prime must demonstrate. Additionally, NASA believes the SSME, ET, and RSRM elements of the program are too developmental to place in hands of contractors. NASA MSFC has also retained control of the sustaining engineering function. These issues will impede competitive sourcing initiatives in the same way they have impeded the broadening of SFOC.

Force is describing here is not simply additional outsourcing, but a substantive transfer of management functions and a sharing with NASA of the responsibility for safe operation of the Space Shuttle. There is little doubt that transferring additional roles to the private sector, especially major shifts in authority, will not come easily. Yet the Task Force has found that the private sector is capable of assuming additional functions and successfully accomplishing the important missions that lie ahead for the Shuttle. This requires significant changes in contracting strategy. In the decades that follow, NASA and other users may be able to buy tickets to transport humans to space with very little oversight from the government. The journey toward that goal will begin with additional steps to transfer more Shuttle operational authority to the private sector. In accomplishing this shift, safety must remain the central concern.

MAINTAINING A PRIORITY ON SAFETY

Safety has always been paramount within the Shuttle program. Certainly the greatest concern that was expressed to the Task Force in regard to competitive sourcing centered on safety. Some senior NASA officials expressed a conviction that Shuttle safety would be immediately threatened if a competitive sourcing initiative resulted in the loss of NASA oversight, or in the private sector playing a greater leadership role.

The Task Force placed a great deal of emphasis on the issue of Shuttle safety, interviewing NASA and contractor engineers and managers and studying in detail the many processes put in place to ensure the safety of the crew and system. The Task Force also studied other complex, privately operated engineering enterprises where there is great potential for loss of life and property. The Task Force found, that although some firms have not maintained high safety standards, in general, firms operating in the aviation, nuclear, and oil and gas sectors, for example, operate with an impressive commitment to the safety of the public and their employees. Within many industries the financial stakes match the potential for financial loss associated with losing a Shuttle orbiter. In terms of the potential for loss of life, some private firms, such as those involved in running nuclear plants, deal with risks that vastly exceed those of the Shuttle program. In short, the Task Force found that the private sector's need to operate profitably does *not* entail compromises in safety. Indeed, in industries most analogous to Shuttle operations, safety and profitability are inextricably linked on both the revenue side (safety attracts customers) and on the cost side (safety lowers insurance costs). Even deregulation, a strategy that some NASA officials liken to competitive sourcing, does not automatically lead to unsafe conditions. In fact, the Task Force found that

in practice the opposite is actually true—safety improvements have often followed deregulation.[32] The fact that the private sector can establish safety leadership is aptly demonstrated by the fact that NASA itself has baselined the practices of the Dupont Corporation as a standard by which to measure the safe performance of both agency and contractor employees.[33]

The Task Force is confident that under the right contractual incentives, the private sector can maintain, and continue to improve, Shuttle safety. NASA should be able to successfully transfer additional responsibility and control under a competitive sourcing strategy, building a human space transportation industrial base that will serve the nation's current and future needs. The Task Force considered the transition of additional management and engineering functions and considered the many operational aspects that are unique to the Shuttle program. Without question, the transportation of humans into orbit is an endeavor with unusual operational elements. The contractor community does not have the final say for launch decisions, although SFOC has helped bring the contractors to a higher state of readiness to accept more responsibility. For these reasons, the Task Force focused on creating an additional strategy for ensuring safety during a competitive sourcing transition.

One of the most important trademarks of a safe organization noted by the Task Force is independent monitoring. An independent safety organization can operate either within or external to a company. When the safety function is internalized, private firms create reporting mechanisms that isolate the safety unit from the profit-making side of the company. United Airlines, for example, created a robust safety program led by an executive reporting directly to the Chairman of the Board. SSP is a diverse program combining government employees and the employees of dozens of contractor companies. For this reason, the Task Force recommends that, in a competitive source environment, an independent safety process for the Shuttle be established separate from both the government and existing contractor communities. An Independent Safety Assurance Office (ISAO) would be a new organization responsible for providing an added dimension to Shuttle safety. The organization would provide oversight of both NASA and company safety practices, participate directly in the CoFR process, and assist with the design of practices that constitute continuous improvement to Shuttle safety.

---

[32]Bier, V., *Effects of Electricity Deregulation on Nuclear Power Safety* (also released as Nuclear Regulatory Commission Report CR-6735), University of Wisconsin, Madison, WI, 1998.

[33]NASA, SSC, *Business Management Manual,* SPG 8730.1, January 3, 2001.

Today, contractors are responsible for a very high percentage of Shuttle ground and flight operations. Although NASA has retained leadership in many areas, the sheer magnitude of contractor activity leads to a conclusion that the contractors could begin to take a more active role in launch authorization. NASA, the new ISAO, and the contractor with operational responsibility could share in signing the CoFR. The Task Force has proposed a "three-key" safety process, shown in Figure 4, to encapsulate a joint launch authority strategy. Under this process, a launch of the Space Shuttle could not take

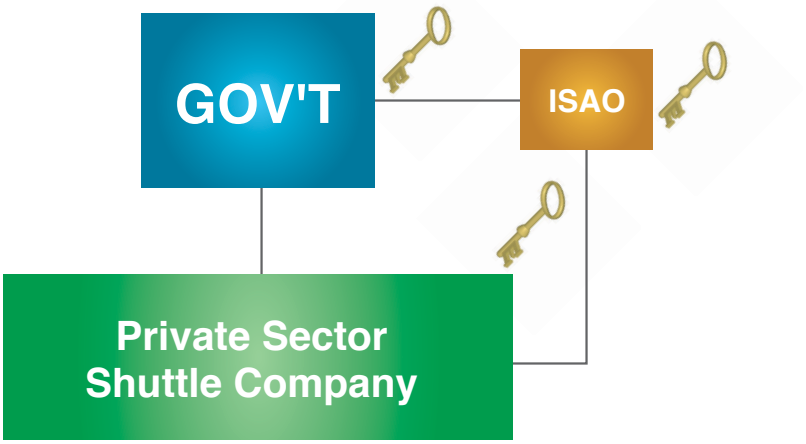

Figure 4—A "Three-Key" Safety Process

place without the concurrence of all three parties. Providing the operating contractor with a "launch key" reflects a true alignment between the responsibility contractor employees currently have in practice and the authority they must acquire if the private sector is to provide human space transportation leadership. That the proposed ISAO would also hold a launch key is indicative of the pivotal role that independent assessment plays in terms of ensuring safety, free of either launch pressures or concerns of profitability.

For a private firm operating the Shuttle, an added feature of launch authority is liability. Irrespective of whether the private sector or NASA owns the assets, contractors are responsible for the launch and potential loss of several lives and billions of dollars of hardware. It is reasonable to expect a company with such a responsibility to share in the liabilities

associated with launching the Shuttle. Third-party liability for Shuttle launch is readily available and an insurance facility exists (though it is now dormant) for the purchase of third-party liability insurance. More important, however, is the creation of a first-party (property damage) liability regime for contractors launching the Shuttle. Since the value of launch assets exceeds the existing industry capacity for first-party insurance (estimated to be $880 million in 2002), an operating contractor can assume only partial liability for damages to assets. The Task Force, in polling insurance underwriters, found that approximately $250 million could be available to insure a Shuttle launch; above this value the government would have to indemnify. This value does, however, represent a significant offset to potential financial losses. In a competitive sourcing environment, with the private sector assuming greater responsibility, it is reasonable to require the operating contractor to provide liability coverage of approximately $250 million. The contractor could choose to self-insure or to turn to the insurance market for first-party coverage.[34] In either case, this represents a substantial degree of financial vulnerability to a commercial operator. If the operator self-insures, the financial stake in safety is direct. If it buys insurance, the rate charged will reflect insurers' assessment of operational safety—an assessment that will become better with experience, so that the link between safety improvements and insurance savings will become more precise. An important corollary to the notion of requiring the operating contractor to share both launch authority and launch liability is the profit potential that should be made available. The real risk of financial damage from a loss must be coupled to adequate financial gain for continuous safe performance of the Shuttle system.

Private operation is no barrier to an optimal level of safety in Shuttle operations. In considering competitive sourcing options, it is necessary to create an environment in which a commitment to safety remains paramount within both NASA and the contractor community. The current system of flight rules, safety practices, and highly trained and dedicated personnel provides a solid foundation on which to build competitive sourcing initiatives.

---

[34]Recovery of insurance premiums under the contract would most likely be permissible under such a construction. However, contract restrictions and penalties can be so structured as to make current and past premiums unallowable under the contract so that the net effect is a true financial risk to the operating contractor.

OPTIONS FOR COMPETITIVE SOURCING

The Task Force identified seven competitive sourcing options that could be evaluated by NASA and the space policy community. At the outset of the Task Force's activities, guidance was given by NASA and OSTP to avoid advocating a single option but instead to present the strengths and weaknesses of the various options without bias.

The Task Force realized that it will be a challenge to reduce this set of options to one or two that can be analyzed in much greater detail. Selection requires a set of criteria by which to compare the strengths and weaknesses of the various options. The Task Force set out a dozen criteria that NASA can use to guide the selection of competitive sourcing option:

- Provide for safer operations
- Engender positive cultural change
- Broaden the competitive contractor base
- Reduce transaction costs
- Provide flexible and robust operations
- Promise savings leading to re-investment
- Create clear lines of authority and responsibility
- Reduce implementation complexity
- Promote innovation within Shuttle system
- Encourage independent contractor operations
- Free up NASA civil service resources
- Meet diverse future and unanticipated requirements.

The options identified by the Task Force break down into three classes. The first class contains four options representing various methods of revising the contractual architecture of the Shuttle program. The second class contains two options that can be considered privatization in that assets are transferred to a private firm. The final class contains a single option that involves the formation of an authority separate from NASA to operate the Shuttle with a mixture of government and contractor personnel.

Options for Contract Restructuring

There is a relatively small number of large aerospace firms engaged in Shuttle operations, and many of these contracts represent sole-source relationships with NASA. A competitive sourcing strategy could consist of a restructuring of contracts and the relationship between the government and private firms, with NASA retaining ownership of assets. Many of the concepts described earlier, such as right-sizing or "shared liability," can be pursued within initiatives to restructure contracts. Restructuring allows NASA to design a relationship that best fits the nation's long-term human space transportation requirements and the goals of competitive sourcing.

Figure 5 portrays four notional options that constitute Contract Restructuring. The first option is called "Enhanced Outsourcing," which represents very little change to the existing organization of the contractors and their relationship to NASA. In this option, NASA would intensify its efforts to transfer additional responsibilities and functions to the private sector. As stated earlier, the Shuttle program is already heavily outsourced; in this option the outsourcing effort would grow further. This option, as well as others, implies the consistent shrinkage of the SSP, in terms of overall staffing levels, as additional work is shifted to the contractor base.

The next option is called Functional Consolidation. This option involves the decomposition of the SFOC contract into constituent elements. The primary goal in presenting this option is to create smaller, more numerous contracts. Creating more contracts, theoretically smaller in size and scope, and more focused along centers of commercial expertise, reduces the barrier to entry for competing firms. In Figure 5, the "Flight Hardware Contracts" are shown in contrast to the other contract areas since these represent sole-source relationships. The Functional Consolidation option might require some moderate amount of growth in the number of NASA employees involved in the Shuttle program since integration and procurement workloads would most likely increase.

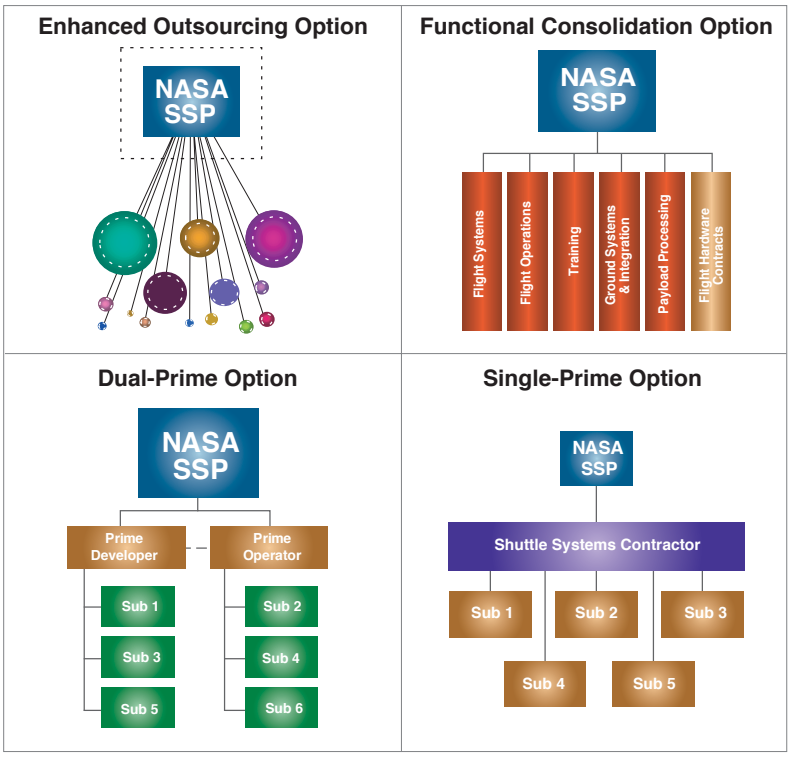

Figure 5—Notional Competitive Sourcing Options Involving Contract Changes

A third restructured form is the Dual Prime. Maintaining two prime contracts is intended to separate the task of developing hardware from the task of operating it. The relationship is an analog to an airline operator and aircraft manufacturer. The integration function could be designed to be left in the hands of the two prime firms, or NASA could continue to serve in the role of system integrator. Since the procurement of hardware would pass to the Prime Developer, NASA's transaction costs should be reduced under this option.

The final restructuring option is the creation of a Single-Prime contract. As previously mentioned, this was the intended progression of SFOC. A single prime contractor would present one central interface to NASA. Although it is not an essential feature of a single prime, it is likely that the procurement of Shuttle flight hardware, a complex and labor intensive job at NASA, would become a contractor responsibility. A single prime contractor also presents NASA with a smaller coordination challenge,

since the integration role would largely transfer to the contractor. This leads to a significant opportunity to accomplish cultural change at NASA.

Changing the relationship between NASA and the private firms that support the SSP will not come without costs. The potential novation of contracts, additional competitions, and personnel adjustments are likely to increase near-term costs. These additional costs must be weighed against the potential benefits that could accrue from such disturbances. An additional concern is the potential impact on safety that stems from realignments. Safety is often best served by stability of management and engineering functions, and this factor will have to be carefully evaluated. Also, achieving cultural transformation at NASA and enhancing the leadership role of the private sector is not automatic in these various Contract Restructuring options. The contract structures presented in these four options are all familiar to NASA. Without purposeful direction, the agency could invest in substantive contract shifts, fail to overcome internal resistance to changing roles, and find itself in the same operational mode. As mentioned earlier, it should not be assumed that contract restructuring will automatically lead to competition. The Shuttle program provides few opportunities for competition on large contracts and the likely effectiveness of steps designed to improve competition in this supplier base must be carefully evaluated.

Privatization Options

The Task Force identified two options that could be considered methods for privatizing Shuttle assets. Privatization carries with it some important implications in terms of the direction of the SSP. Both of the notional privatization options drawn in Figure 6 are marked by the absence of a Space Shuttle Program within NASA. In one option, the SSP would yield responsibility for Shuttle to a private firm and cease operations. In a more evolved form, human space transportation would no longer be anchored by NASA at all; other parts of government would regulate commercial space transportation operations, and NASA would simply be one customer of the industry. In both cases, the private sector would be responsible for the safe transport of humans to orbit.

Another important element of a privatization strategy is irreversibility. Once privatization occurs it will be very difficult to return to a government-contractor relationship. Privatization requires careful analysis and a firm commitment from the government.

Privatization is built around the concept of asset transfer and the Task Force did not address the detailed cost of assets as they might be transferred under a privatization initiative. It is clear, however,

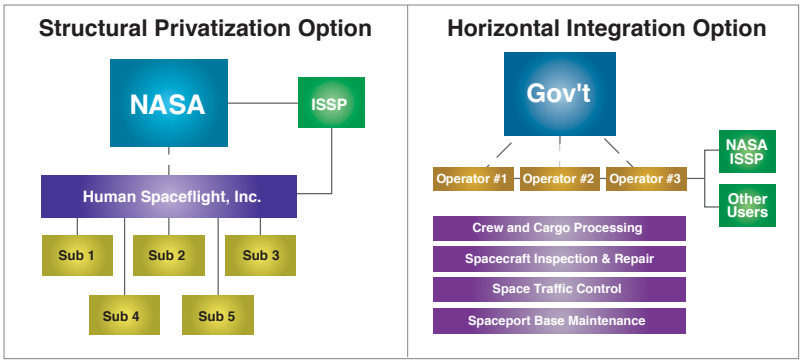

Figure 6—Notional Competitive Sourcing Options for Privatization

that the current demand model does not support the transfer of assets at prices based on replacement values. Asset discounting (possibly including negative asset value, i.e., having to pay the contractor to accept transfer of the assets) would be needed in the short term to accomplish privatization.

The first privatization option shown in Figure 6 is called Structural Privatization. The firm selected to privatize the Shuttle would, in large part, assume the role of the current SSP. NASA would maintain a limited oversight of a "human spaceflight" company operating the Shuttle system and procuring flight equipment. Customers would contact the privatization firm directly for human space transportation services and pay the service price, and not the cost, of a ride to space.

Another notional privatization option is Horizontal Integration. This option is designed to roughly mimic airport operations and is built upon a foundation of nested contracts that support several vehicle operators. These operators could own one or two orbiters supplying services to the customer community. One operator, for example, could own *Endeavour* and *Atlantis* serving an ISS customer. Another operator could own *Columbia* and service NASA space science and other potential government agencies interested in flying technology demonstrator payloads. A third operator might own *Discovery* as well as be a service provider for Russian human space transportation assets. Operators could also combine human and cargo transportation services. The main feature of this option is the

diverse nature of flight services being offered by operators supported by a stable base of horizontally integrated contractors. A decision by NASA to build future launch systems that operate with the Shuttle to provide alternate access to space is a natural fit for this option. This option is also consistent with a notion of operating the current launch complex at KSC as a regional municipal spaceport.

Given the earlier argument that the demand for Shuttle services is one-dimensional, privatization might be a strategy that NASA cannot contemplate until later, with the appearance of a more robust market for Shuttle services or those of a follow-on vehicle. Of the contract restructuring options, the single-prime option leads naturally to the notion of structural privatization, which, in essence, is a direct corollary. The creation of a single-prime could emerge first, followed by privatization at a time when demand for human space transportation services grows. While privatization is difficult to implement now, it does have the distinct advantage of dramatically changing NASA's culture, freeing the agency for a greater R&D focus. Privatization also provides access to credit markets, an important feature in terms of the maintenance of critical assets.

An Authority Option

The Task Force examined a third class with a single option that is shown in Figure 7—the notional Space Authority option. An authority is a hybrid organizational structure that accomplishes many of the goals of competitive sourcing. Creating a Space Authority for human spaceflight has two important aspects: (1) it establishes and builds upon a corporate instrument to organize the Shuttle program, and (2) it provides a means of raising debt capital in the form of bonds. Authorities are organizational structures that operate in situations characterized by limited commercial competition, or where prices must be carefully controlled. An authority typically is established in circumstances where inherent barriers to competition, or other flaws in the market setting, make the ideal of purely commercial supply unachievable.

The spectrum of existing authorities is wide and diverse, ranging from organizations that differ little from conventional government agencies to institutions that are essentially regulated private firms. They are most obviously seen in the form of municipal or regional transportation authorities, the entities that manage local bus, rail, and airport facilities and services, but also operate in various finance and service industries.

A space authority could be formed in many ways; the one shown in Figure 7 would acquire the SSP as well as the operating component of the

ISS program. Since it is presumed that the authority would procure follow-on launch systems, it would also acquire, from NASA's Office of Aerospace Technology, the groups responsible for developing requirements for next-generation systems.

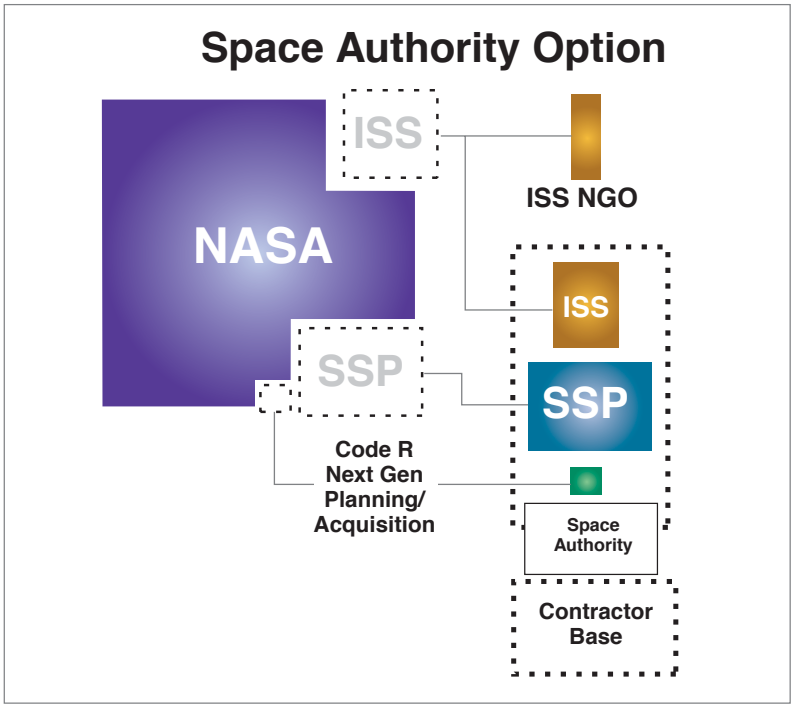

Figure 7—A Notional Space Authority Option for Competitive Sourcing

Since an authority is often viewed as a pseudo-governmental institution, its creation might be construed as a step backward from the notion of competitive sourcing. A spaceflight authority does, however, provide a clear mechanism for changing NASA's culture. As shown in Figure 7, the authority would acquire the major portion of HEDS assets and personnel. Virtually all operational elements of HEDS would be aligned under the new authority, freeing NASA to focus on R&D. This includes freeing the human exploration community to plan future missions without the need for concern about human transportation to LEO.

The Task Force recognizes that forming a space authority would be a dramatic shift not only in NASA's culture, but in the political relationships between the SSP and the NASA field centers, as well as the existing relationships between NASA and its oversight offices. A spaceflight authority could also be viewed as a transitional form since it

would be relatively straightforward to privatize the entity if and when the commercial market for Shuttle services or its follow-on matures sufficiently.

Another important aspect of a spaceflight authority is that NASA can begin the process of organizing along these lines now. By reformulating the management structures of the Space Shuttle and Space Station programs, NASA can begin to pull together the operational components of human spaceflight, with the potential benefit of removing any existing redundancies.

Some Common Themes

The options presented so far are structured to present NASA with a strategic choice. Each option represents a unique future, but there are some common themes. Most important of these common themes is the need to preserve safety. *It is important to note that the diagrams shown in the previous three figures do not identify the ISAO mentioned earlier as being critical to the success of a competitive sourcing solution.* This is because *all* options should include this organizational structure as a link between the government and the operating contractor. The key to establishing the ISAO is not the competitive sourcing option that NASA selects; rather, it is the decision to share launch responsibility, authority, and liability that should trigger the creation of the ISAO.

Another common theme among competitive sourcing options is the potential for providing Shuttle services at a fixed price. It is hoped that once Space Station assembly is complete, Shuttle servicing will become more routine, an outcome supportive of fixed price operations. Under fixed pricing, savings accrue to the private operator as increased profits, and not to the government. Therefore, NASA must extract any significant savings due to restructuring of the Shuttle program before a shift to a fixed price footing can be considered to prevent the operating contractor from extracting windfall profits. This is another important reason for pursuing right-sizing. Fixed pricing could exacerbate safety concerns since the private firm might be inclined to trim costs in the name of profitability. While the Task Force found that other cross-incentives would prevent such shortsightedness on the part of a private Shuttle operator, there are no guarantees and additional safeguards are warranted under a fixed price contract, particularly until an appropriately risk-sensitive insurance market develops. For this reason, the creation of an ISAO should precede a shift to fixed price.

Whatever competitive sourcing option NASA selects, it is likely that it will take some time to design optimal implementation plans. The steps

required to put the options outlined above in place are many in number and complex in form. The Task Force estimates that it will take at least two years to initiate a competitive sourcing plan. As this plan is being formulated, however, NASA can simultaneously begin the process of right-sizing the program to meet expected levels of demands.

CONCLUSIONS

The Task Force was challenged to carefully examine the Shuttle program and develop options to accomplish the various goals of a competitive sourcing. These goals had sometimes contradictory implications, which will require NASA to weigh the importance of these goals and to employ consistent evaluation criteria during deliberations.

There is no simple solution to the challenges of competitive sourcing. It is an initiative that will have profound impact on NASA and the future of the civil space program. Yet the Task Force concludes that NASA must pursue competitive sourcing in one form or another. NASA set out on a path of greater reliance on the private sector when it first conceived SFOC. Agency managers undertook this important step with the realization that ultimately NASA must be willing to relinquish operational roles as soon as practical in order to pursue the high-risk, high-payoff missions at which it has long excelled. Admittedly, the Space Shuttle is an imperfect instrument in terms of commercial operations. The system is exceedingly complex, the risks are high, and the post-*Challenger* operational environment is far more cumbersome than originally envisioned by agency planners. The private sector can, however, succeed in this environment if competitive sourcing is methodically initiated. This requires determination on the part of both the government and the private sector.

It is unlikely that a privately operated Shuttle will soon succeed in discovering new demands for Shuttle services. The system is simply too expensive and complex to attract fledgling commercial space ventures. It is possible that some limited demand might emerge from commercial and other government sources. However, in the near-to-mid-term, the primary source of demand for Shuttle services will continue to be supporting the International Space Station.

The lack of demand and associated limited income streams, and the lack of property insurance, will make it difficult to consider the transfer of assets to the private sector; at least at full value. Privatization, if NASA should choose to pursue such a course, will have to be based on asset

transfer at highly deflated prices. It is unlikely that privatization will be a future option for the Shuttle program.

Other options for competitive sourcing require restructuring of existing contracts. The Task Force presented four such formulations, each with advantages and disadvantages that NASA will have to weigh carefully. The supplier environment surrounding the Shuttle program is profoundly noncompetitive. The bulk of Shuttle contract spending flows to Boeing and Lockheed Martin, an effective duopoly in this supplier base. The barriers to entry into the Shuttle market are quite high and the payoffs limited given likely contract options. Further, it is unclear, given the current limited number of options, that what little competition can be generated will lead to improved efficiency and cost reduction.

A classic response to existing market forces and operational realities would be for NASA to establish a space authority to operate the Shuttle and future human transportation vehicles. Authorities have many forms and can be so designed as to accomplish many of the goals of competitive sourcing. An authority, though it is based on the creation of a corporate instrument, might not be viewed as a "competitive" action in the spirit of reliance on the private sector. A space authority could, however, be an important first step on the way to the privatization of human space transportation should demand grow.

Any of the competitive sourcing options that the Task Force has prepared for NASA will take time to implement and will require close interaction with the private sector. NASA cannot quickly restructure the Shuttle program to be consistent with competitive sourcing practices. First the agency must embark on a period of right-sizing to match the expected launch rate and realign the management structure to more closely match a form that private firms prefer. The first step is providing the Program Office with the greatest latitude possible in designing and initiating new management structures. To address private sector concerns and to seek guidance on procedural steps, the Program Office should work closely with the management of commercial firms, opening a dialog for exchanging ideas on how best to secure efficiencies and ensure that safety is maintained, and hopefully improved, during the transition. The Task Force expects stiff internal resistance to change, particularly from field center directors whose staff and program allocations will be affected by this significant change in strategy. NASA leadership must aggressively step forward to guard this transition and to elucidate plans that ensure that field center core competencies are retained to support future programs.

Maintaining a focus on safety is of primary importance during this transition. NASA must retain a prominent role in Shuttle safety while allowing industry to take leadership in key areas. The private sector can successfully operate the Shuttle safely. Both NASA and the private sector can share launch authority and private firms can retain some liability for processing and launch operations. The Task Force recognizes the importance of this reordering of responsibilities, but these actions reflect the true nature of risk. Overseeing this transition, and ensuring that safety is paramount, should be an independent safety office.

The Task Force purposefully did not focus on the many structures of governance available to NASA for implementing a competitive sourcing strategy. NASA's first task is to select an option that will constitute a new relationship between the government and the private sector for the Shuttle program. The options presented by the Task Force were designed to bound the problem, outlining broad structural boundaries for the NASA/industry interface. NASA senior managers will need to weigh the goals and selection criteria the Task Force has presented and make a final decision that meets current and future requirements. Only then can governance structures be selected that most effectively implement the chosen competitive sourcing strategy.

A significant challenge to competitive sourcing is concern over NASA's human resources. For many options, competitive sourcing requires a substantive transfer over time of functions currently performed by civil servants. Transferring employees to comparable positions in the private sector will be very difficult—at times requiring the development of incentives that do not presently exist and at other times requiring the replacement of critical skills needed for other NASA programs. NASA must begin to analyze now the options for employee redistribution, and identify not only the solutions to the situations described above but also, when necessary, new and challenging career activities for individuals being displaced by competitive sourcing initiatives.

Competitive sourcing is a key element in a strategy of redesigning NASA for the future. Yet, it is one of many new initiatives that will reshape the agency and must, therefore, be sculpted within a strategic setting. Future launch vehicle decisions, new strategies for utilizing and operating the Space Station, and plans for the commercialization of space, are examples of parallel initiatives that will affect, and be affected by, the path selected for competitive sourcing.

RECOMMENDATIONS

The Task Force recommends that NASA carefully review the competitive sourcing options and weigh the benefits of transitioning lead responsibility for Shuttle operations out of NASA. Competitive sourcing offers many advantages to NASA that could prove compelling when evaluated within a strategic context of options for developing next-generation launch systems, the operations and utilization of the Space Station, and future human exploration initiatives. NASA's leadership should consider creating a structured decisionmaking process within which these broad strategic choices can be analyzed.

These recommendations are directed to NASA management. While many competitive sourcing options will require the support of the White House and Congress, the immediate steps that must be taken are largely up to NASA. The recommendations are described in the following seven sections.

Selecting Options

Implementing a competitive sourcing strategy will take time, as the process requires detailed planning to maintain safety and to ensure cross-program integration. In down-selecting competitive sourcing options for further consideration NASA should:

- *Create a small working group of senior managers to evaluate and select options.* Members should be selected from the Office of Space Flight, Office of Safety and Mission Assurance, Office of the Chief Financial Officer, Office of Aerospace Technology, and the Office of the Administrator, to review, evaluate, and select competitive sourcing options. Additionally, since human resource management is expected to be a major consideration in a competitive sourcing strategy, the group should include a member from the Office of Human Resources and Education.
- *Select a subset of competitive sourcing options for additional review.* Review the goals and selection criteria for competitive sourcing and weight them in terms of relative importance to NASA. Study the strengths and weaknesses of the various options and apply the evaluation criteria to select a smaller menu of alternatives.
- *Ensure close cooperation with industry.* Prepare a mechanism for the working group to interact closely with senior industry leadership to exchange ideas and ensure that both government and private sector officials voice concerns.

Program Restructuring

Restructuring of the SSP is an important corollary and prerequisite to competitive sourcing. An important first step is the consolidation of SSP contract, personnel, and facility authority to the Space Shuttle Program Office at NASA JSC. This first step facilitates the complex job of right-sizing the program with some degree of isolation from internal NASA politics that would otherwise stall such an initiative. To begin the process of program restructuring, NASA should:

- *Place authority and responsibility for SSP contracts within the Program Office*. One reflection of this shift would be transferring SSME, RSRM, and ET contract authority from MSFC to the Shuttle Program Office at JSC. As part of competitive sourcing, NASA should then plan to transfer responsibility for hardware procurement out of the agency in a stepwise fashion.
- *Ensure that the civil servant workforce supporting the SSP should be accountable to the SSP.* Adjustments in organizational structure should be considered to provide SSP ownership of workforce and project management (performance evaluation, awards, etc.).
- *Replicate a single company structure where field center personnel provide support directly to the SSP*. Project management and supporting workforce currently operating within a matrix management system should be transitioned to a direct reporting structure.

Business Development

Although the Task Force concluded that creating demand for Shuttle services will be very challenging, it is important for NASA to do everything it can to reach new customers. Generating commercial interest in the supplier base is equally important. To build new business externally and internally, NASA should:

- *Take whatever steps are possible to develop the market.* This includes creating a modest marketing initiative within the Shuttle program, creating an aggressive pricing policy for customers with limited budgets, and reinvigorating outreach programs. NASA should examine the advantages of combining this marketing initiative with similar activities within the SSP.
- *Empower the contractor with Shuttle operational authority to aggressively pursue new opportunities and offer significant rewards for success.* This

includes retaining the majority of earnings from the provision of Shuttle services above a predetermined basis.

- *Consider making "human spaceflight" the target of competitive sourcing vice the "Space Shuttle."* This should broaden interest in the program and possibly entice new firms to consider competing for operation of the Shuttle.

Maintaining Safety

Pursuing competitive sourcing should always remain focused on improving safety. This requires government industry teamwork and pathways of open communication. To stay focused on safety during competitive sourcing, NASA should:

- *Demonstrate a willingness to accept the private sector playing a leading role in Shuttle safety.* This means the demonstration of confidence in private sector capabilities, as well as a clear statement of expectations. NASA should be willing to help train private sector staff in critical skill areas to ensure that capabilities are built in where needed.
- *Establish an Independent Safety Assurance Office.* The ISAO should be an entity separate and apart from both NASA and the Shuttle operational contractor. The ISAO should remain insulated from subjective performance evaluations and other factors that could deter independence. NASA should evaluate federally funded research and development center (FFRDC) and Employee Stock Ownership Plan (ESOP) formulations as preferred governance structures for the ISAO.
- *Establish a "Three-Key CoFR" process in which NASA, the ISAO, and the operational contractor share Shuttle operational authority.* This new process should be designed to ensure a partnership aimed at joint problem resolution while requiring consensus prior to launch.

Human Resources

People have been the Shuttle program's greatest assets and NASA should ensure that competitive sourcing options preserve the workforce's ability to contribute to the program and transition to programs that are professionally challenging. It is essential that human resource planning begin early. To begin the process, NASA should:

- *Form a "transition team" to clarify personnel and skills essential to Shuttle operations.* The transition team should include representatives from the Office of Space Flight and the Office of Human Resources and

Education. This team should prepare a time-phased profile for transferring Shuttle operational functions along with a plan for ensuring the transition of appropriate personnel to the private sector. A future staffing target should be established reflecting the minimum number of NASA personnel and skills needed to provide operational oversight of the program. To the greatest extent possible, this team should incorporate plans for the design and operation of future launch systems with the express goal of minimizing NASA operational staffing.

Liability

The Task Force has stated that the private sector can successfully take a leadership role in Shuttle operations, reaching an inevitable point at which government oversight of human space transportation is minimal. The first step requires that private firms be given operational authority. Commensurate with this authority is the responsibility of operating the Shuttle system with the greatest care. Some degree of liability should be borne by the private sector in keeping with this new operational authority and NASA should:

- *Include in competitive sourcing a "shared liability" strategy where the operational contractor participates in the financial risk of Shuttle operations.* Further analysis is required, but a notional level of first-party liability should be set at $250 million for damages per orbiter with the government indemnifying above this amount. Private industry should be allowed to either self-insure or purchase insurance. If the operational contractor elects to purchase insurance, clauses should be so designed as to require recovery of a set number of prior premiums in the event of damage/loss.

Operational Emphasis

As NASA transitions the Shuttle program to a competitive sourcing regime, emphasis must be placed on reducing R&D activities associated with the system—the system must be "operationalized" to the greatest extent practical. At the same time, activities currently under way to ensure that the Shuttle system remains safe must be completed, and future projects to deal with aging infrastructure and safety modifications should be thoroughly evaluated. To monitor the many aspects associated with making the Shuttle program more operational in nature, NASA should:

- *Create a Terms of Reference for common use of the terms associated with Shuttle upgrades.* This includes such terms as preplanned product

improvement (P3I), sustaining engineering, obsolescence, safety upgrades, supportability improvements, depot maintenance, plant maintenance, and facility revitalization. These definitions should be condensed wherever possible and budget lines reflecting the final set of definitions should be clearly identified.

- *Prepare a long-term budget based on a comprehensive review of required Shuttle modifications.* Budget plans should be formulated based on alignment of costs into the various categories defined above. Evaluate the impact of alternative program termination dates on necessary Shuttle investments. Assess the value of planned safety improvements using quantitative risk management techniques. Rank order proposed investments in SSP improvements in terms of their ability to reduce risk, improve performance, and reduce cost. Consider termination of engineering modifications to the STS unless quantitative benefits can be clearly demonstrated.

ACKNOWLEDGMENTS

This analysis of the Space Shuttle program required extensive interaction with government and industry leaders, as well as employees involved in day-to-day planning and operations. At no point during Task Force deliberations did members receive anything less than the full and open cooperation and support of NASA and the community of contractors. For that support, and for the encouragement offered, the Task Force is deeply grateful.

Task Force members began this research with visits to key installations. These exchanges built a solid foundation for more detailed assessments and were vital to the successful completion of this report. The Task Force appreciates the open door policy we found at NASA field centers and corporate Shuttle facilities. The Task Force also benefited greatly by the many detailed briefings generously provided by members of the aerospace community with an interest in the future of the Space Shuttle program.

The Task Force also wishes to thank the many members of the RAND staff who labored to prepare numerous quantitative analyses on very tight schedules, and who provided major assistance in the preparation of this report.

ABBREVIATIONS

AA	Associate Administrator
ASAP	Aerospace Safety Advisory Panel
B&P	Bid and Proposal
BLI	Budget line item
BMAR	Backlog of maintenance and repair
BMD	Ballistic missile defense
CLCS	Check-out and Launch Control System
CoFR	Certification of Flight Readiness
CRV	Current replacement value
CSLAA	Commercial Space Launch Activities Act of 1995
CSRS	Civil Service Retirement System
DoD	Department of Defense
DOE	Department of Energy
DFRC	Dryden Flight Research Center
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
ESOP	Employee Stock Ownership Plan
ET	External tank
FACS	Financial and Contractual Status
FERS	Federal Employees Retirement System
FFRDC	Federally funded research and development center
FRR	Flight Readiness Review
FTE	Full-time equivalent
GSFC	Goddard Space Flight Center
HEDS	Human Exploration and Development of Space
HSF	Human Space Flight

IRR	Internal Rate of Return
ISAO	Independent Safety Assurance Office
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
LEO	Low-earth orbit
LIM	Launch Integrator Manager
LLC	Life cycle cost
MAF	Michoud Assembly Facility
MEO	Most effective organization
MLP	Mobile Launch Platform
MSFC	Marshall Space Flight Center
NAPA	National Academy of Public Administration
NASA	National Aeronautics and Space Administration
NPG	NASA Program Guideline
NPPS	NASA Personnel/Payroll System
NSF	National Science Foundation
OMB	Office of Management and Budget
OPM	Office of Personnel Management
OSF	Office of Space Flight
OSMA	Office of Safety and Mission Assurance
OSTP	Office of Science and Technology Policy (White House)
OTA	Other transaction authority
PM	[Space Shuttle] Program Manager
PPI	Preplanned Product Improvement
R&D	Research and development
R&PM	Research and Program Management
R&QA	Reliability and Quality Assurance
RIF	Reduction in force
RLV	Reusable Launch Vehicle

RSRM	Reusable solid rocket motor
S&TPI	Science and Technology Policy Institute
SCRAM	Safety Control Rod Axe Man
SMA	Safety and Mission Assurance
SFOC	Space Flight Operations Contract
SLI	Space Launch Initiative
SPO	Shuttle Program Office
SRB	Solid rocket booster
SSME	Space Shuttle main engine
SSP	Space Shuttle Program
SRM	Solid rocket motor
SSC	Stennis Space Center
STS	Space Transportation System
TSP	Thrift Savings Plan
USA	United Space Alliance
U.S.C.	United States Code
VAB	Vehicle Assembly Building
WSTF	White Sands Test Facility