International Space Station Operations Architecture Study

Final Report

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By

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Through

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CSC

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Preface

This report was prepared by the International Space Station (ISS) Operations Architecture Study Team. Computer Sciences Corporation (CSC) formed the team in response to a Request for Proposal (RFP) from the National Aeronautics and Space Administration (NASA). The Study Team consists of 23 members, 14 of whom acted as Lead or Core members, responsible for managing and producing the report. The remaining Expert members took part in discussions related to their areas of expertise; they also helped Lead/Core members write the report or served as independent reviewers. Appendix B contains biographical sketches of all team members.

To keep attracting the best researchers, foster commercial opportunities, and operate the ISS efficiently, NASA asked the National Research Council (NRC) and others to study the long-term utilization and operation of the ISS. These studies include the NRC report on *Institutional Arrangements for Space Station Research* (Reference 1), which recommended a utilization approach that uses a Space Station Utilization and Research Institute (SSURI) to manage ISS research in a manner similar to that used for the Hubble and Chandra telescopes. The NRC also made operational recommendations in their report on *Engineering Challenges to the Long-Term Operation of the International Space Station* (Reference 2), which urged improvements in assembly elements, increased funding for preplanned program improvements, and more focus on sustaining engineering practices. NASA also chartered a study on *Options for Managing Space Station Utilization* (Reference 3) that discussed various forms of SSURIs that NASA could apply to ISS research. The Study Team has considered these forms and has included selected derivatives in the options it evaluated. Finally, NASA itself has conducted several studies on the feasibility of commercializing the ISS (References 4-6). These internal studies have largely examined ways to establish a low-Earth-orbit marketplace and economy dominated by the private sector and to begin the transition to private investment in order to offset the operations costs of the Space Shuttle and the ISS.

Keeping in mind many of the issues contained in the above-cited studies, NASA awarded a General Services Administration (GSA) Management, Organizational and Business Improvement Services (MOBIS) contract to CSC in January 2000 to study and develop an operations architecture and an acquisition strategy to implement that architecture. Originally, NASA was to provide a family of possible architectures for the contractor to review and evaluate. In an April 2000 revision to the original tasking, NASA opted to have the Study Team develop and evaluate a family of options (see Appendix A). The revised tasking is as follows:

- "**Study team formation and clearances**. The contractor shall assemble a team of experts in space flight operations, to include launch site flight hardware processing, and space-based research. The team, as a whole, shall have prior experience with: Space Shuttle and Space Station operations, and space research; experience with non-governmental organizations (NGOs) and/or government corporations; and experience with commercial space enterprises. Experience with corporate re-engineering also desired. Team members will be screened by the contractor to determine that no conflict of interest currently exists, which might bias study results. The results of the screening will be provided to NASA."

- **"Development and assessment of possible ISS operations architectures**. The contractor shall develop possible ISS operations architectures that consider both recent National Research Council (NRC) recommendations related to ISS research structures and additional guidance provided by the OSF. The contractor shall assess the possible architectures to determine the architecture most likely to achieve OSF and Agency strategic plans. The term 'architecture' as used herein is defined as an integrated organizational structure for space operations and research on-orbit wherein all components are described in terms of roles, responsibilities, contractual relationships, and regulatory or policy authority."

- **"Cost-benefit analysis**. The contractor shall provide a cost and benefit analysis for the recommended architecture, using a NASA-provided estimate for ISS operations costs as a comparator."
- "**Acquisition strategy development**. The contractor shall recommend an acquisition strategy for the recommended architecture to be used as a guide for the implementation of the architecture. The strategy shall address any changes required to the existing ISS and Agency operations contracts structure, and a practical timetable for the implementation of the recommended architecture. The strategy shall also address: the impact of the architecture on the ISS international partners; requirements for legislative action prior to implementation; liability issues that must be addressed prior to implementation; public safely issues arising from new or modified NGO or contractor relationships with the government; and approaches to guarantee an adequate level of government expertise in space flight operations."

The team gathered information for this report during visits to NASA Headquarters, Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), and Kennedy Space Center (KSC). After each information-gathering session, the team met in closed sessions to further develop the report. The basic parts of this report discuss the

- Findings and recommendations developed throughout the study (Section 1)
- Operations architectures developed by the team (Section 2)
- Evaluations of candidate architectures and cost-benefit analysis of the recommended architecture (Section 3)
- Acquisition strategy to bring about an orderly phasing of the implementation (Section 4)

The Study Team thanks the many NASA and contractor participants who provided data, briefing materials, and extended discussions and advice. Each NASA organization gave the team key staff members to prepare briefings, answer many questions, and ensure outstanding physical accommodations and administrative support at each stop along the way. Appendix D contains information on the briefings the team received at the various NASA centers. In addition, special thanks go to the following individual leaders for their time, resource commitments, and guidance provided to the Study Team:

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  - Gary Jahns

Preface References

1. National Research Council (Space Studies Board and Aeronautics and Space Engineering Board), *Institutional Arrangements for Space Station Research,* Washington, DC: National Academy Press, 1999

2. National Research Council (Aeronautics and Space Engineering Board and Commission on Engineering and Technical Systems), *Engineering Challenges to the Long-Term Operation of the International Space Station,* Washington, DC: National Academy Press, 2000

3. Swales Aerospace, *Options for Managing Space Station Utilization*, Beltsville, MD: October 1999

4. National Aeronautics and Space Administration (NASA), *Economic Development of the International Space Station*, paper presented by Mark Uhran at the Space Technology and Applications International Forum (STAIF-2000), Albuquerque, NM, February 2000

5. NASA, *Commercial Development Plan for the International Space Station* (Internal NASA document), Washington, DC, November 16, 1998

6. NASA, Report to Congress on “Opportunities for Commercial Providers on the International Space Station,” Washington, DC, May 1999

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Executive Summary

Overview

The International Space Station (ISS) Operations Architecture Study Team has devised a recommended "operations architecture" for United States (U.S.) use during the Operations phase of the ISS program. This architecture, termed the Center Expertise option, proposes a contract framework with a National Aeronautics and Space Administration (NASA) Field Center-based program structure founded on center-specific expertise. The strong institutional base of each NASA center is called on to manage the work delegated to it by the ISS Program Office (ISSPO). This approach recognizes the strength of the specific NASA institution, helps maintain critical human spaceflight institutional expertise, and reduces contract costs by taking advantage both of competitive contracting and use of local rates.

The Study Team shares NASA's belief that the goal of the Operations phase of the ISS program is to perform world-class research that benefits the citizens and develops the economies of the member countries. This report addresses the NASA responsibility to bring utilization benefits that are commensurate with the investments made in the program. To focus more sharply on that goal, the team's recommended architecture also establishes a Space Station Utilization and Research Institute (SSURI) to be procured through a new ISSPO contract. The SSURI, in turn, establishes a single top-to-bottom Utilization Operations function that, subject to contract limitations, performs the U.S. research and selection processes, manages the research interface to the ISS program, communicates the benefits of ISS research, and implements Utilization Operations services for the program. Because the ISSPO is heavily involved with the assembly of the ISS, and will be for the next 5 years, the SSURI acquisition is phased in a slow, deliberate manner to foster its growth in stages, thereby ensuring that the program and the new SSURI would grow in a safe, compatible manner. Section 4 covers the phasing steps.

ISS Program Background

Design and development of the ISS has proceeded since the mid-1980s, and redesigns have occurred when needed to meet NASA's objectives. The current design has been in production for several years, and its first components are already in orbit. Much of the U.S. hardware has been delivered to NASA's Kennedy Space Center (KSC) for final acceptance and flight preparation. At the same time, agreements with the international partners have grown and evolved. Using International Memorandums of Understanding, NASA has formed a partnership with the European Space Agency (ESA), the National Space Development Agency of Japan (NASDA), the Canadian Space Agency (CSA), and the Russian Space Agency (RSA). In addition, the U.S. has entered into similar bilateral relationships with Italy and Brazil using subcontract-like agreements.

As more ISS elements are successfully assembled, the daily focus is shifting from Assembly to Utilization and Operations. The Utilization focus is to perform the best research possible over a wide range of scientific and engineering disciplines, while simultaneously providing a productive environment and a real opportunity for commercial development. The Operations focus during this era is to operate the ISS safely and efficiently so as to provide enhanced ongoing research utilization and meet the needs of the utilization community. Operations-phase responsibilities include visits to the ISS by the Space Shuttle and other transportation systems to

- Resupply/return consumables and research components
- Remove and replace failed or degraded ISS components
- Redesign or improve selected functional capabilities

- Exchange crews
- Reboost the station

Finally, flight crews and ground-based operators will manage ISS systems to optimize the research capability.

To achieve such world-class research, the international partners must attract the best investigators and furnish the resources needed. The resources consumed in conducting any research activity include crew time, power, storage volume, heat rejection, microgravity levels, and data-transmission bandwidth. Both the Utilization and the Operations communities have developed initial plans and processes to help manage the overall resource allocations that are available to each partner for each stage of construction and for the operational ISS.

The Architecture Options Developed and Evaluated by the Team

The Study Team looked at the two major ISS functions of

- Utilization
- Operations and Maintenance

Early on, the team further defined the Operations and Maintenance function into six other primary functions:

- Program Management
- Flight Systems Operations
- Logistics and Maintenance Operations
- Launch Site Operations
- Safety Operations
- Sustaining Engineering and Pre-Planned Program Improvement (P3I)

Study Team deliberations then produced five architecture options whose features are summarized as follows:

1. ***Program Evolution.*** This option essentially continues the current approach. It assumes significant NASA personnel participation, control via a Lead Center, and expanded support by existing or similar contractors to cover ISS Operations. (Consolidation of contract support into a single contractor is allowed.) To accomplish this option, NASA must maintain adequate numbers of skilled personnel to manage ISS Utilization activities. This option is included in this evaluation primarily because it is the basis of the current program cost estimates and is, therefore, the point of departure for comparison with the other options. It is also considered a viable option by many NASA personnel.

2. ***Center Expertise.*** This option creates a SSURI to which management of the U.S. ISS Utilization would be contracted from the ISS program. The SSURI is anticipated to be a consortium of research and commercial institutions that supports the broader investigative community in the conduct of research aboard the ISS and manages the implementation of that research. This option also "partitions" and assigns responsibility for the remaining U.S. ISS Operations and Maintenance functions according to NASA Field Center expertise using direct civil servant involvement. As with the Program Evolution option, this civil service involvement

maintains the NASA expertise and ensures the availability of this skill base when needed to resolve major issues. Further, it allows synergistic consolidation of functions and contracts consistent with center responsibilities and assignments. Finally, the expectation is that by partitioning contracts and responsibilities as described in this option, the potential for vigorous competition will exist through the life of the ISS.

3. ***Single Prime.*** This option is similar to the Center Expertise option, but it differs in that it consolidates all of the Operations and Maintenance contracted support under one contract. It would also reduce NASA personnel participation in the major program implementation functions to one of surveillance and audit, i.e., to a role of "insight."[1] This is similar to the approach used by the Space Shuttle program with the Space Flight Operations Contract (SFOC). Synergism with other programs is encouraged but not at the expense of losing internal program synergism. The prime contractor performs all technical Operations and Maintenance support integration. Utilization Operations management is vested within the SSURI, as in the Center Expertise option.

4. ***Privatized SSURI Prime.*** This option is a modification of the Single Prime option to attach the Single Prime contract to the SSURI. It therefore places Operations and Maintenance contractor support and Utilization Operations under the SSURI. The SSURI would be responsible for these functions through a contract to the program. NASA personnel participation in the major program implementation functions would be reduced to one of surveillance and audit, i.e., to a role of "insight." NASA would retain the Program Management function.

5. ***Dedicated Commercial.*** This option assumes that the U.S. segment of and interests in the ISS are obtained by a commercial entity that operates and maintains the station. The commercial activity is "profit seeking," entirely in support of company objectives. Operation would be independent of NASA, except as a customer. Utilization management would be performed by the commercial entity in whatever fashion deemed appropriate. International partners may be involved in the operation through commercial interests within their own countries or through direct government arrangements with the U.S. commercial entity.

The Recommended Architecture: Center Expertise Option

Study Team members understand the complexity and size of the ISS program's technical undertaking, and believe that NASA and the international partners will succeed in making the station a reality that benefits all people. The Study Team also believes that the overall complexity remains a real concern for the foreseeable future, during both the Assembly and Operations phases. The following four factors significantly influenced the recommendations in this report:

- **Complexity of the ISS.** The station's technical complexity is enormous. It involves difficult designs, delicate negotiations across many international borders, and an intricate assembly process. These characteristics require a strong management organization to control a complex engineering activity that must be operationally successful. This complexity, in turn, drives the requirement for a mature Program Management organization supported by a strong Sustaining Engineering base.

[1] "Insight" refers to a reduced level of NASA participation in the day-to-day activities of the program operations as compared to "Oversight." It typically means that NASA personnel monitor the ongoing activity to ensure compliance with approved processes but that contractors plan and perform all aspects of the operation. NASA personnel are expected to support certain types of problem analysis and resolution, such as out-of-family system failures. "Oversight" refers to in-depth NASA participation and, in some cases, accountability for planning and conduct of the operation.

- **Research Purpose of the ISS.** The purpose is to achieve outstanding research results from scientific and commercial research in space. The main success criterion is the benefit derived from the research. The research itself is conducted over many technical disciplines, and performing this research makes heavy demands on all the resources available on orbit. Of particular concern is that the program's emphasis on the complexity could overshadow a reasonable emphasis on the research to be conducted, that is, the purpose of the ISS. For this reason, the Study Team recommends the establishment of a strong SSURI charged with the broad responsibility of managing the research utilization of the ISS. The SSURI must have sufficient stature within the research community to provide this community with a sense of "ownership" and sufficient authority within the NASA hierarchy to effect changes that promote the execution of the highest possible caliber of research.

- **Complexity of the Operations.** ISS program operations requires extensive Flight Systems Operations and Maintenance activities, performed by many international partners, using a diverse set of transportation systems to maintain and support the orbiting infrastructure. This requirement, in turn, calls for a team of experts to plan and design the steps and processes to make it work. These complexities again pointed to the need for a strong Program Management function and also supported the need for a clear-sighted Utilization Operations organization to manage the demands on the overall operation.

- **Inherent Government Functions.** The complexity of the program and its operations; the need to protect international investments and safety; and the need to properly honor the international relationships drove the Study Team to conclude that, for the foreseeable future, strong government involvement in the ISS must continue. The government must continue to serve as a steward to protect U.S. investments by ensuring that the entire venture is safe, productive, and achieved in a fair manner at a reasonable cost.

With these thoughts as background, the Study Team devised and then evaluated the candidate operational architectures described earlier. The team recommends the Center Expertise architecture option as the best suited to meet NASA's needs during the ISS Operations phase. See Figure ES-1.

The Center Expertise option includes the following primary elements:

- A SSURI, an institute/consortium contracted by the ISSPO and located in the U.S., to manage ISS Utilization activities from management through implementation; ISS program-level functions to be located at or near JSC and implementation-level activities to be located at or near NASA Field Centers

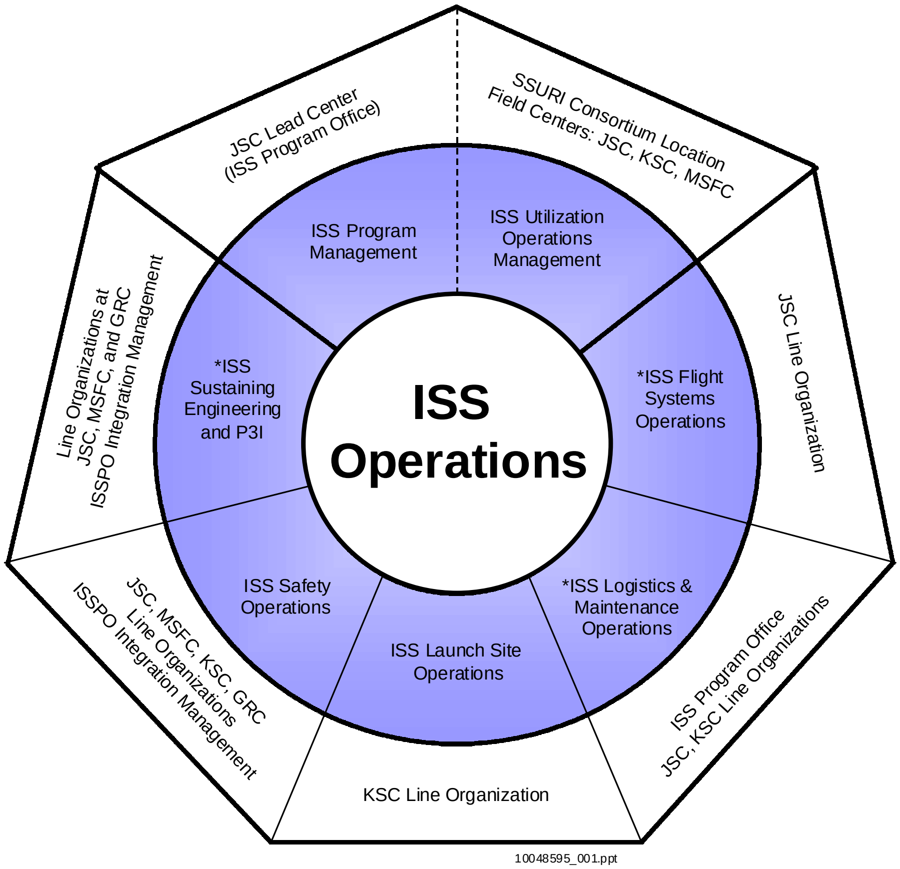
- A Lead Center Program Office at Johnson Space Center (JSC) to manage requirements, policy, and program planning and to provide programmatic oversight of Support Center functions located at NASA Field Centers

- ISSPO Support Centers to locally manage the delegated operations and maintenance functions:

  – At JSC, Sustaining Engineering, logistics engineering, logistics on-orbit operations, ISS Flight Systems Operations, cargo integration, and Pre-Planned Program Improvement (P3I) of the ISS Assembly

  – At KSC, Launch Site Operations and Logistics ground storage and Maintenance Operations

  – At Marshall Space Flight Center (MSFC) and Glenn Research Center (GRC), Sustaining Engineering and P3I for facility-class payloads



*The Logistics and Maintenance Operations function is performed by the ISSPO with support from Flight System Operations and Sustaining Engineering and P3I. Unit storage, preparation for launch, and refurbishment to specifications are Logistics and Maintenance Operations activities located at KSC.

Figure ES-1. Center Expertise Option—Function Assignments

- SSURI Support Centers to locally manage the Utilization functions delegated by the SSURI:
  - At MSFC, payload operation planning and payload operations
  - At KSC, payload physical integration support
  - At the SSURI consortium location, Utilization Operations management
  - At JSC, program-level payload planning integration and payload training support
- Implementation of contract procurement at the designated centers to support the functions delegated to the centers through the SSURI or the ISSPO

The recommended architecture allows eventual phaseover to a more "privatized" format that would result in more of the work being contracted in an attempt to release NASA personnel for other activities. The ISS Operations and Maintenance and the Utilization activities and processes would need to be stable and contractor capability would have to be demonstrated before such a transition; however, in addition, certain Safety Operations and Sustaining Engineering and P3I functions would not be candidates for a general competition. Specific items to be contracted could either follow the Single Prime option or the Privatized SSURI Prime option models. Finally, actual phaseover plans must consider impact to international partner interests and the U.S. commitments to them.

Evaluation of the Architecture Options

To better understand the advantages and disadvantages of each option, the Study Team used two methods to evaluate the options:

- A Delphi evaluation of the ability of the option to satisfy the Human Exploration and Development of Space (HEDS) Strategic Plans
- A Risk Assessment approach that considers potential risks to the ISS program, risks based on the architecture's ability to transition and function successfully

For the recommended options, a traditional Cost-Benefit Analysis (CBA) was performed.

HEDS Evaluation. The Study Team used a Delphi evaluation to rate the ability of each option to satisfy each of the HEDS Strategic Plans. For each strategic plan, the team developed a perfect-score model; then using a 1-to-7 scale, where 7 is the best score, the team assigned values for each option for each goal. NASA furnished weightings to be used for each plan. The weighted scores were then summed for each option.

Table ES-1 presents the scores. The Center Expertise option was a strong winner for the model to use during the first half of the program. It scores well across all categories, may also produce real cost benefits over time, and keeps a strong NASA presence during the early Operations years. Phasing to a more contracted approach for the later years of the program could use either the Single Prime or the Privatized SSURI Prime option; the variable is the extent of necessary NASA personnel participation and the stability of the overall program activities.

Table ES-1. Architecture Option Evaluation Scores Based on Ability To Meet HEDS Strategic Plans

HEDS Strategic Plan Goal	Option Name				
	Program Evolution	Center Expertise	Single Prime	Privatized SSURI Prime	Dedicated Commercial
Enable Humans To Live and Work Safely in Space	1.88	2.10	1.50	1.20	0.68
Facilitate the Expansion of Scientific Knowledge	1.20	2.10	2.10	2.10	0.30
Foster the Commercial Development of Space	0.70	0.90	0.90	0.90	1.30
Facilitate the Exploration of the Space Frontier	0.40	0.40	0.40	0.40	0.10
Foster Sharing the Experience and Benefits of Discovery	0.25	0.70	0.40	0.70	0.10
Summary	**4.58**	**6.20**	**5.60**	**5.30**	**2.48**

Risk Assessment. The team also developed a Risk Assessment to further understand the ability of the options to be implemented successfully with the least amount of program risk. The team assessed each option in terms of its impact on safety, research, cost, schedule, operations, and the international partners. Table ES-2 contains the assessment results. The Center Expertise option, along with the Program Evolution option, was assessed to have the lowest risk of the five options evaluated. This result implies that the Center Expertise option would be the easiest to move toward successfully. The Single Prime and the Privatized SSURI Prime options reflect the reduction of NASA hands-on control. A subsequent move toward either the Single Prime or the Privatized SSURI Prime option would be made easier by implementing the Center Expertise option now.

Table ES-2. Risk-Assessment Summary by Factor

Risk Parameter	Option Name				
	Program Evolution	**Center Expertise**	**Single Prime**	**Privatized SSURI Prime**	**Dedicated Commercial**
Safety	Very low	Low	Low	Moderate to low	Moderate to high
Research	Moderate	Low	Low	Very low	Moderate to high
Cost	Moderate	Low to moderate	Low to moderate	Low to moderate	Low
Schedule	Moderate	Very low	Low	Low	Moderate
Operations	Low	Very low	Low	Moderate	Moderate to high
International Partner	Low	Low to moderate	Moderate	Moderate	Moderate to high
Composite	**Low to moderate**	**Low to moderate**	**Moderate to low**	**Moderate**	**Moderate to high**

CBA. Clearly, tangible costs associated with establishing the Center Expertise option will occur early in the ISS program, whereas tangible benefits will be difficult to estimate until after implementation. Furthermore, many of the benefits will be intangible, for example, a greater acceptance of and participation in the ISS program by the scientific community and commercial organizations, resulting in high-quality research. These intangible benefits will eventually manifest themselves as tangible benefits and cost savings/avoidances, but it will take several years before the benefits/savings can be quantified. Table ES-3 shows the high-level CBA results.

Table ES-3. Summary of CBA Results (Annual) for the Center Expertise Option

Consideration	Cost		Benefit	
	Tangible	**Intangible**	**Tangible**	**Intangible**
Implement Center Expertise Option—Create SSURI	■ New SSURI organization $10 to 40.0M/year ■ New SSURI facilities $2.5 M/year	■ Work force morale ■ “Just more overhead” ■ Program vs. Research competition	■ Customer-Supplier relationship should reduce program-wide costs, e.g., standardized selection and integration could save $25 to $100 M/year	■ Highest quality and/or quantity of research ■ Improved outreach satisfaction ■ Increase in research funding sources
Implement Center Expertise Option	■ New distributed ISSPO organization	■ Increased management complexity	■ Contract competition savings of about $25 M/year ■ Synergy with other similar functions at each Field Center	■ Local tailoring of Field Center contracts (increase in productivity) ■ Field Center “ownership” in the program

Costs of creating the SSURI are clearly near term and tangible, for example, new facilities, additional people, and procurement costs. Some early tangible benefits should arise from competitive pricing. The Study Team foresees that the Customer-Supplier relationship of the SSURI and the ISSPO would mutually develop more streamlined processes, which would also yield tangible benefits. NASA’s response to the Study Team’s challenge to find ways to reduce the length of the payload integration templates from 3 years to 1 year for defined classes of payloads is a small indicator of how the relationship should work.

Acquisition Strategy for the Recommended Architecture

The acquisition strategy focuses on forming the SSURI consortium by the end of 2001 and putting the full Center Expertise option in place shortly after Assembly Complete. This timing allows the SSURI, the new utilization function, to grow in deliberate steps over 3 to 4 years before causing major changes to the ISSPO Operations and Maintenance functions. The growth is defined in steps—with each step described, goals identified, and success measures specified to pace and manage the growth. As a function contracted from the ISSPO, the full-form SSURI would be a top-to-bottom integrated Utilization organization for the program. It would plan and implement the utilization of proposals selected by NASA Headquarters; oversee hardware development; provide the interface to the program for all payloads; serve as a research advocate; assist the Principal Investigators (PIs); negotiate the international process; and assist researchers by providing data, analyses, models, and the like to the ISSPO. In addition, the SSURI would work with the ISSPO to expedite decisions, find ways to streamline the payload integration processes, manage the Utilization Operations functions, serve as an archive of research information, and funnel research results to the utilization community. Table ES-4 characterizes the growth of the Center Expertise architecture option and the gradual shift to the Privatized architecture. It also depicts the architecture growth and evolution.

Table ES-4. Growth and Evolution of the Recommended Architecture

Function	ISS Program Phase			
	Current 2000	Assembly Phase 2000-2005	Stable Operations 2006-2010	Mature Operations 2011-2015
Program Management	Centralized Program and Projects	Transition to Centralized Program and Distributed Projects	Centralized Program and Distributed Projects	TBD: Based on need selected from options family included in report.
Utilization Operations	Managed by Program Office	Transition to SSURI	SSURI Project	
Flight Systems Operations	JSC Program Support (Line Organization)	Transition to JSC Line Organization Project	JSC Line Organization Project	
Logistics and Maintenance Operations	Program Office	Transition to JSC and KSC Line Organizations	JSC and KSC Line Organization Projects	
Launch Site Operations	KSC Program Support (Line Organization)	Transition to KSC Line Organization Project	KSC Line Organization Project	
Safety Operations	Program Office, Center Safety Offices	Program Office, Center Safety Offices	Program Office, Center Safety Offices	
Sustaining Engineering/P3I	Program Office	Transition to JSC Line Organization Project	JSC Line Organization Project	

As the ISS matures and operations become more stable, the recommended architecture should be adjusted to become a more "privatized" program. The Study Team does not recommend that a fully "privatized" option be implemented, but it encourages NASA to develop a more privatized approach that allows civil service personnel to transition to new development activities where appropriate. The options developed for this report should offer NASA enough flexibility to evolve to whatever best suits the needs in the FY 2010 timeframe and beyond.

Study Team

The ISS Study Team consists of former NASA, academic, and industry personnel with broad experience and expertise in space utilization and large, human spaceflight program management. The team was divided into Lead/Core members responsible for developing the actual report and Expert members who helped Lead/Core members and/or served as Expert reviewers. Short biographies of all team members appear in Appendix B.

Section 1. Introduction and General Findings

1.1 Overview

This section explains the

- Background of the International Space Station (ISS) Operations Architecture Study
- Guidance provided by the National Aeronautics and Space Administration (NASA) for the study
- Information-gathering methodology
- Findings and recommendations (and some observations and suggestions) that came out of the Study Team's deliberations

NASA asked the ISS Operations Architecture Study Team to develop and evaluate potential ISS "operations architectures." NASA has described the operations architecture as an integrated organizational structure for space operations and research on-orbit wherein all components are described in terms of roles, responsibilities, contractual relationships, and regulatory or policy authority.

NASA required each architecture to address the Utilization and Operations and Maintenance functions for the Operations phase of the ISS program. The scope of the effort was to include a "non-governmental organization" (NGO) to manage the utilization research activities, a Lead Center to manage the program's Operations and Maintenance functions, and Support Centers to implement the programs. The infrastructure was to be supported by contractors. Architecture design guidance from NASA was to use the Human Exploration and Development of Space (HEDS) Strategic Plans. The team was also advised to (1) consult with the ISS Program Office (ISSPO) and ISS program supporting personnel at the major NASA Field Centers and (2) study and understand the concept of operations currently used to manage the Hubble Space Telescope.

The Study Team gathered information during a series of NASA site visits. The team held closed deliberations at each site to discuss the presentations, crystallize their thoughts on possible architectures, and design "homework" assignments for the next meeting. They also developed evaluation templates to examine each option under the same conditions. These templates used the HEDS Strategic Plans, a functional risk assessment methodology, and a traditional cost-benefit analysis of the recommended architecture option. Finally, the team devised an acquisition strategy for the recommended option.

1.2 Study Background

The Operations and Utilization architecture defined in the original Operations Task Force (OTF) report has served the Space Station program well (References 1 and 2). NASA requested this current study to find ways to improve the Operations and Utilization architecture by emphasizing a return on investment and an exploration of other successful models that were not available at the time of the OTF deliberations. The new models of interest are the operations of the Hubble Space Telescope Science Institute (STScI) and the Chandra Observatory. This is an opportune time to address the planned architecture because the uncertainties of program operation are diminishing as Assembly proceeds and the implementors are now working in the program.

The ISS is now being assembled on orbit. The size and complexity of the effort are enormous. The assembly flights are many, the logistics support is complicated, and the partnership of space-faring nations represents the greatest peacetime technical collaboration ever undertaken. The U.S. leads the partnership and contributes the largest number of space assets. Even so, the success of the venture is tied to the cooperation of all the international partners and the eventual results obtained from the research.

All international partners contribute parts of the on-orbit infrastructure and user accommodations that, by economic proportion, establish the allocation of total laboratory assets. The U.S. provides laboratory, habitation, and centrifuge modules (the centrifuge module was built by Japan and provided under a bilateral agreement); an airlock; a cupola; the nodes that connect the pressurized infrastructure; most of the non-Russian utilities and operating systems; the truss infrastructure that holds them in place; the logistics carriers [built by the Italian Space Agency (ASI) and provided under a bilateral agreement as part of the U.S. contribution]; and the transportation services for crews and logistics resupply during the Assembly phase. Russia provides the pressurized habitation and research space, the external support structures that hold the Russian systems and modules together, and the transportation services for crews and logistics resupply during the Assembly phase. Japan provides a laboratory; a pallet of external attach points; a manipulator arm to work with the installation and removal of external payloads; and a logistics module. The Europeans provide a pressurized laboratory module. Canada provides the large manipulator arm and the mobile servicing system used to assemble ISS elements.

All international partners contribute to an infrastructure that supports the Logistics and Maintenance and Operations resupply-and-return activities. Throughout the Operations phase, the U.S. furnishes Space Shuttle transportation services for flight crew exchanges and logistics/experiment-carrier exchange of research and operations support items. Russia provides similar services with the Progress and Soyuz vehicles. The U.S. and Russia supply the ability to return items to the Earth, as the other partner transporters are deorbited and burned during reentry or are returned in the Space Shuttle cargo bay. The Japanese and the Europeans provide logistics-carrier delivery to the ISS. Canada contributes robotic services to assist the external installation of transported cargo and support the capture and installation of the non-Space Shuttle-delivered carriers. Figure 1-1 depicts the international partners' orbiting assets.

During Assembly, the orbiting infrastructure gradually becomes more capable and more robust. A key milestone is reached when flight crews can permanently occupy the ISS. The initial occupation period leaves three crew members onboard, without Space Shuttle support, along with a Soyuz return vehicle for up to 3 months at a time. A crew of six can remain at the station once their habitation needs are met and the second Soyuz return vehicle is available onboard. Finally, a crew of seven can remain onboard once the U.S. Crew Return Vehicle (CRV) is delivered on orbit. Figure 1-2 shows the ISS Assembly sequence with its operational capability plateaus.

For onboard operations planning, crew time is considered a schedulable resource. Onboard activity consists of research, activities of daily living in space, maintenance and operations to care for the orbiting facility, and time to care for the health and well-being of the crew. All other supporting resources, such as rack volume, power, heat rejection, stowage volume, data system access, up-mass, and down-mass, are scheduled through a complex planning activity. That planning activity had its allocation "shares" established through the original agreement on infrastructure contributions contained in the Memorandums of Agreements across the partnership.[2] Figure 1-3 illustrates the utilization shares of the U.S. and its international partners. These shares are adjusted through bartering. The ISSPO "keeps the books" on these agreements and adjusts the allocations accordingly. In addition, the crew complement consists of citizens from the member countries in the same proportions.

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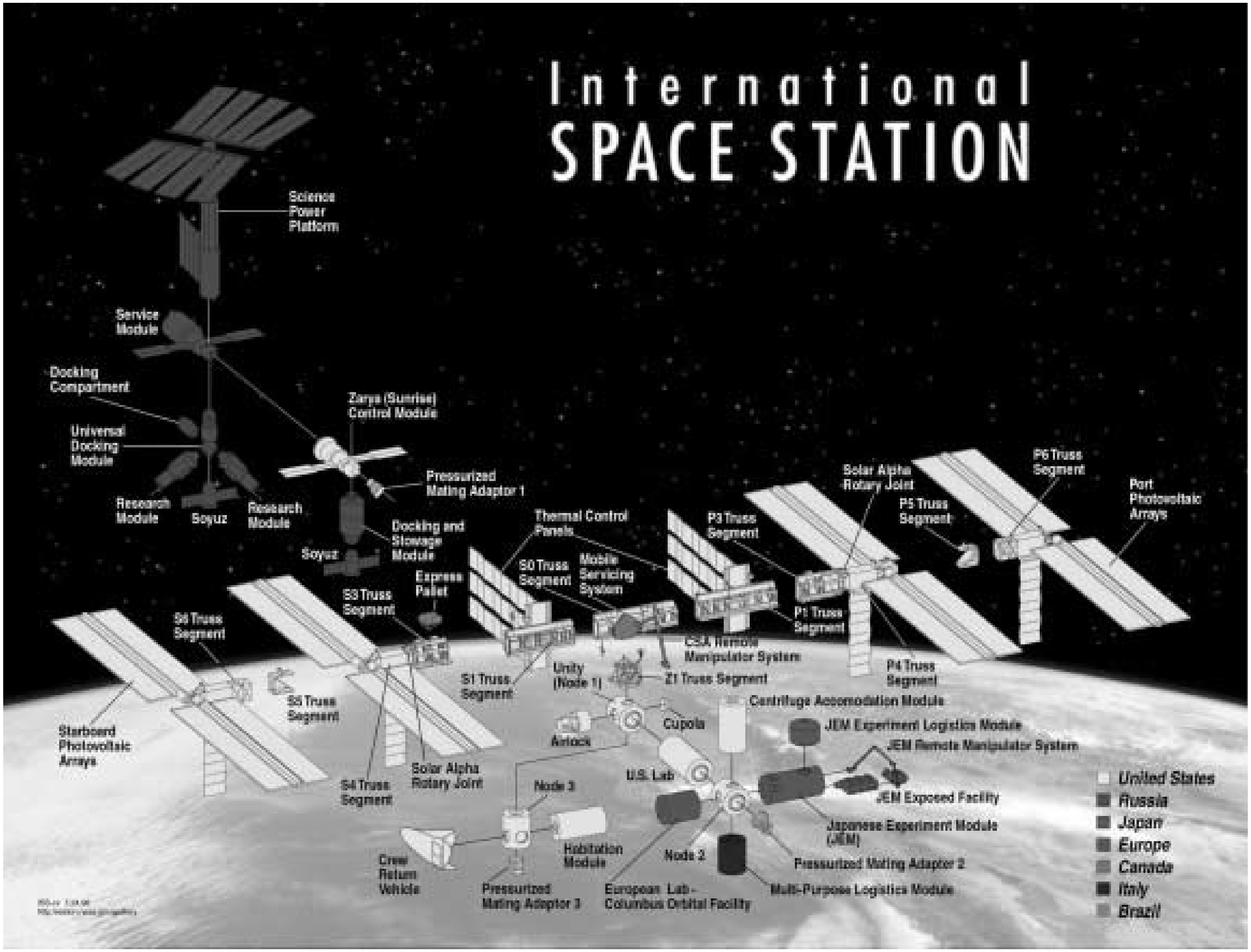
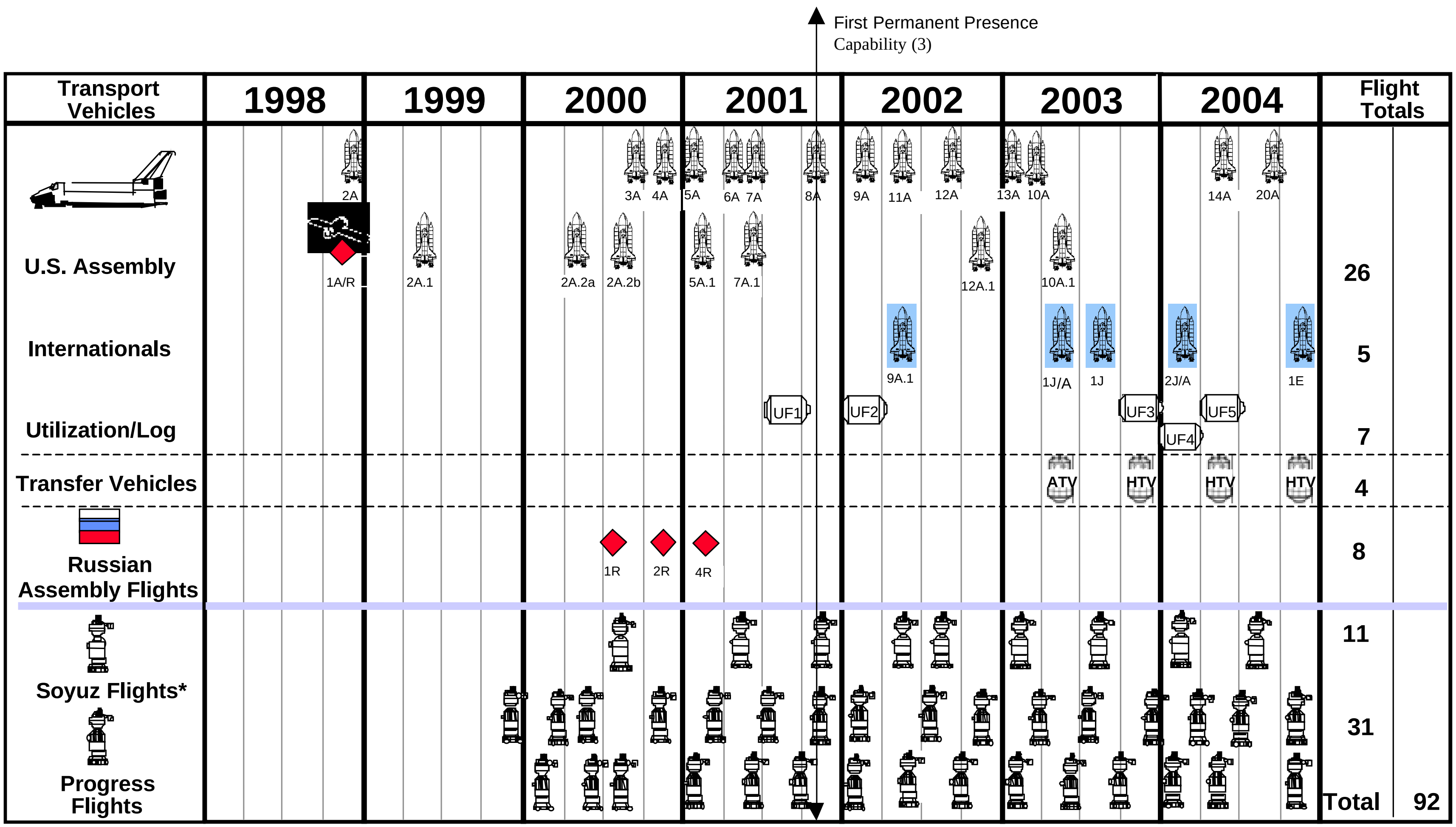
[2] In January, 1998, NASA Administrator Daniel Goldin signed three bilateral memorandums of understanding (MOUs) with his counterparts from the Russian Space Agency (RSA), the European Space Agency (ESA), and the Canadian Space Agency (CSA). A similar MOU was signed with the government of Japan in February 1998. These new agreements superseded previous agreements among the U.S., Europe, Canada, and Japan signed in 1988; they reflect changes to the ISS program resulting from significant Russian participation in the program and program design changes undertaken by the original partnership in 1993. [Source: NASA ISS Agreements Web Page]



Courtesy of NASA, 2000

Figure 1-1. International Partners' Orbiting Assets



* Soyuz flights do not include Soyuz modules launched on 1A/R and 1R.

Note: The Study Team prepared this report using Revision E of the Assembly sequence and its related Operations budget forecast.

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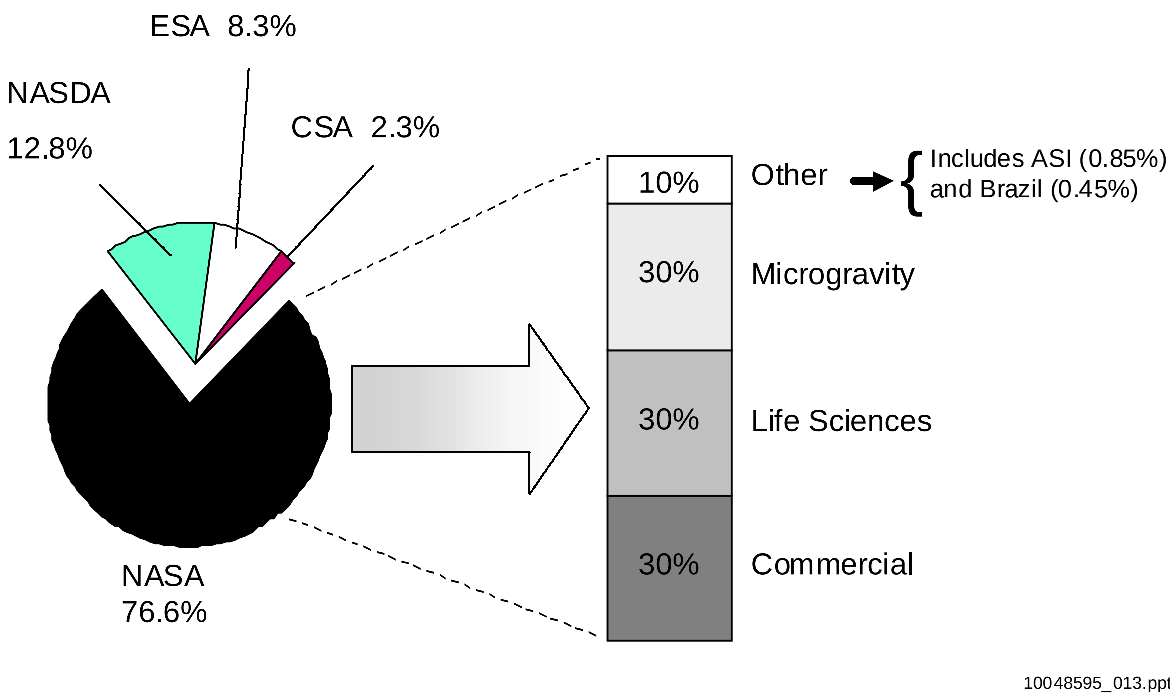
Figure 1-2. ISS Assembly Sequence With Operational Capability Plateaus

For the U.S., the partnership-level allocations are suballocated by discipline areas and are then further allocated to the actual research projects flown on a per-increment basis (time between successive Space Shuttle visits). All research allocations are bounded by the actual ISS resources available at any given time. Distribution of the international partner allocations is the responsibility of the partners. Total resource use is planned and monitored by both the operations and utilization communities to avoid exceeding the operational capability of the ISS.



NOTES: 1. International partner shares are based on mutually agreed-to MOUs between NASA and member nations.

2. NASA's allocation of its own shares is based on internal planning guidelines.

Figure 1-3. Utilization Shares Showing International Partner and U.S. Breakouts (Without Bartering)

The scope of this study is limited to the U.S. ISSPO roles and the research performed under the U.S. resource allocations. The Study Team believes that its recommendations are suitable for international-partner inclusion and encourages NASA to begin the necessary discussions with the partners to implement the broader interpretation of the recommendations. In addition, discussions on the commercial interests were limited by NASA to the activities of the Commercial Space Centers, and those discussions did not include the potentially large number of unsolicited-proposal areas of interest. The Study Team believes that much of this activity should also fall within the Space Station Utilization and Research Institute (SSURI) portfolio and that NASA should review this area for further participation by the SSURI.

1.3 NASA Guidance

A main criterion for evaluating the options was to determine the architecture most likely to achieve Office of Space Flight (OSF) and NASA Strategic Plans. The OSF and Agency Strategic Plans are themselves contained in the HEDS Strategic Plans. The Study Team based its evaluation of the architectures on the likelihood of an architecture to achieve the goals set forth in the HEDS Strategic Plans. Those goals seek to

- Enable Humans To Live and Work Safely in Space
- Facilitate the Expansion of Scientific Knowledge
- Foster the Commercial Development of Space
- Facilitate the Exploration of the Space Frontier
- Foster Sharing the Experience and Benefits of Discovery

Table 1-1 expands the definitions of each Strategic Plan goal.

Table 1-1. HEDS Strategic Plans: Goals and Definitions

Strategic Plan Title/Goal	Definition of Strategic Plan Goal
Enable Humans To Live and Work Safely in Space	■ Provide safe, affordable, and improved access to space ■ Operate the ISS to advance science, exploration, engineering, and commerce ■ Ensure the health, safety, and performance of humans living and working in space ■ Meet sustained space operations needs while reducing costs
Facilitate the Expansion of Scientific Knowledge	■ Investigate chemical, biological, and physical systems in the space environment, in partnership with the scientific community ■ Expand collaborative research on the ISS that will further human exploration of the solar system ■ Extend significantly scientific discovery on missions of exploration through the integrated use of human and machine capabilities
Foster the Commercial Development of Space	■ Improve the accessibility of space to meet the needs of commercial research and development ■ Foster commercial endeavors with the ISS and other assets
Facilitate the Exploration of the Space Frontier	■ Invest in the development of high-leverage technologies to enable safe, effective, and affordable human/robotic exploration ■ Conduct engineering and human health research on the ISS to enable exploration beyond Earth orbit
Foster Sharing the Experience and Benefits of Discovery	■ Engage and involve the public in the excitement and benefits of—and in setting goals for—the exploration and development of space ■ Advance the scientific, technological, and academic achievement of the nation by sharing our knowledge, capabilities, and assets

The Study Team used the detailed statements, where applicable, to assess each architecture option's ability to further advance the HEDS Strategic Plans. Team members estimated scores based on the perceived ability of the considered option to improve or degrade the current status of the ISSPO. Then, they developed a numeric scoring method to evaluate each HEDS statements that described each strategic plan. Values of 1 through 7 were assigned. Section 3, *Architecture Evaluations and Cost-Benefit Analysis for the Recommended Option*, contains the scores and the rationale for each value compared with the family of options. The Study Team also received guidance from the ISSPO, which is included here as Table 1-2 (Reference 3).

Table 1-2. Principles Required To Safely, Efficiently, and Effectively Manage the ISS

Principle Category	Principle Definition
General principles required to safely, effectively, and efficiently perform required functions	■ Safety must be an embedded part of the culture and management system. It is the lifeblood of the human spaceflight program. ■ The management system and architecture (MS&A) should be constructed in a way that provides the mechanism for the Program Office and its direct support to be a smart buyer. ■ The MS&A should be constructed such that strong checks and balances exist between the program office/direct program office support and contracting organizations for all critical budget and technical decisions. Profit margin should not motivate the final decision processes and authority. ■ A strong Sustaining Engineering function that is supported by an Engineering institution and augmented by a healthy P3I Program is necessary to maintain a safe and healthy long-term program. ■ Russian and Canadian elements and ground facilities are in the critical path and must be an integral part of the core operations. All international partners are an integral part of the safety management, resource management, and operations management. ■ The payload operations/core systems operations interface must be carefully defined and managed.
The resultant organization and architecture should cultivate and maintain these attributes	■ Accountability and responsibility should be tightly joined at all levels in the organization (individual and team accountability). ■ Individual and corporate rigor and discipline to do the job right, regardless of cost and schedule impact, is mandatory. ■ A constant pursuit of excellence and individual skills and experience must be pursued and honed; a constant refreshing of the workforce with appropriate skills is important. ■ A strong Systems Engineering function with adequate and thorough analysis with validated models is necessary. ■ A global team is key. Communications and sharing of data, concepts, and ideas across the team are mandatory. ■ Continual learning from close calls and outside sources (industry, academia, etc.) is mandatory. ■ The management system must be timely and responsive to problemsolving and customer needs.
Other safety-related recommendations	■ Contracts should not have cost-reduction incentives outside of normal cost-performance requirements. Additional cost contract incentives beyond normal expectations can encourage decisions that destabilize the program and increase its risk. ■ A stand-alone risk-management plan that levies requirements on contractors should be required. ■ An independent assessment of the effectiveness of safety-related processes should be required. ■ The ISSPO must ensure that the payload integration architecture meets program safety requirements; it must also ensure that SSURI processes that implement the program meet safety requirements.

1.4 Information-Gathering Methodology

The Study Team consists of members with broad experience in areas relevant to developing an operations architecture for the ISS. Short biographies of team members appear in Appendix B. The Study Team gathered information from the major ISS NASA Field Centers: Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), Kennedy Space Center (KSC), Ames Research Center (ARC), and Glenn Research Center (GRC); NASA Headquarters; the ISSPO; and the STScI. Team members also referred to such recent publications as *Engineering Challenges to the Long-Term Operation of the International Space Station*; *Institutional Arrangements for Space Station Research*; and *Options for Managing Space Station Utilization* (References 4-6).

Study Team visits yielded valuable data. Each center was asked to discuss its planned roles in the ISS for the Operations era. Each center also agreed to cover its own Utilization interests and to host presentations for utilization topics as needed by the team. During these visits, the ISSPO and a wide range of Utilization Operations organizations [including research program offices (RPOs), research institutes, and Commercial Space Centers] presented data to the team; that data defined their interests in the current and future architecture of the ISS. Appendix C contains agendas for these meetings.

After formal presentations and often-extensive follow-up discussions, the team worked in closed sessions to consolidate what they had learned and discuss the implications of candidate architectures. Architecture concepts emerged from these deliberations. Several follow-up sessions were incorporated to better understand the options' implications. These follow-up sessions included visits to the STScI, the JSC ISSPO, and NASA Headquarters, and they involved various Core Team members or primary authors of the report.

The major impetus in gathering information was to find a way to fit a SSURI either into the existing ISSPO infrastructure or into a new infrastructure that the team was asked to develop. At the midterm presentation, agreement was reached on which structure should be used by the team to connect the SSURI and the ISSPO. The Study Team then finished the larger total architecture picture with meaningful options.

Team members were impressed with the scope of the ISS program, the materials presented, and the expertise of the presenters. The team sincerely appreciates the cooperation of the presenters and the ISS program participants in providing in-depth data and responses to the team's questions. They contributed significantly to the team's understanding of the ISS Operations phase.

1.5 Discussions and Findings – General

This section captures the findings, recommendations, observations, and suggestions developed by the team as a result of the site visits, follow-up meetings, and team deliberations. The findings and recommendations form the basis for the architecture definitions. The observations and suggestions represent additional factors identified during the fact-finding process; these observations and suggestions offer the potential for further improvements in ISS Operations. Because discussions usually involved the full team, the operations, utilization, safety, acquisition, international, and cost-benefit/risk views could be considered at the same time. The results of this work gave the team a better understanding of contracting strategies, the need to retain NASA's "smart buyer" capability, safety experience for NASA human spaceflight programs, and the potential role of a "non-governmental organization (NGO)." These discussions resulted in the architecture options described in Section 2.

Study Team members understand the complexity and size of the ISS program's technical undertaking, and believe that NASA and the international partners will succeed in making the station a reality that benefits all people. The Study Team also believes that the overall complexity remains a real concern for the foreseeable future, during both the Assembly and Operations phases. The following four factors significantly influenced the recommendations in this report:

- **Complexity of the ISS.** The station's technical complexity is enormous. It involves difficult designs, delicate negotiations across many international borders, and an intricate assembly process. These characteristics require a strong management organization to control a complex engineering activity that must be operationally successful. This complexity, in turn, drives the requirement for a mature Program Management organization supported by a strong Sustaining Engineering base.
- **Research Purpose of the ISS.** The purpose is to achieve outstanding research results from scientific and commercial research in space. The main success criterion is the benefit derived from the research. The research itself is conducted over many technical disciplines, and performing this research makes heavy demands on all the resources available on orbit. Of particular concern is that the program's emphasis on the complexity could overshadow a reasonable emphasis on the research to be conducted, that is, the purpose of the ISS. For this reason, the Study Team recommends the establishment of a strong SSURI charged with the broad responsibility of managing the research utilization of the ISS. The SSURI must have sufficient stature within the research community to provide this community with a sense of "ownership" and sufficient authority within the NASA hierarchy to effect changes that promote the execution of the highest possible caliber of research.
- **Complexity of the Operations.** ISS program operations requires extensive Flight Systems Operations and Maintenance activities, performed by many international partners, using a diverse set of transportation systems to maintain and support the orbiting infrastructure. This requirement, in turn, calls for a team of experts to plan and design the steps and processes to make it work. These complexities again pointed to the need for a strong Program Management function and also supported the need for a clear-sighted Utilization Operations organization to manage the demands on the overall operation.
- **Inherent Government Functions.** The complexity of the program and its operations; the need to protect international investments and safety; and the need to properly honor the international relationships drove the Study Team to conclude that, for the foreseeable future, strong government involvement in the ISS must continue. The government must continue to serve as a steward to protect U.S. investments by ensuring that the entire venture is safe, productive, and achieved in a fair manner at a reasonable cost.

G1 Finding – Approximately 4 years remain before scheduled Assembly Complete is reached. Planning and experiment definition for operations after Assembly Complete should be, and are, happening now.

G1 Recommendation – The Study Team recommends that **an increased focus needs to be placed immediately,** within the ISS program, on preparing for the Operations phase.

G2 Finding – The SSURI is important in effective ISS utilization during the Operations phase. The team agrees that timely acquisition of the SSURI will be the prime factor in achieving a successful Operations-phase program. The SSURI must begin functioning in time to influence systems engineering changes that can be expected during Assembly and initial Operations. A procurement of this magnitude and complexity would normally require 12 to 18 months. Phase-in of the SSURI and transition of functions from currently responsible organizations to the SSURI would require an additional 6 to 12 months.

G2 Recommendation – SSURI acquisition should begin now. The team recommends that acquisition of the SSURI begin immediately and that the procurement process be expedited to have the SSURI under contract as soon as possible. The SSURI consortium must be formed; universities must be informed about NASA's interest in world-class research; a draft Request for Proposal (RFP) must be issued for comment; and a final RFP must be issued for the procurement.

G3 Finding – The timing for selecting an operations architecture is important. Each of the Operations and Maintenance phase functions is currently being performed, in some form, in the ISS development program. Section 4.3 discusses the current contracts providing these functions. All except the Space Flight Operations Contract (SFOC) contract expire before Assembly Complete. Several expire within 1 to 2 years from the current date. Because a replacement contract vehicle or vehicles must be provided before the existing contracts expire to ensure continuity and smooth transition of ISS support, procurement activities must be started in the near term. The Operations-phase organizational architecture must be selected before proceeding with procurement activities. The procurement and transition phase-in of the SSUR1 would take 18 to 30 months.

G3 Recommendation – Selection of the operations architecture should begin now. The Study Team recommends that NASA select and proceed immediately with implementing the Operations-phase architecture, including appropriate contractual actions.

G4 Finding – Transitioning to a new architecture and organization will be complex. Because of the complexity involved in changing existing ISS program processes, roles, and responsibilities during the Assembly period, in particular, it is clear that recommendations related to an operations architecture must be thoroughly developed, planned, and managed during implementation.

G4A Recommendation – A Master Transition Plan is needed. The Study Team strongly supports NASA development of a Center Expertise Master Transition Plan that governs implementation of the phases shown in Section 4. The team envisioned that such a plan would be a "partner" effort between the ISSPO and the implementing projects, including the SSURI. Typical contents and considerations would include detailed transition schedules of roles and responsibilities, criteria for effecting transition (e.g., SSURI demonstration of capability and stability of processes), support-facility planning, international partner impact planning, and post-transition, mutual-support plans.

G4B Recommendation – NASA should immediately form a SSURI Implementation Board. That board should be led by a well recognized NASA expert in Utilization and program Operations. The board should report to the NASA Administrator and report progress, remove roadblocks, and generally help facilitate the program's activities in acquiring, transitioning, and making the SSURI operational.

G5 Finding – NASA is responsible for a return on ISS investment. NASA, as the steward of the ISS funds, is responsible for providing a return on the public's investment in the ISS, commensurate with the size of the annual operational investment in the ISS. The recommended architecture is a step toward meeting that responsibility.

G5 Recommendation – A corporate approach toward research investment should be taken. NASA must develop a corporate approach to evaluating progress in meeting the requirement of returning benefits commensurate with the ISS investment. The HEDS enterprise should establish measures and evaluate progress toward achieving this goal.

1.5.1 Discussions and Findings – Operations and Maintenance

NASA is the global leader in human spaceflight vehicle development and operations. It has accumulated over 40 years of expertise in these areas. A concern exists that the projected lifetime of the Space Shuttle and ISS programs will result in personnel burnout and erosion of skills needed for future human space exploration. Safety cannot be compromised in any architecture. The ISS program relies on the fleet of Space Shuttle vehicles to assemble the station. The ISS international partners rely on a collection of logistic support vehicles to maintain the station. Although research is the primary goal of the Operations phase, a robust ISS Operations and Maintenance program is essential to ensuring research success.

The Study Team identified two U.S. objectives for the ISS program, that is, to have

1. A major international cooperative project for mutual national benefit while demonstrating U.S. leadership
2. A space-based, world-class research facility to support U.S. scientific research and U.S. economic development

NASA must select an operations architecture that will foster these objectives. Objective 1 clearly implies that NASA's operating infrastructure must provide utmost assurance that such a facility is safe and reliable for its intended purpose. Therefore, no compromise of ISS safety or integrity can be made. Likewise, pursuit of Objective 2 cannot conflict with this ground rule. If optimizing utilization operating efficiency in pursuit of Objective 2 conflicts with this ground rule, then operating efficiency, rather than ISS safety, must be compromised.

O&M1.1 Finding – NASA has funding and stewardship responsibilities for the ISS. The ISS is not commercially self-supporting at this time and will not be in the foreseeable future. ISS operations will therefore require extensive government funding. NASA has a continuing government responsibility to serve as the steward of the American public's interests in the ISS.

O&M1.1A Recommendation – NASA must support liability mitigation of risk for ISS assets. To provide the continuing government liability-risk protection associated with operating government assets, NASA must provide Operations requirements control and system configuration and upgrade control. ISS assets will remain under government ownership.

O&M1.1B Recommendation – NASA must control overall safety of the ISS. As part of its continuing government responsibility for overall safety, NASA must provide total Operations safety-assessment control to avoid any potential conflict that users and/or private contractors have with maximizing experiment operation/revenue.

O&M1.1C Recommendation – NASA must contain costs of the ISS. As part of its continuing government responsibility for cost containment, NASA must

- Encourage competition for services to ensure that excessive returns on government investment are not paid to private industry
- Encourage private sector investment to the maximum extent possible to leverage U.S. government ISS investment
- Encourage strategic partnerships with other federal or state governments to harmonize infrastructure investment plans and expenditures

O&M1.1D Recommendation – NASA must ensure the use of fair business practices. As part of its continuing government responsibility to ensure fair business practices, NASA must

- Ensure that market forces govern expenditure of services, consistent with U.S. government ISS program objectives
- Ensure that ISS accessibility is fairly administered, and approve the final flight manifest

O&M1.1E Recommendation – NASA must ensure world leadership in human spaceflight. As part of its continuing government responsibility to ensure world leadership in human spaceflight, NASA must ensure that high-risk ISS activities associated with the national goals of human spaceflight are properly supported.

Discussions with the ISSPO led the Study Team to identify a series of Operations and Maintenance architecture considerations that should be maintained in any form of architecture implemented. Figure 1-4 describes these suggestions.

- The ISS program must be independent of vested interests and must remain a smart buyer**.** Thus, it is important to
  - Maintain and replace, for the long term, ISSPO civil service management and acquisition skills
  - Provide a source of replenishment over the life of the program
- All program functions need to be attached to NASA institutions to have a base of support (a pipeline of smart people to staff the function) and to have an engineering base large enough to work through the real problems. Field Center institutions are the backbone of NASA. Space Station functions need to be shaped and fitted into NASA's institutional resources.
- Key facilities must be maintained as is or reconstituted to support long-duration needs. These facilities would be required for maintenance and logistics; module processing; crew training; avionics/software revisions; and command-and-control capability to support Operations and Utilization for the life of the program.
- NASA has developed geographically based expertise centers over time. These capabilities are
  - At KSC, launch, landing, and physical payload processing and integration
  - At JSC, mission control, program management, and sustaining engineering
  - At MSFC, propulsion systems, payload engineering, and payload on-orbit operations
- To take advantage of the geographically distributed expertise in both the NASA and contractor ranks, the NASA civil servant workforce should have a meaningful role in supporting the program and in overseeing contractor work at their facilities.
- Contracts should be structured to avoid overlapping responsibilities and to ensure clear interfaces.
- The ISSPO must be responsible for providing and managing the ISS support infrastructure. This arena should include the large facility-class payloads developed by the ISSPO as part of the core infrastructure.
- The ISSPO must continue to manage and control resources and forecast their availability for Operations and Maintenance and Utilization.

Figure 1-4. Operations and Maintenance Architecture Suggestions

1.5.2 Discussions and Findings – Utilization

The planned ISS is a cutting-edge facility that will offer humans the chance to improve life on Earth and find ways to make spaceflight easier and more accessible. For the ISS to succeed, beyond the feat of assembling a complex orbiting laboratory, the research performed in space must be of the highest caliber and must return real benefits to the citizens whose taxes help the ISS to achieve the objectives . Up to this point, research budgets have been modest to ensure that the ISS structure is actually built. But now is the time to significantly broaden ISS outreach efforts to ensure that the best researchers are recruited from the scientific, technical, and commercial research communities who will sponsor and perform this work.

A goal of any proposed architecture is to enhance ISS output in terms of knowledge and products that could benefit people on Earth and support future space activities. Moving toward a research community "ownership" should enhance this output, enabling the ISS to be successful.

The Study Team also had strong appreciation for the quality of NASA research already conducted in space. Operations and research results from the Skylab, Shuttle, and Shuttle-Mir experiences are laudable. As various operations architecture options were considered, the team recognized that the selected architecture must preserve the successful management and support of research within NASA. The utilization goal must be to increase the range and breadth of the research community that will participate on the ISS.

The team also recognizes recent initiatives to further improve and expand the outreach to research communities. NASA's technology plans and associated roadmaps include several NASA Headquarters codes and Field Centers. NASA Research Announcements (NRAs), Cooperative Agreement Notices, and the like, associated with Research Opportunities and recent publication (on a Web site) of a *Users' Guide*, indicate a positive direction for using the ISS for productive research.

1.5.2.1 SSURI Concept

To attract the best talent to the SSURI, the opportunity for people to conduct independent research is a necessity. Thus, researchers affiliated with the SSURI should have the ability to propose research in response to NRAs and Announcements of Opportunity just as NASA Center researchers do now. In addition, the SSURI's support of selected flight Principal Investigators (PIs) at other organizations places it in the role of an "umbrella" organization. These research organizations include (1) the established institutes [those connected to NASA centers like JSC and other agencies like the National Institutes of Health (NIH) and universities]; (2) government research entities (within NASA and other agencies such as the Departments of Defense, Energy, and Commerce, for example); and (3) Commercial Space Centers. On an organization chart, one would draw a "solid" line from these organizations through the SSURI to the ISS program for research to be performed on the ISS.

Value added from an architecture having an "umbrella" organization such as a SSURI would include a single, standardized entry point for the various research communities to use the orbiting station and a single point of contact for the ISS program to the U.S. research community. Such an architecture would also increase efficiency in the review processes required for flight. All utilization funds for U.S. research on the ISS would go through the ISSPO to the SSURI.

1.5.2.2 Flight Experiment Selection, Development, and Integration Processes

Today's payload integration process must deal with the entire complement of the Assembly sequence and the Space Transportation System (STS) carriers. By necessity, the generic sequence for these carriers ("payloads" to the transportation world) across the international partnership is complex and warrants a comprehensive integration process. The Utilization portion of the integration process generally rides in or on the carriers noted above. Discussions around reducing payload integration times are aimed at the research or experiment items that fly in or on the major transportation system carriers. To be successful and efficient in the stable Operations timeframe, the experiment integration activity should be standardized/classified to simplify the investigator team's involvement in integration, and a "research-knowledgeable" advocate is needed to assist the PI through the approval process once an experiment is selected as a candidate for flight. Before experiment selection, the Utilization goals should be focused to achieve the HEDS objectives through ISS capabilities.

The approval process requires the PI to negotiate at least the following events from utilization concept development through ISS-funded flight hardware production and operation. A goal of the SSURI is to significantly reduce the research-selection times and the ISSPO payload integration templates.

Selection Phase:

1. Science Concept Review (SCR): Usually 2 to 3 years after selection.
2. Requirements Definition Review (RDR): 1 to 2 years after SCR.
3. Internal NASA Reviews.

Development Phase:

4. Authority to Proceed (ATP): Where NASA commits resources for building flight hardware. A firm budget is established. The approving official is the Research Program Manager at the Lead Center or the Lead Center Director (for monies exceeding $5 million). It usually occurs 3 months after RDR.
5. Preliminary Design Review (PDR): When the hardware design is about 30% complete.
6. Critical Design Review (CDR): When the hardware design and test plans are about 90% complete.

Integration Phase:

7. Pre-Ship Review (PSR): Conducted by the performing NASA Center just before the hardware is shipped for integration with the launch container (about 3 years after RDR and 18 months before flight).
8. Certification of Flight Readiness (CoFR): A series of CoFRs exists to certify readiness of the ISS payload. These processes are currently under review.

Additional safety reviews are required to certify payload flight readiness:

9. Phase 0 Safety Review: Around RDR.
10. Phase 1 Safety Review: Around CDR.
11. Phase 3 Safety Review: Around PSR.

Not only would the SSURI be instrumental in guiding researchers through this process, it would also be key in reshaping and streamlining the process by virtue of working with the ISSPO in a strong Customer-Supplier relationship.

1.5.2.3 Utilization Interface Considerations

When one examines the role and responsibility of a proposed SSURI, several key interfaces must be understood and defined.

- Integration of international partners. Several informal research groups are in place that have generally formed around specific disciplines. A SSURI may evolve from an informal support of these activities to more formal interactions (if the partner agreements and NASA Headquarters see this arrangement as beneficial).

- Preflight Research Support
  - Ground-based research is necessary as a precursor to flight on the ISS. Funding of this work can determine/enable the research to fly on the ISS or on another transportation system. SSURI participation in the advocacy for funding would be appropriate and would gain support for the SSURI role in the research communities.
  - A linkage to the research funding organizations and the SSURI is necessary to ensure that the research/hardware planning and prototype development is at a stage of maturity that allows consideration for flight.
- Payload Integration. The interface to the researcher for all payload integration would be through the SSURI.
- Operational Decision Making During Flight. Utilization Operations would come under the SSURI as part of the top-to-bottom architecture responsible for performing world-class research.
- Commercially Sponsored and "Industrial" Research. The single-point-of-contact expert advocate and user-centered emphasis aspects of the SSURI should also be attractive to the commercially sponsored and "industrial" research groups.
- Crew Considerations. To optimize Utilization success, the crew should have strong involvement with the SSURI, and the SSURI should participate in crew training and selection for flight for a particular increment. The training participation should be according to program processes and should be tightly coordinated with the ISSPO to avoid excessive costs.
- Pre-Planned Program Improvement (P3I) and Sustaining Engineering. Both activities are important to ISS success, and it is critical (especially for P3I) that the user community has a strong input. The ISS should evolve to support the changing and projected needs of research being performed on the station.

U1 Finding – ISS Utilization management from concept to flight-results reporting needs to be ISS focused. No single Utilization organization is managing the overall research development, prioritization, hardware development and testing, mission integration, operations, and communication of results to the public.

U1 Recommendation – Organizationally focus ISS research activity. The team recommends that a top-to-bottom Utilization management and implementation architecture be developed within NASA and the ISS program to focus, organize, and streamline Utilization on the ISS.

U2 Finding – The utilization community is detached from the ISSPO. Even though the HEDS organization has a common set of goals, the research community is detached from the larger processes and decisions that control the common destiny of the ISS program.

U2 Recommendation – Structure utilization management as part of the total program. Bring the utilization community's goal setting, budgeting/funding allocation, and decision-making processes together, under the same organizational umbrella from NASA Headquarters to the ISSPO and the NASA Field-Center level.

U3 Finding – The forecast length of time for research selection, development, and integration is excessive. The 36-month payload integration timeline, currently projected by the ISSPO, is excessive for the Operations phase. If it is not reduced significantly, the timeline will increase the cost of operations and severely constrain the research opportunities available on the station.

U3 Recommendation – NASA should begin planning for simple-to-complex payload integration timelines. NASA should immediately begin developing research integration plans for the Operations phase of the ISS program. These plans should establish payload-categorized templates that are responsive to research area needs, can influence the payload hardware design, and can standardize the analytical process to fit into shorter integration timelines. These timelines should include Operations-era scenarios in which ISS facility-class payloads and onboard operational racks are in service. As a goal, conducting research on the ISS should be no more difficult than conducting research in a ground-based facility, except for the transportation.

U4 Observation – Crew research time is a precious commodity. Utilization time aboard the ISS a precious commodity. The crew time and the microgravity level are the primary reasons that researchers are interested in access to the ISS. Without the "people," the research work could be relegated to satellites. Efforts to increase the available crew time and/or improve the overall efficiency of crew and ground operations could increase the benefit of research operations on the ISS.

U4 Suggestions – Increase effective crew research time.

- To increase the number of available crew hours devoted to research, NASA should begin a program to increase crew-time availability for research. This effort should target 70% (of the scheduled work-related crew time) as that desired for research with a seven-person crew. This effort should consider such actions as improving operations efficiencies, bartering or purchasing time from Russia, and allowing flight operations personnel to run remote operations from the ground.
- To increase the effectiveness of in-flight research, NASA should use Mission Specialists or science astronauts to work in the SSURI as participants at all levels of the organization. Candidate crew persons could jointly or individually work to develop research payloads, serve as co-investigators, and become intimately familiar with the research goals and equipment that is currently flying or being developed for later flight.
- To optimize increment-specific research, crew flight assignments should consider crew-selection recommendations from the SSURI to take advantage of specific crew talents and training to meet flight research requirements.

Section 1 References

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2. NASA Space Station Redesign Team, *Final Report to the Advisory Committee on the Redesign of the Space Station*, Washington, DC, June 1993
3. Thomas Holloway, *Principles Required To Safely, Effectively, and Efficiently Perform Required Functions.* Presentation to International Space Station Operations Architecture Study Team, NASA/Johnson Space Center, February 23, 2000
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5. National Research Council (Space Studies Board and Aeronautics and Space Engineering Board), *Institutional Arrangements for Space Station Research*, Washington, DC: National Academy Press, 1999
6. Swales Aerospace, *Options for Managing Space Station Utilization*, Beltsville, MD: October 1999

Section 2. ISS Operations Architecture Descriptions

2.1 Overview

This section presents the five options developed by the Study Team over many hours of deliberations. The data included in Section 1 was used as a guide, along with the original study guidelines, to develop the set of architecture options. The five chosen options are (1) Program Evolution, (2) Center Expertise, (3) Single Prime, (4) Privatized SSURI Prime, and (5) Dedicated Commercial. Table 2-1 describes these options at a high level. The team has concluded that this set of options addresses a sufficiently broad spectrum of configurations that meaningful discriminators will be apparent from the evaluation. The options are realistic opportunities for all but the Dedicated Commercial option. The Dedicated Commercial option would not be feasible today, but it could be a candidate if true commercial opportunity developed sufficiently to move to an all-commercial structure. The functions are completely defined, and responsibility is assigned to entities that are characteristic of the option. The functions that would then be procured through contracting are also identified. Section 3 explains how the team evaluated the options.

Table 2-1. Characteristics of the Five Candidate Options

Option Characteristics	Option Name				
	Program Evolution	Center Expertise	Single Prime	Privatized SSURI Prime	Dedicated Commercial
Central Program Management	√	√	√	√	
Central Project Function Management	√		√	√	
Distributed Project Function Management		√			
Utilization Institute		√	√	√	Optional[1]
Utilization and Operations Institute				√	Optional
NASA Liaison Management					√
Commercial ISS Management					√
NASA Flight Crew Management	√	√	√	√	Optional
NASA Personnel Participation	√	√	√	Optional	Optional

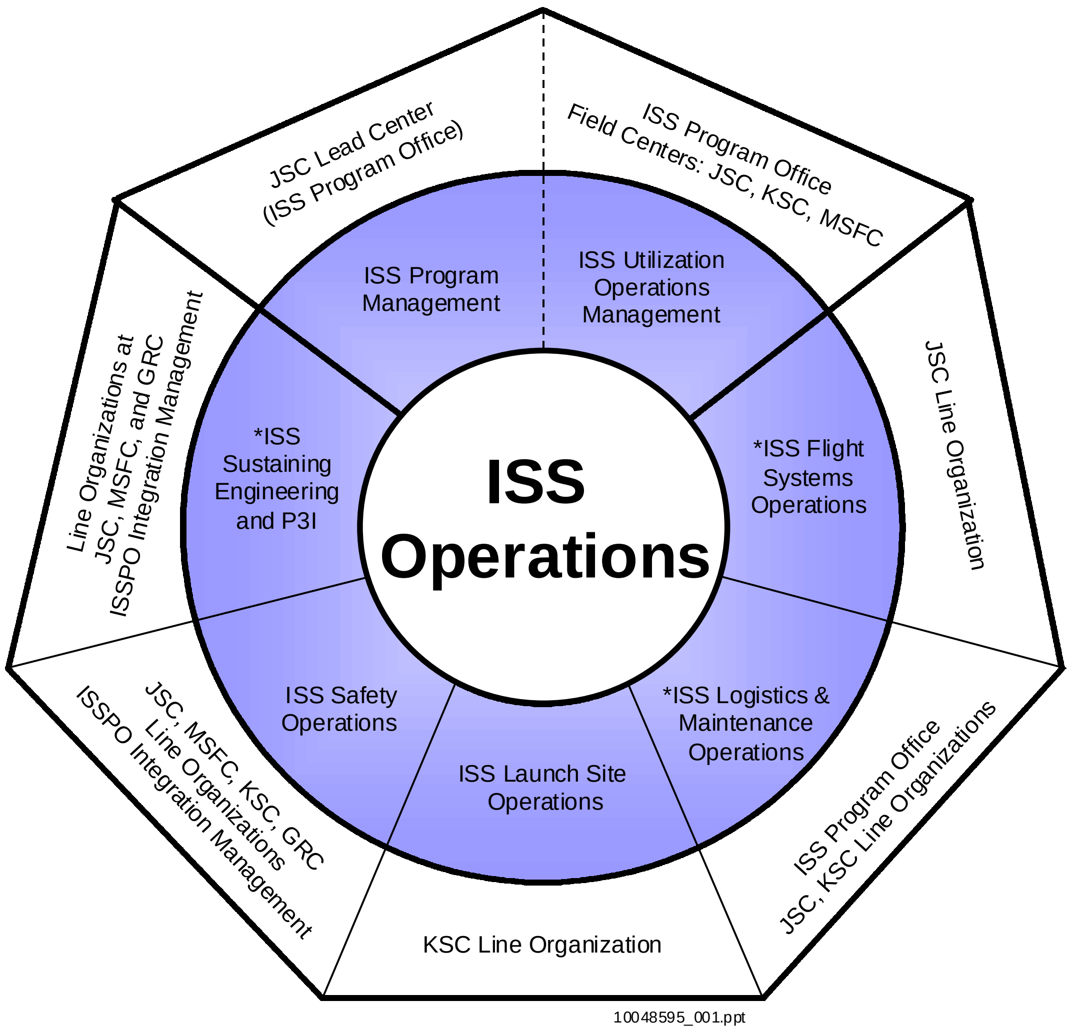
[1] In all cases, "Optional" means that certain subfunctions must be negotiated either with the SSURI or the commercial corporate entity.

2.2 Architecture Options

Range of Options

The Study Team identified several architecture options and ultimately narrowed the field to the five options described in Table 2-1.

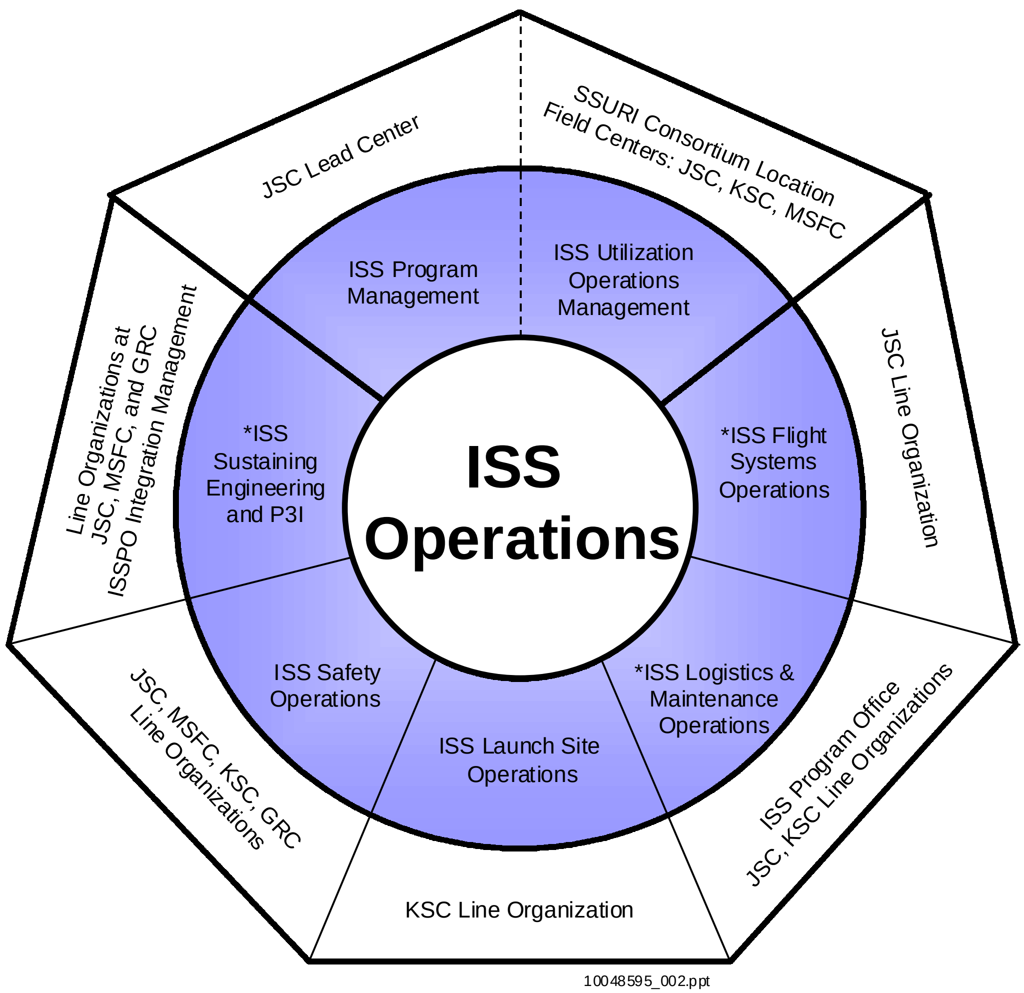
1. ***Program Evolution Option.*** Figure 2-1 shows the function assignments of the Program Evolution option. This option essentially continues the current approach. It assumes significant NASA personnel participation, control through a Lead Center, and expanded support by existing or similar contractors to cover ISS Operations. (Consolidation of contract support into a single contractor is allowed.) To accomplish this option, NASA must maintain adequate numbers of skilled personnel to manage ISS Utilization activities. This option is included in this evaluation primarily because it is the basis of the current program cost estimates and is, therefore, the point of departure for comparison with the other options. It is also considered a viable option by many NASA personnel.



*The Logistics and Maintenance Operations function is performed by the ISSPO with support from Flight System Operations and Sustaining Engineering and P3I. Unit storage, preparation for launch, and refurbishment to specifications are Logistics and Maintenance Operations activities located at KSC.

Figure 2-1. Program Evolution Option—Function Assignments

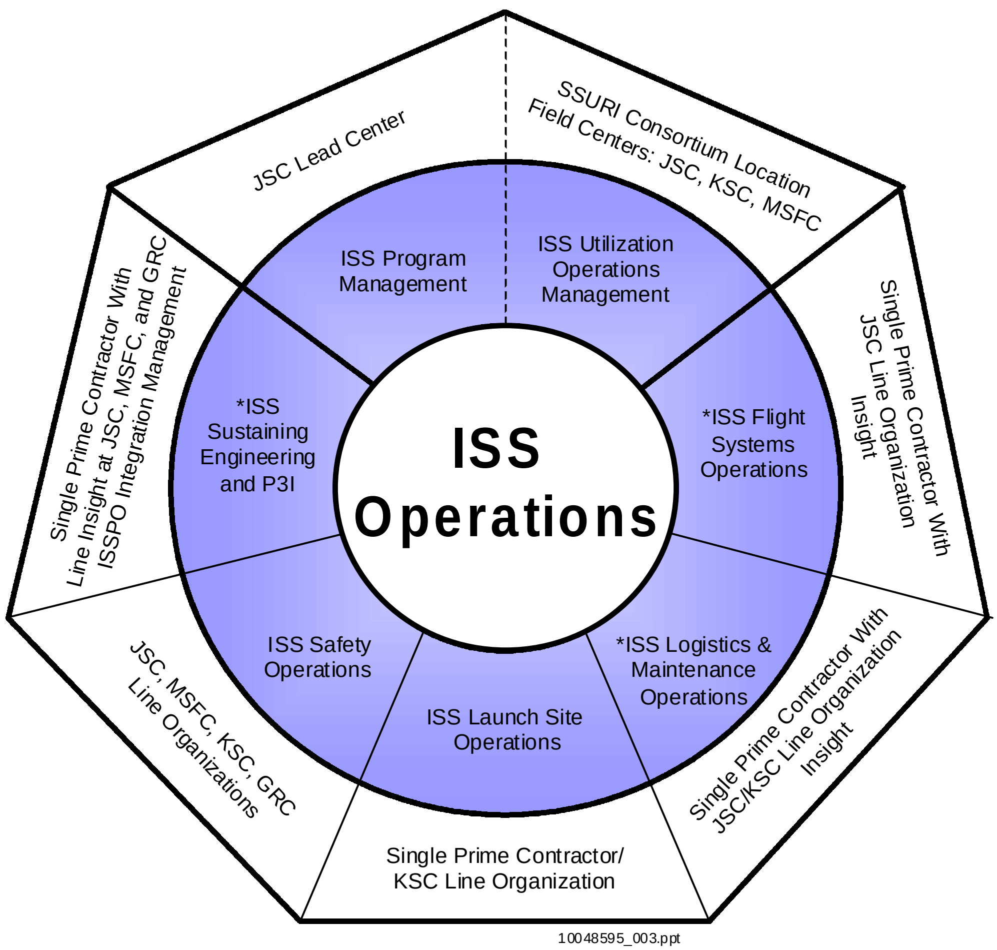
2. ***Center Expertise Option.*** Figure 2-2 shows the function assignments of the Center Expertise option. This option creates a SSURI to which management of the U.S. ISS Utilization would be contracted from the ISS program. The SSURI is anticipated to be a consortium of research and commercial institutions that supports the broader investigative community in the conduct of research aboard the ISS and manages the implementation of that research. This option also "partitions" and assigns responsibility for the remaining U.S. ISS Operations and Maintenance functions according to NASA Field Center expertise using direct civil servant involvement. As with the Program Evolution option, this civil service involvement maintains NASA expertise and ensures the availability of this skill base when needed to resolve major issues. Further, it allows synergistic consolidation of functions and contracts consistent with center responsibilities and assignments. Finally, the expectation is that by partitioning contracts and responsibilities as described in this option, the potential for vigorous competition will exist through the life of the ISS.



*The Logistics and Maintenance Operations function is performed mainly by Flight Systems Operations with support from Sustaining Engineering and P3I. Unit storage, preparation for launch, and refurbishment to specifications are ground storage and maintenance activities located at KSC as part of the overall Logistics and Maintenance Operations function.

Figure 2-2. Center Expertise Option—Function Assignments

3. ***Single Prime Option.*** Figure 2-3 shows the function assignments for the Single Prime option. This option is similar to the Center Expertise option, but it differs in that it consolidates all of the Operations and Maintenance contracted support under one contract. It would also reduce NASA personnel participation in the major program implementation functions to one of surveillance and audit, i.e., to a role of "insight." [3] This is similar to the approach used by the Space Shuttle program with the Space Flight Operations Contract (SFOC). Synergism with other programs is encouraged but not at the expense of losing internal program synergism. The prime contractor performs all technical Operations and Maintenance support integration. Utilization Operations management is vested within the SSURI, as in the Center Expertise option.

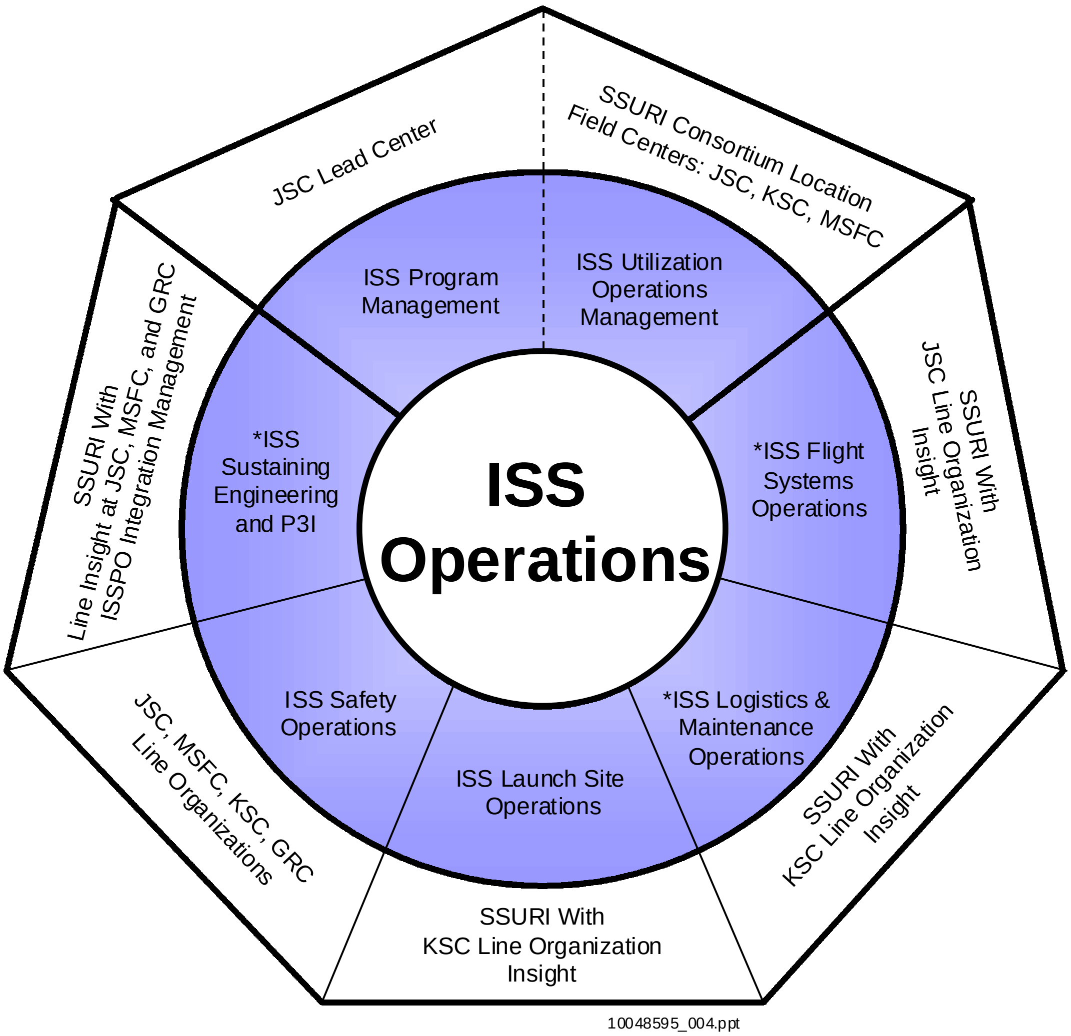


*The Logistics and Maintenance Operations function is performed mainly by Flight Systems Operations with support from Sustaining Engineering and P3I. Unit storage, preparation for launch, and refurbishment to specifications are ground storage and maintenance activities located at KSC as part of the overall Logistics and Maintenance Operations function.

Figure 2-3. Single Prime Option—Function Assignments

[3] "Insight" refers to a reduced level of NASA participation in the day-to-day activities of the program operations as compared to "Oversight." It typically means that NASA personnel monitor the ongoing activity to ensure compliance with approved processes but that contractors plan and perform all aspects of the operation. NASA personnel are expected to support certain types of problem analysis and resolution, such as out-of-family system failures. "Oversight" refers to in-depth NASA participation and, in some cases, accountability for planning and conduct of the operation.

4. ***Privatized SSURI Prime Option.*** Figure 2-4 shows the function assignments for the Privatized SSURI Prime option. This option is a modification of the Single Prime option to attach the Single Prime contract to the SSURI. It therefore places Operations and Maintenance contractor support and Utilization Operations under the SSURI. The SSURI would be responsible for these functions through a contract to the program. NASA personnel participation in the major program implementation functions would be reduced to one of surveillance and audit, i.e., to a role of "insight." NASA would retain the Program Management function.



*The Logistics and Maintenance Operations function is performed mainly by Flight Systems Operations with support from Sustaining Engineering and P3I. Unit storage, preparation for launch, and refurbishment to specifications are ground storage and maintenance activities located at KSC as part of the overall Logistics and Maintenance Operations function.

Figure 2-4. Privatized SSURI Prime Option—Function Assignments

5. ***Dedicated Commercial Option.*** Figure 2-5 shows the function assignments for the Dedicated Commercial option. This option assumes that the U.S. segment of and interests in the ISS are obtained by a commercial entity that operates and maintains the station. The commercial activity is "profit seeking," entirely in support of company objectives. Operation would be independent of NASA, except as a customer. Utilization management would be performed by the commercial entity in whatever fashion deemed appropriate. International partners may be involved in the operation through commercial interests within their own countries or through direct government arrangements with the U.S. commercial entity.

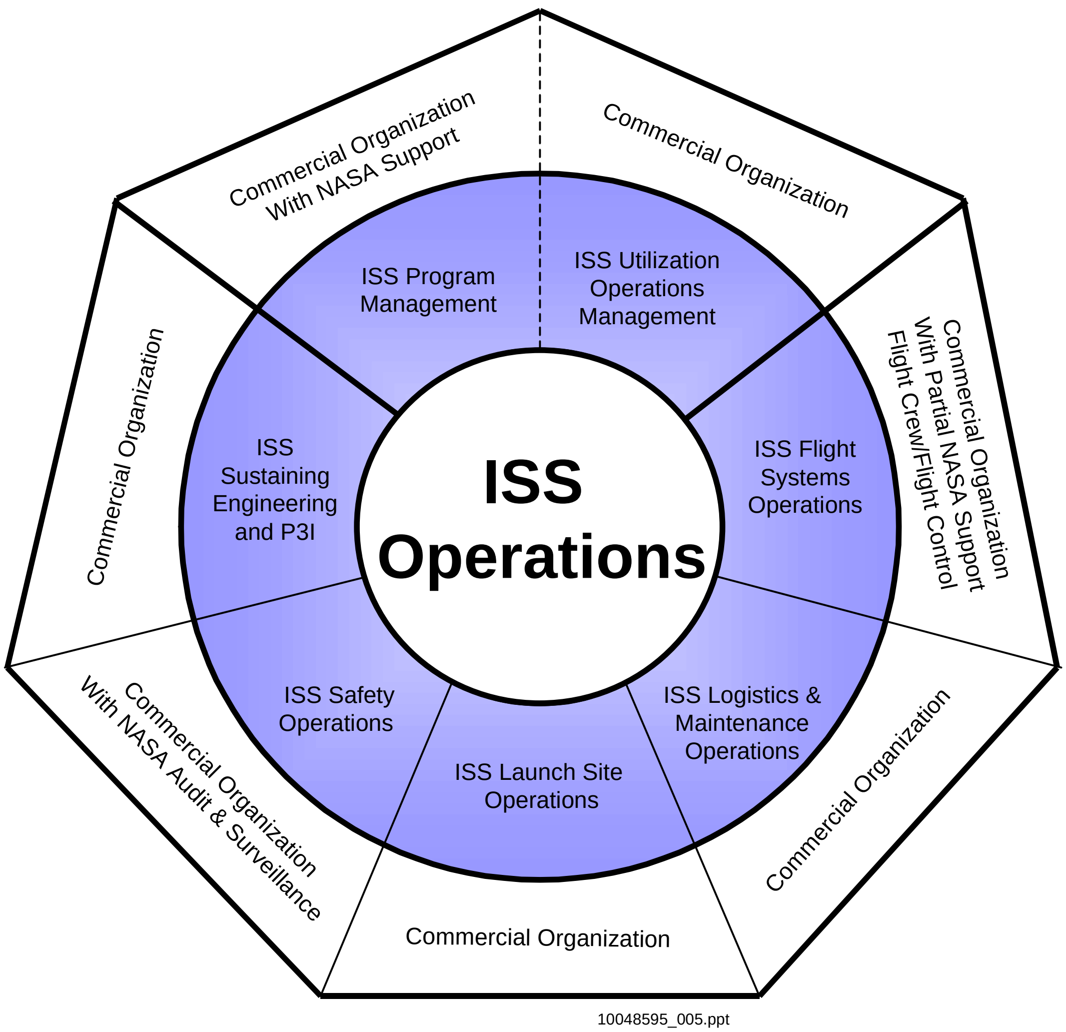


Figure 2-5. Dedicated Commercial Option—Function Assignments

2.3 Description of Architecture Options

The Center Expertise Option is described first because it is the Study Team's recommended choice and therefore includes more detail. It serves as a point of reference for discussions of the other options. Tables 2-2 through 2-6, at the end of Section 2, show the allocated functions for each option.

2.3.1 Center Expertise Option: Delegates Project Functions to Field Centers and Creates the SSURI

This section describes the Center Expertise option in detail.

2.3.1.1 Program Management

Program Management, in this option, includes the subfunctions of program planning, financial resources acquisition and management, schedule management, requirements and configuration management (including operations, safety, and P3I), and program performance measurement. These subfunctions are performed by a dedicated Program Office within the NASA Lead Center, consistent with current NASA policies governing the roles and responsibilities of NASA Headquarters and Lead Centers. In addition, this function is responsible and accountable for all other program functions that are delegated for implementation to external organizations. In particular, the ISS Program Manager remains responsible and accountable for the Utilization Operations of the ISS, as planned and executed by the SSURI.[4] Figure 2-6 shows the funding flow and authority pathway for the Center Expertise option.

NASA Headquarters, the Human Exploration and Development of Space (HEDS) enterprise, is expected to be the prime advocate for the program within NASA and in the external environment within the Executive and Legislative Branches of the government. This office is also expected to lead program efforts regarding international partner and public affairs policies.

In concert with the NASA Support Centers, the Program Office at the Lead Center would be responsible for converting Headquarters policies and budgets into implementing plans and requirements suitable for submission to NASA Support Centers for detailed implementation. This approach typically means the Program Office would perform the subfunctions of strategic/tactical planning and would develop the related requirements for implementation. The Program Office would also

- Develop the schedule requirements
- Provide the necessary funding and monitor Support Center implementation progress at a level of detail consistent with the detail of the requirements
- Provide program integration of activities that span multiple program functions at the program requirements level

Inter-Center integration within a delegated function would be performed by the responsible Center.

The Lead Center staffs the Program Office with experienced government personnel. Use of contractor personnel in Program Office positions is inconsistent with the desire to maintain NASA participation in Operations so as to retain a core set of technical and managerial skills. Therefore, only administrative contract support is envisioned.

The program would have NASA representatives at the Field Centers and institutions where program requirements are implemented; these personnel would perform inherently government functions of maintaining expertise and insight on the SSURI as well as other contractor efforts providing direct support to the Program Office for Operations and Maintenance.

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[4] NPP 7120.4, *NASA Headquarters, Lead Centers, and Support Centers*.

NPG 7120.5, *NASA Program and Project Management Processes and Requirements*.

"These processes establish the Program Manager as the Lead Center Directors' agent for total execution of an assigned program. All supporting functions are accountable to the Program Manager, who, in turn, is responsible to the implementing organizations for the subfunctions identified. All implementing projects, including Utilization, will provide a project manager (may be a contractor) accountable to the Program Manager for the execution of delegated functions."

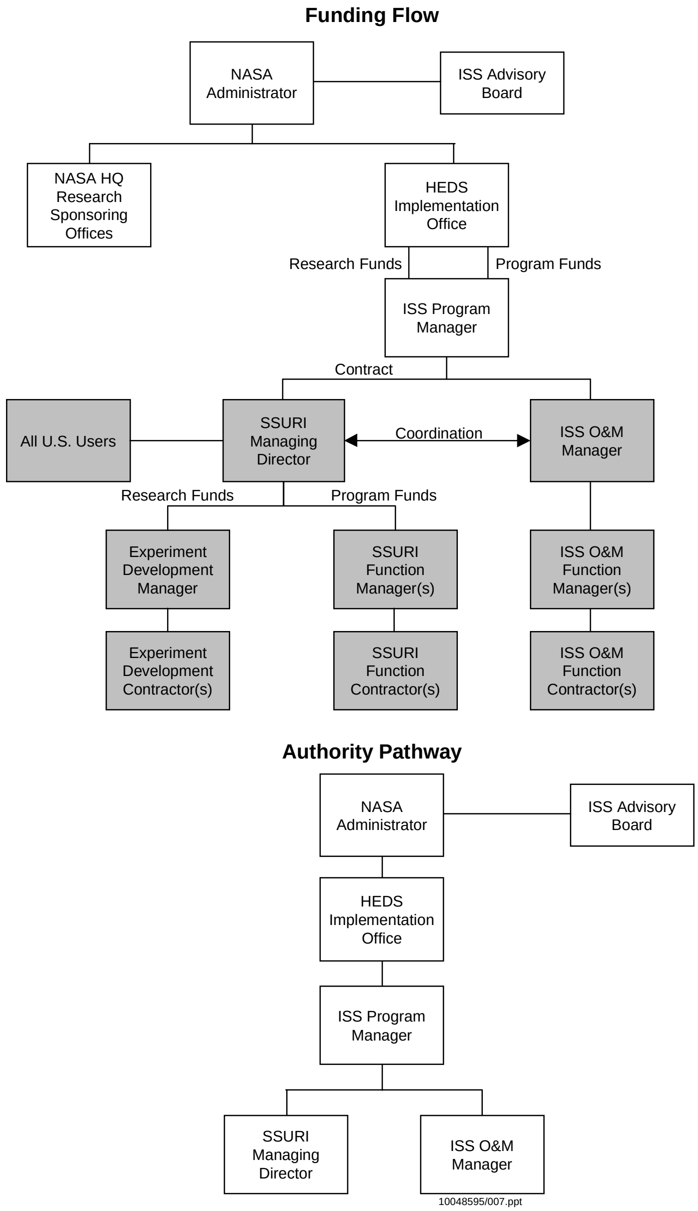

Figure 2-6. Center Expertise Option Organization Funding Flow and Authority Pathway

The Study Team envisioned strong sensitivity to Utilization plans and requirements on the part of the Program Manager and the staff of the Program Office. Since the SSURI would be contractually accountable to the Program Manager for accomplishing the utilization goals and objectives, it is expected that the Program Office would monitor this contract in much the same way NASA typically monitors any large-scale contract. Inadequate progress toward meeting these goals and objectives could be grounds for terminating and recompeting the SSURI contract. A Contracting Officer (CO) and a Contracting Officer's Technical Representative (COTR) would be necessary. The Study Team envisioned the COTR to be supported by a NASA performance evaluation team (technical management representatives, as in the SFOC entity) with membership corresponding to the major SSURI functions. This team needs to be selected on the basis of appreciation and sensitivity to the Utilization objectives of the ISS program. And, the COTR is expected to report SSURI performance assessment directly to the Program Manager. Additionally, the Study Team envisioned routine inclusion of the SSURI Managing Director in key program management forums and an otherwise close working relationship between the ISS Program Manager and the SSURI Managing Director.

2.3.1.2 Utilization Operations

The SSURI is a contract organization responsible to the Program Manager for developing and conducting the U.S. part of ISS Utilization activities. The SSURI is envisioned to be a consortium of research institutions, similar in concept to the Hubble Space Telescope Science Institute (STScI), with commercial consortia members. Scientists and specialists having strong affiliations with the user scientific, engineering, and commercial communities would staff the SSURI, which would be the integrator of all Utilization activity going to the ISS. It would be the integrating hub for the family of RPOs, Commercial Space Centers, discipline research institutes, and other government agencies that develop payloads for Space Station research. A total staff of SSURI and contractor personnel, comprised of skilled project managers, business managers, scientists, engineers, and technicians, is envisioned. A contract would exist between the Program Office and the SSURI for all Utilization functions. In addition, a dedicated support service contractor is anticipated for the SSURI, but this choice is left to the discretion of the SSURI. Figure 2-7 shows the structure of the Center Expertise option.

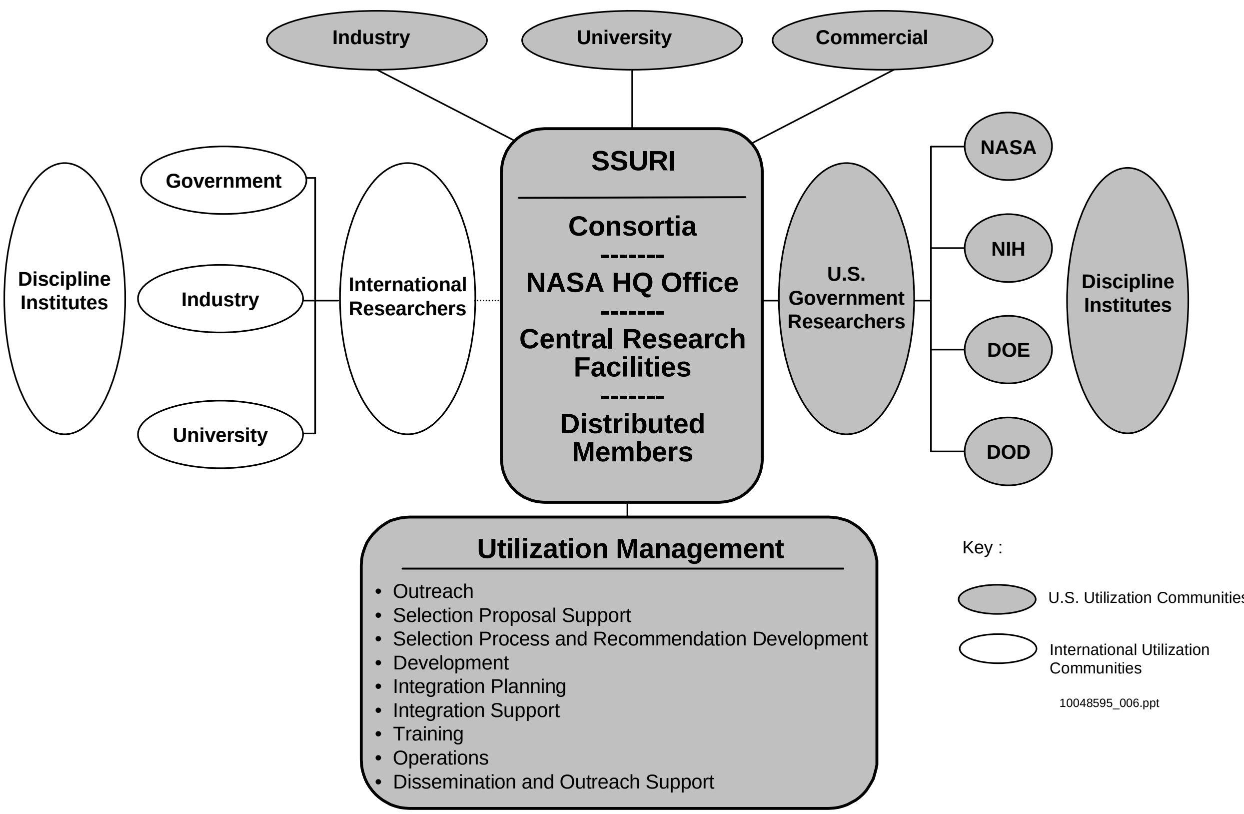

Figure 2-7. SSURI Organization-Centered View

Because of the extensive Utilization facilities and expertise that reside at the NASA Field Centers and because these resources are shared with other NASA programs, it is not anticipated that the SSURI would duplicate these capabilities. Rather, the SSURI would be responsible to the Program Office for managing all Utilization support activities at the Field Centers and would determine funding allocations for these ISS Utilization activities across NASA. Further, because of the extensive interfaces with ISS

Operations and Maintenance functions managed by the JSC ISSPO, it is envisioned that the SSURI would need to maintain a “central resident office” located near the Program Office. If needed, resident offices could also be located at other Field Centers and at NASA Headquarters (for research selection support).

The SSURI would provide the program interface to all U.S. users of the ISS. This interface would include scientific researchers who enter the NASA system via Field Center RPOs; through other U.S. agencies; commercial users who may enter the system directly through the SSURI; commercial researchers through Commercial Space Centers; and internal NASA users who propose Development Science Objectives or any Detailed Test Objectives that use Utilization resource allocations. The SSURI would be responsible for conducting a proactive ISS Utilization Outreach program and for accommodation planning and integration to the commercial community of users. The SSURI would provide active support to the commercial user community. It would also develop the Utilization manifest requirements. This product would be a prime contribution to the development of the integrated flight manifest. The SSURI would therefore maintain a close working relationship with the Program Office in this area.

The SSURI would also generally be responsible for representing the program to commercial users of ISS services. However, there is a class of commercialization that the Study Team believed should be controlled by the Program Office. This class involves promotional activities, such as advertising, using government resources. The class also includes endeavors in which a commercial activity would change the basic configuration of the ISS Flight Systems Operations function. Since the ISSPO manages the overall configuration of the ISS Flight Systems, endeavors of this type require Program Manager or NASA Headquarters approval.

The SSURI would be responsible to NASA for supporting the international partner utilization planning and execution. NASA would remain responsible for overall international partner integration and coordination according to international agreements.

Strategic planning for research activity aboard the ISS remains a NASA Headquarters function. However, it is envisioned that the involvement of the SSURI, with its strong ties to the research community, would be welcomed as a partner in this process. With respect to tactical planning for ISS Utilization, the SSURI would be the lead organization.

The SSURI would be responsible for developing experiments that have been selected for flight aboard the ISS. This activity is analogous to that of the Program Payloads Office today. The activity would be managed by the SSURI staff and performed directly through a Principal Investigator (PI) or Payload Developer contract, or indirectly through the Field Center RPOs, which is basically the same as is done today. As part of this activity, the SSURI would be responsible for determining, acquiring from the Program, and administering ISS program budgets for these implementers. The SSURI would provide staff to help the Utilization researchers meet the Operations and Maintenance payload integration requirements. This effort may include performing analyses, developing reports, and drafting procedures. The SSURI would serve as the user interfacing agent with the ISS and the Space Shuttle program for experiments that are flown and operated on both the ISS and the Space Shuttle (i.e., middeck experiments that may be precursors to ISS experiments).

The SSURI would be responsible for detailed user integration into the ISS, that is, developing and implementing payload integration processes that are certified by the Program Manager. Process certification is necessary in order for the Program Manager to control overall safety and to ensure compatibility with other program integration processes. It is expected that the SSURI would improve the efficiency of the user integration processes.

The SSURI would be responsible for the ISS Payload Operations Integration Function (POIF), as currently defined within the program. This function includes integrating Utilization operations planning and real-time ground support to the experiment flight operations. The POIF function would develop crew timelines according to the international allocation of resources and would "keep the books" on actual consumption of these resources. The supporting Payload Operations Integration Center (POIC) facilities at MSFC would be operated by MSFC in a "host" mode under contract to the SSURI. The SSURI would determine and provide ISS funding for the POIC, the United States Operations Center (USOC), and the Payload Data Services System (PDSS).

The SSURI would be responsible for ISS Utilization payload ground processing at the launch site as currently defined within the program; these are the Utilization functions traditionally performed by the KSC ISS/Payloads Processing Directorate. The SSURI would fund all launch site ISS payload support facilities and services, when required for ISS Utilization support. The Program Office would continue to directly fund those launch site facilities and services that are required for Operations and Maintenance, including Assembly. The Study Team recognizes that these facilities and functions provide synergistic support across both the Operations and Maintenance and Utilization activities.

NASA would have limited participation in both the POIF and payload ground processing activities for inherently government functions of contractor performance as well as for maintaining core skills within the civil service staff. The Field Center civil service personnel would also ensure that delegated program-requirements implementation processes are adequate.

The Study Team envisioned that the SSURI would participate with the JSC Flight Systems Operations' function to select and train flight crew members well suited to the Utilization objectives of individual increments. The JSC Flight Crew Operations Directorate (FCOD), as the line organization responsible for crew selection and assignment, would select the final crew based on all flight requirements. The JSC Missions Operations Directorate (MOD), as the line organization responsible for overall crew training, would make the final determination of overall training plans. However, the Study Team recognized the need for stronger participation by Utilization advocates in this activity and recommends that JSC implement a process to encourage and allow this participation. The SSURI would also be responsible for experiment training, some of which would be conducted as part of the crew integrated training.

Finally, in terms of the Program Management function, the SSURI would be responsible for defining user requirements for planned upgrades to ISS flight and ground systems, including core systems and experiment facility-class systems. In addition, the Program Manager could delegate responsibilities for developing selected facility-class experiment facilities to the SSURI and would approve all system development funded by the program.

2.3.1.3 Flight Systems Operations

Flight Systems Operations includes all subfunctions associated with planning, training, and conducting flight operations. These functions are those traditionally performed by the JSC FCOD and the JSC MOD. Given the top-level requirement to maintain government participation in these activities for the purpose of developing NASA personnel skills and experience for future programs, the Study Team found no reason to change existing responsibilities. Indeed, considerable synergism (e.g., shared facilities, shared skill bases, shared line organization management, shared contracts) has already been realized within these organizations between the Space Shuttle and ISS programs. Separating either program's Flight Systems Operations functions from the other would result in major cost impacts to both.

The Study Team envisioned an operationally skilled government staff (including astronauts) supported by a single Flight Systems Operations contractor with support scope similar to the existing SFOC work. Indeed, the team recognized that most, if not all, of the Flight Systems Operations functions are already included in the SFOC and that this contract term of performance extends through FY 2006. This staff would be responsible for the traditional tasks of mission planning, flight crew selection and training, flight controller selection and training, and conduct of ground support to the flight. Government personnel would continue to exercise responsibilities analogous to the Government Accountable Functions (GAFs) of the SFOC. These functions basically include the “command and control” positions and the “operations capability development” management positions within the overall activity. Training, including the interface with the SSURI for payload integration, is envisioned to become a Contractor Accountable Function (CAF) at Assembly Complete or shortly thereafter.

One aspect of the Study Team recommendation is the delegation of payload/experiment analytical integration, including the traditional cargo engineering integration activity, to this function. This function, in concert with increment system planning and requirements, also includes transportation support planning. In fact, the Study Team envisioned delegation of most “operations-oriented” planning activity to this function, as opposed to retaining such functions within the ISSPO. NASA should perform a detailed analysis of the feasibility of this recommendation, but the Study Team’s sense is that every effort should be made to restrict the Program Office functions to those of program planning, resource management, requirements management, configuration control, and program performance measurement. Therefore, subfunctions such as ISS total payload analytical integration are to be delegated, in this case, to the Flight Systems Operations function. The on-orbit Utilization Operations planning and integration would be performed by the SSURI, and it would exchange information with the Flight Systems Operations function. (Note, in Table 2-7, that the subfunction of on-orbit logistics and maintenance is delegated to the ISS Flight Systems Operations function. This subfunction incorporates the traditional in-flight maintenance activity.)

Assuming that JSC maintains two line organizations (FCOD and MOD) in support of this program function, the directors of both of these organizations would be accountable to the Program Manager for conducting and performing this function. As such, these directors would be active members and participants in all Program Management forums. To achieve the expected outcome, it is essential that both organizations maintain extensive interfaces with the SSURI for the purposes of Utilization accommodation planning, integration with ISS systems operations planning, and conducting the real-time operations. ISS Flight Systems Operations must maintain and support proper “integration” forums with SSURI operations management personnel to ensure overall ISS operations integrity.

2.3.1.4 Logistics and Maintenance Operations

The Logistics and Maintenance Operations function involves both engineering and operations components. The engineering component includes development and maintenance of the informational technical database that contains the Logistic Support Analysis records and related manufacturing source data. This component also includes original equipment manufacturer (OEM) status and management, inventory management, sparing analysis and procurement, and repair procedures analysis. These activities are closely affiliated with Sustaining Engineering and are performed by the ISSPO or a line organization at JSC.

The operations component of Logistics and Maintenance Operations includes on-orbit activities, ground storage/maintenance/repair activities, and ground transportation services. On-orbit activities encompass the traditional “in-flight maintenance” activity including crew maintenance/repair/removal/replace procedures and training, on-orbit anomaly identification and resolution, and equipment-utilization tracking. The activity is closely affiliated with the Flight Systems Operations function and, therefore, would be performed with that function. The ground storage/maintenance/repair activities encompass provision and operation of ground storage and repair facilities and tools and the related technical staff needed to provide repair services for returned orbital replacement units (ORUs) consistent with ISS program support requirements developed by the logistics engineering activities described above. The activity would be performed by the KSC line organization. Ground transportation services encompass those planning and execution activities associated with transporting logistics items between the point of origin/repair and the launch site; this includes transport via the Guppy or commercial aircraft/ground transportation. This activity would be performed by the ISSPO or a JSC line organization.

The Logistics and Maintenance Operations functions described above are performed by the identified organizations for all ISS Flight Systems. For ISS multi-experiment facilities, or “facility-class” payloads, the activities could be performed by these organizations if determined to be cost effective by the SSURI. In all cases, the Study Team believed there were opportunities for synergistic contract consolidation within the Centers with other programs, and that is encouraged in this recommended option. Also, the Study Team envisioned the Logistics and Maintenance Operations functions to be delegated to program support contractors in all areas with government personnel performing audit and surveillance of contractor activity. (If NASA needs to maintain these skills as part of its core skills program, it should be possible to establish GAFs and CAFs, similar to the SFOC, as a way of providing NASA personnel participation.)

2.3.1.5 Launch Site Operations

Launch Site Operations for this option is envisioned to be a KSC line-organization responsibility in support of the Lead Center Program Office at JSC. The subfunctions of resupply/return processing, payload-to-vehicle interface test support, and support to ISS elements/payloads required by the ISS vehicle (i.e., Operations and Maintenance) would be performed and funded as direct program responsibilities. The subfunctions of experiment integration and test support and launch site support to the SSURI/PI would be performed in support of the SSURI, according to SSURI requests and funding. The Launch Site Operations function would be either a stand-alone contractor or would be consolidated with other similar KSC support contractor functions according to KSC desires. KSC government personnel would participate in areas of critical core technical skills that NASA desires to maintain or in inherently government functions (e.g., site support to the SSURI/PI). These roles would be defined by KSC and identified as GAFs to the contractor. All other functions would be CAFs, and NASA participation would be limited to enough audit and surveillance to certify that the contractor is following approved work processes.

2.3.1.6 Safety Operations

Safety Operations for this option is the responsibility of NASA and the ISS program. The existing NASA Risk Management processes used at NASA Headquarters, Lead Centers, and implementing centers remain. Therefore, the program would approve the safety requirements and would perform final certification that the flight components of the Utilization effort are safe for the mission. The responsibility for complying with safety requirements would be assigned to all implementing organizations, including the SSURI. Assessment, surveillance, and audit would be performed by Lead Center Program Management and by the implementing centers, including the SSURI.

Integration of the SSURI into the NASA risk management processes would require that the SSURI assess the user’s implementation of the program’s safety requirements and provide the program-required information and certifications to the program safety review board structure. The SSURI would be the user’s representative of all safety-related program activity.

Although the SSURI would provide oversight on the user’s implementation of requirements, NASA would generally perform insight on this activity and on the SSURI processes. Program certification would be required for SSURI processes and facilities that implement safety requirements.

With the SSURI being responsible to the program for ensuring program requirements compliance, and eventually the certification of experiment integration into experiment facilities, the Study Team expects a reduction in the safety effort required by the utilization community.

2.3.1.7 Sustaining Engineering and P3I

ISS flight systems Sustaining Engineering for this option is the responsibility of the Program Office. The Sustaining Engineering function includes analysis and recordkeeping of in-flight and ground systems anomalies, support to the operations and ground support teams on ISS systems issues, and design of systems changes when sub-par systems performance dictates modifications. The Program Office is envisioned to perform the integration of the Sustaining Engineering activity but to rely on the responsible development Field Center expertise for technical insight support. The Study Team envisioned a Sustaining Engineering contractor that is principally responsible for detailed technical support to the program. This contractor would also be responsible for P3I development support under Program Office direction. The Program Office would be responsible for defining the content of P3I in concert with the SSURI for user-driven requirements. Government personnel are expected to lead this activity as an inherent government function associated with defining requirements for ISS growth.

Sustaining Engineering for the multi-experiment facilities (facility-class payloads) would be the responsibility of the SSURI, where the user community has primarily developed these facilities. The program Sustaining Engineering contractor would support this activity as needed via agreement between the program and the SSURI.

2.3.1.8 How the Center Expertise Option Works

Operations Concept. The ISSPO performs the assessments and determines the increment manifests with support from Flight Systems Operations, Logistics and Maintenance functions, and the SSURI. The ISSPO then arranges for transportation services with the Shuttle and international partner organization and supports in-flight activity through the Flight Systems Operations and SSURI functions. The SSURI participates in the commercial and research definition and selection and hardware development; provides PI assistance and interface to the Operations and Maintenance integration process; develops the increment research timeline; provides PI access to the on-orbit operations; and archives data and supports dissemination of results.

Organization**.** The ISSPO retains central control for budget, safety, and configuration management functions and assigns project responsibility to NASA Field Centers, according to their expertise. These responsibilities include Operations and Maintenance functions of Flight Systems Operations, Logistics and Maintenance Operations, Launch Site Operations, certain safety functions, and Sustaining Engineering/P3I.

Contracts**.** The ISS program uses the SFOC/successor contract to support all STS Flight Systems Operations and NASA launch operations, the Payload Ground Operations Contract (PGOC)/successor contract to support ISS Launch Site operations, and the prime contract to provide all development and sustaining support. The Utilization function will be performed by the SSURI.

Authority**.** The ISSPO Program Manager delegates Operations and Maintenance responsibility to the cognizant ISSPO manager and Utilization to the SSURI manager.

Funding**.** The ISSPO Program Manager funds all Utilization and Operations and Utilization operations and development activity. Research development funding is advocated by the research codes with SSURI assistance.

Budget. The Office of Space Flight (OSF) obtains funding based on requests developed by the ISSPO and the Headquarters research codes. The ISSPO Program Manager is the advocate for the total budget. PI funding is advocated by the NASA Headquarters Utilization codes.

2.3.2 Program Evolution Option: Continues the Current Approach

Figure 2-8 shows the organizational funding flow for the Program Evolution option.

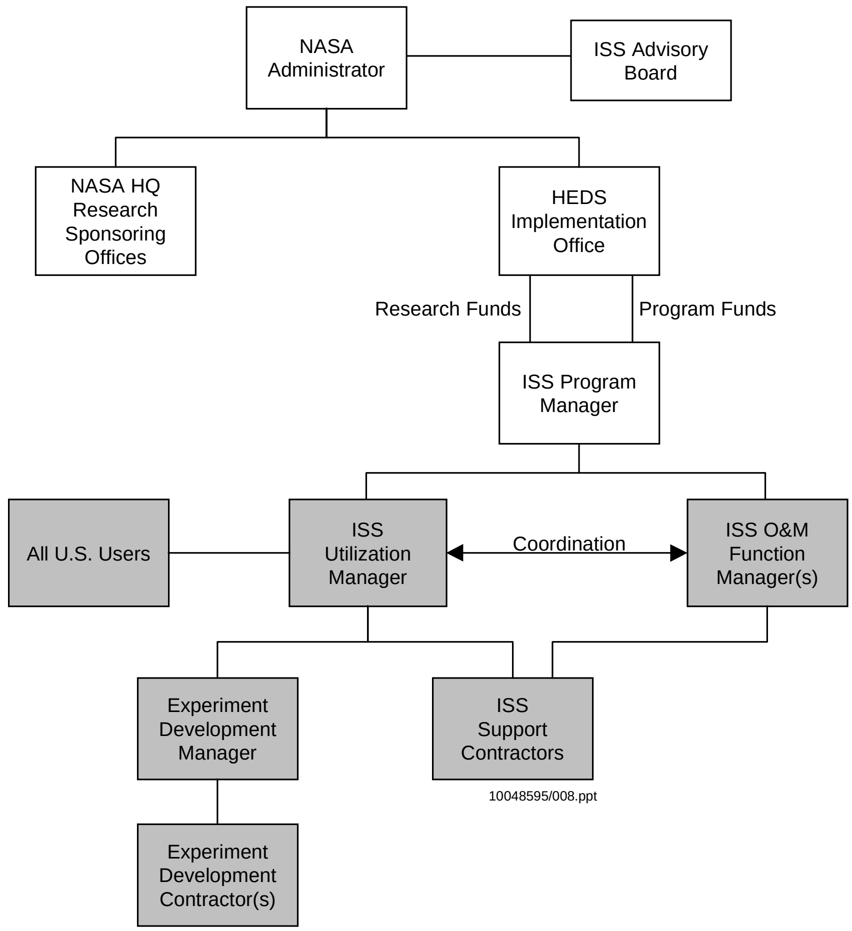

Figure 2-8. Program Evolution Option Organization Funding Flow

2.3.2.1 Program Management

The Program Management function for the Program Evolution option is the current Lead Center Program Office structure and approach. It is focused toward maintaining evolutionary development of the ISS. That is, it is a centrally controlled process for all program activity, including all aspects of Utilization and Operations and Maintenance of the core ISS facility. This option, therefore, does not implement the SSURI but, instead, retains a sizable staff internal to the ISSPO to manage ISS Utilization. It also retains a sizable staff to manage the Operations and Maintenance function. Oversight is provided at the technical level for most program activity. The ISSPO provides program integration of most activities at the implementation level and is supported by a current staff of about 300 government employees supported directly by about 600 contractor support service personnel, exclusive of the prime development contractor.

The Program Manager would integrate the diverse elements of the program. A major task will be to balance the needs of the Operations and Maintenance activities with those of the Utilization activities. Because of the scope of these two activities, major assistance in the management of both is required. Both are delegated down one level in the NASA organization.

2.3.2.2 Utilization Operations

The ISSPO manages Utilization Operations for this option through an internal Payloads Office or equivalent. The Center RPOs at MSFC and JSC provide research development support. Implementing line organizations at MSFC, JSC, and KSC provide additional payload operations support. The program provides the principal interface to the user community, including commercial users, and provides user integration into the ISS. The program is responsible for developing the flight manifest, both payload and integrated.

NASA Headquarters is responsible for selecting NASA-funded research to be flown on the ISS, based on established peer review processes. The program would support this process with technical evaluations of candidate payloads. Once a payload is approved, the program provides funding for the development and operation of the selected payloads.

In general, the program provides all of the subfunctions described for the SSURI in the Center Expertise Option. Government employees populate the lead positions with most technical support supplied by a support service contractor.

2.3.2.3 Flight Systems Operations

JSC's FCOD and MOD perform the Flight Systems Operations function in this option with major support by a single prime operations contractor (currently, United Space Alliance). The Program Evolution option is identical to the Center Expertise option, except that it does not include performance of the payload/experiment analytical integration function, which is retained within the ISSPO, and it does not use a single contractor dedicated only to Flight Systems Operations. Otherwise, performance of all subfunctions as described under the recommended Center Expertise option applies. The Program Evolution option is characterized by retention of the "command and control" and "operations capability development" activities as GAFs to be managed and performed by government personnel. All other activities are designated CAFs and are carried out as performance-based activities by the contractor.

2.3.2.4 Logistics and Maintenance Operations

Logistics and Maintenance Operations is performed by the ISSPO in this option. Major support is obtained from the prime development contractor and from program support service contractors. The logistics engineering, on-orbit operations, and ground operations functions are performed with significant participation of NASA personnel. These functions include on-orbit maintenance planning and real-time support to the flight activity and all aspects of ground-based repair, resupply, procurement, and ORU failure analysis. The ISSPO Logistics and Maintenance Operations organization provides overall management and integration.

2.3.2.5 Launch Site Operations

KSC's ISS/Payload Processing Directorate currently performs this function for this option with major support by the PGOC. The approach is very similar to that of the Center Expertise option, except that major Utilization interfaces are with PIs/Payload Developers through the Program Office rather than the SSURI. The function is performed in support of the Program Manager. It includes the subfunctions of resupply/return processing, pre-carrier experiment integration and test support, and payload-to-vehicle interface test support as direct program responsibilities. (The subfunction of ISS Assembly flight support is also performed during the Assembly phase of the program.) The subfunctions of experiment integration and test support and launch site support to PIs/Payload Developers would be performed in support of Payload Developers according to request and funding. KSC government personnel participate in areas of critical core technical skills that NASA desires to maintain in inherently government functions (e.g., site support arrangements with PIs/Payload Developers). These areas are identified by KSC and termed GAFs, or the equivalent, to the contractor. All other functions are CAFs, and NASA participation is limited to enough audit and surveillance to certify that the contractor is following approved work processes.

2.3.2.6 Safety Operations

Safety Operations for the Program Evolution option is the responsibility of the ISSPO for all ISS activities. The Program Office is supported by the Center institutional safety organizations, and any associated contractors, at JSC, MSFC, and KSC for activities at those sites, and by Boeing, the prime ISS development contractor, for integration and development oversight. Established and well-known processes are in place and generally result in safety certification by the program after a series of systems, payloads, and integrated reviews have been successfully accomplished. The program controls the requirements for safety in all respects, including development and operations. Payload Developers are required to demonstrate compliance with the requirements in order to obtain certification for flight. The review process is tiered consistent with the tiered responsibility for payload development and safety implementation within NASA. That is, Payload Developers may be required to support reviews at their sponsoring NASA Center level, at possibly a separate RPO at another Center, followed by further reviews at the program level. This approach is thorough and has a successful track record, but it is lengthy and cumbersome. NASA has streamlined the payload process somewhat but not to the extent envisioned in the Center Expertise option.

Safety Operations for the ISS Flight Systems and for ISS/Payload Integrated Operations is the same as for the Center Expertise option. That is, the ISSPO is responsible for defining safety requirements, with compliance responsibility assigned to all organizations with implementation responsibilities. Government personnel participate in assessments and perform audit and surveillance of contractor activity. Ultimate certification for flight is by NASA.

2.3.2.7 Sustaining Engineering and P3I

Sustaining Engineering and P3I for this option are identical to that of the Center Expertise option except that requirements for P3I are developed internal to the ISSPO, supported by its own payloads office, rather than jointly with the SSURI.

2.3.2.8 How the Program Evolution Option Works

Operations Concept. The ISSPO performs all assessments, determines resupply needs, defines the manifest, arranges transportation services with the Shuttle and international partner organizations, and manages the increment timeline. The ISSPO supports research hardware development through the Field Center RPOs or other contractors, and integrates the transportation services to accommodate the research needs. The PIs are supported by the NASA Headquarters research codes and are responsible for the conduct of the research, its readiness to fly, publication of results, and permanent archival of data.

Organization. This option uses current Lead Center approach with direct support provided by NASA organizations and program-provided contractors. Central ISSPO management controls all functions.

Contracts. The ISS program uses the SFOC/PGOC successor contracts to support all Flight Systems Operations and NASA launch operations, a new the contract to support ground operations, and a new Sustaining Engineering/P3I contract to provide all development, sustaining, and utilization support.

Authority. The ISSPO Program Manager is the point of authority for all ISS functions. NASA organizations report directly to the ISSPO as do the program contractors.

Funding. The ISSPO directly funds all ISSPO development and operations contracts.

Budget. The OSF obtains funding based on requests developed by the ISSPO. The OSF is the advocate for the total budget. PI funding is advocated by the NASA Headquarters Utilization codes.

2.3.3 Single Prime Option: Moves All Operations and Maintenance Program Support to the Prime Contractor and Creates the SSURI

Figure 2-9 shows the organizational funding flow for the Single Prime option.

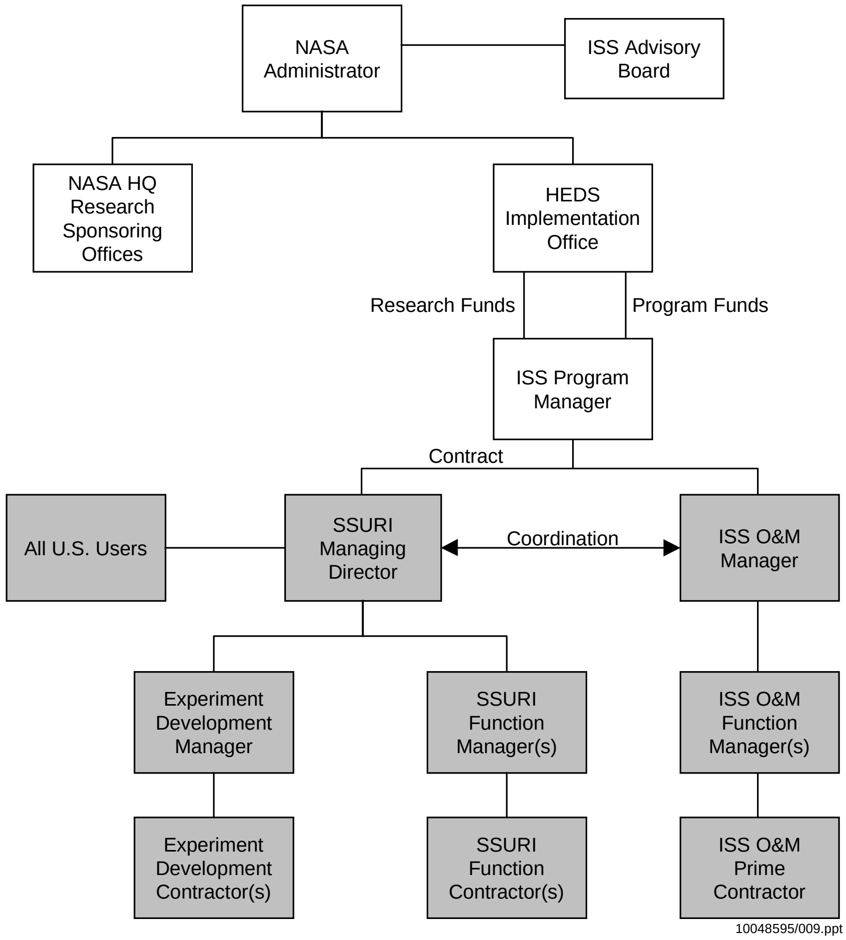

Figure 2-9. Single Prime Option Organization Funding Flow

2.3.3.1 Program Management

The Program Management function for this option comprises all of the program management subfunctions of the Center Expertise option and adds the subfunction of management of the single prime contract. These functions would be performed by a dedicated Program Office within the NASA Lead Center consistent with current NASA policies governing the roles and responsibilities of NASA Headquarters and Lead Centers. This office would be responsible for managing the Program Operations and Maintenance contract support to the NASA supporting centers. This approach would add staffing requirements to the Lead Center to perform the contract administration subfunction, which can be offset by reductions of similar personnel requirements at the supporting centers. Otherwise, this function is identical to that of the Center Expertise option, including oversight of the SSURI. The SSURI would be responsible to the Program Manager for ISS Utilization operations.

2.3.3.2 Utilization Operations

The Utilization Operations function for the Single Prime option is identical to the Center Expertise option, unless NASA elects, for synergy purposes, to also add ISS Utilization contractor tasks to the Single Prime for Operations and Maintenance. In these cases, the SSURI would have contractor interfaces with the single prime. It is envisioned that the SSURI would still have its own support contractor for its dedicated Utilization activities. Therefore, little difference exists in Utilization Operations between the two options.

2.3.3.3 Flight Systems Operations

Flight Systems Operations is an Operations and Maintenance function and is therefore absorbed to a maximum extent within the single prime contract. NASA would retain responsibility for certain GAFs similar to those existing on the SFOC today, while delegating other CAFs to the single prime contract. These GAFs include flight crew selection and assignment and real-time systems operations. This is because it is anticipated that the flight crew cadre would remain government employees and because the real-time flight control execution is a critical core skill for NASA in developing future managers. Indeed, this subfunction is essentially identical to the Center Expertise option since the CAFs in that option already use the process of “insight” management by the government. This role for government employees on CAFs would be one of audit and surveillance of single prime contractor activities to ensure that certified processes are being followed.

The principal difference between this option and the Center Expertise option is in contract administration. For the Center Expertise option, the contractor would be a dedicated Flight Systems Operations contractor, and the contract is presumably administered by the Center procurement organization with principal direct technical support by the flight crew operations and mission operations organization. For the Single Prime option, the contractor would be a program-wide support contractor, and the contract would be administered by the Lead Center procurement organization with principal direct technical support by the Program Office and indirect technical support by the flight crew operations and mission operations organizations. Administration, therefore, would be somewhat more complicated.

2.3.3.4 Logistics and Maintenance Operations

The Logistics and Maintenance Operations function for this option is identical to that of the Center Expertise option, except that the function is absorbed within the single prime contract that includes all program Operations and Maintenance functions. The single prime contractor would be responsible for all aspects of Logistics and Maintenance for ISS Flight Systems and could provide logistics support for ISS multi-experiment facilities if determined to be cost effective by the SSURI. The NASA role would be functionally the same, that being one of audit and surveillance of contractor performance, but evaluation and reporting would be done through the Program Office because the single prime contractor is managed from that level. This option also may not provide the desired synergistic consolidation opportunities of the Center Expertise option since it is part of an all-inclusive program-wide contract. It would, therefore, provide less flexibility to Field Center organizations for implementing their responsibilities.

2.3.3.5 Launch Site Operations

The Launch Site Operations function for this option is identical to that of the Center Expertise option. Utilization functions would be performed in support of and would be funded by the SSURI. In either case, this support would be purchased by the SSURI from the implementing Field Center. The single prime contractor would be responsible for launch site ISS resupply/return processing and payload-to-vehicle interface tests. Launch site support to the SSURI/PI and experiment integration and test would be purchased by the SSURI from the implementing center. The Program Office, as part of the overall single prime contract, would directly fund the ISS Operations and Maintenance subfunctions. KSC facilities, supporting ISS Utilization, could be provided by the center or as part of the single prime contract. Their use by the SSURI would be included in the SSURI charges. The single prime contractor would be responsible for obtaining the CoFR, for launch site activities in direct support of the ISSPO, with NASA responsible for certifying that the single prime contractor follows proper processes.

2.3.3.6 Safety Operations

Safety Operations for the Single Prime option is similar to that of the Center Expertise option, except that the Field Center safety contract support is consolidated into the single prime contract, administered by the Program Office, rather than included in local center contracts. Contractor synergism within the program is provided, but synergism within the Field Center functional responsibility may be lost. NASA would be responsible for overall CoFRs.

In this option, the SSURI would be assigned responsibility for payload safety for a large class of payloads. The Study Team envisioned these to be "buffered" or bounded by program-approved operating envelopes. The SSURI would be responsible for CoFRs for such payloads and for integrating all payload CoFRs with the program CoFR processes.

2.3.3.7 Sustaining Engineering and P3I

Sustaining Engineering and P3I for the ISS systems under this option would generally be the responsibility of the program with support of the single prime contractor. Sustaining engineering, in the sense of supporting the maintenance of the as-delivered capability of the flight systems and avoiding obsolescence would be primarily a single prime contractor responsibility within this overall function. For this function, the Study Team envisioned NASA's role to be one of audit and surveillance, i.e., one of "insight." However, definition and control of requirements for P3I would be a NASA responsibility, in concert with the SSURI, with the single prime contractor role being one of development and implementation. In summary, this function is identical to the Center Expertise option, except that contractor support would be part of the overall program-wide Operations and Maintenance contract as opposed to being a single stand-alone Sustaining Engineering and P3I contract.

2.3.3.8 How the Single Prime Option Works

***Operations Concept*.** The ISSPO performs all assessments; determines resupply needs; defines the manifest; arranges transportation services with the Shuttle and international partner organizations; and manages the increment timeline. The ISSPO manages all aspects of ground, flight, and logistics operations directly or through the prime contractor. This option also creates a SSURI. The SSURI participates in the commercial and research definition and selection and hardware development; provides PI assistance and interface to the Operations and Maintenance integration process; develops the increment research timeline; provides PI access on-orbit operations; and archives data and supports dissemination of results.

***Organization*.** The structure is similar to the Current Evolution option. It uses the current Lead Center approach with direct support provided by the prime contractor with NASA "insight" responsibility. Utilization Operations management is vested in the SSURI, as in the Center Expertise option.

***Contracts*.** The program uses the prime contract to support all ISSPO Operations and Maintenance needs. The Utilization Operations function is supported by the prime contract or by new contract competitions.

***Authority*.** The ISSPO Program Maintenance is the point of authority for all ISSPO Operations and Maintenance functions and resolves conflicts as required.

Funding. The ISSPO directly funds all ISSPO development and operations contracts and Utilization development and operations. NASA Headquarters funds the PIs.

Budget. The OSF obtains funding based on requests developed by the ISSPO and the Utilization codes, as supported by the SSURI, for ISS research development. The ISSPO Program Manager is the advocate for the total budget. PI funding is advocated by the NASA Headquarters Utilization codes.

2.3.4 Privatized SSURI Prime Option: At "Stable Operations," the SSURI Assumes Management of Operations and Maintenance

Figure 2-10 shows the organizational funding flow for the Privatized SSURI Prime option.

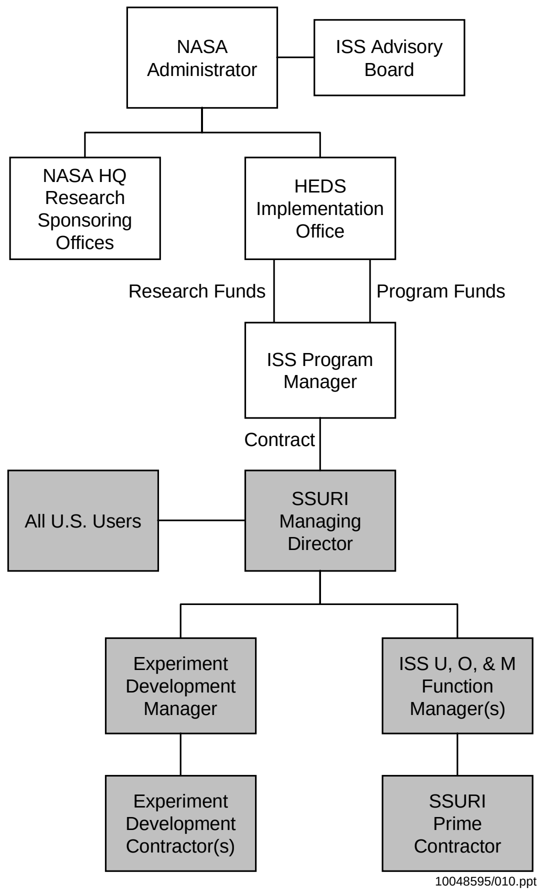

Figure 2-10. Privatized SSURI Prime Option Organization Funding Flow

2.3.4.1 Program Management

The Program Management function for this option is similar to that of the Center Expertise option, including management of the SSURI contract. These functions would be performed by a dedicated Program Office within the NASA Lead Center consistent with current NASA policies governing the roles and responsibilities of NASA Headquarters and Lead Centers. However, most of the day-to-day administration of the program, including the Operations and Maintenance activity, would be delegated to the SSURI through a contract. Therefore, a significant part of the NASA Program Office activity is expected to be one of audit and surveillance of the SSURI activities to ensure compliance with NASA policies and procedures related to program execution. However, the Program Management function within NASA would be responsible for managing the critical inter-program interfaces, such as that with the Space Shuttle program, and would lead the negotiations for NASA institutional resources required to implement the ISS program.

2.3.4.2 Utilization Operations

The Utilization Operations function for the Privatized SSURI Prime option is similar to the Center Expertise option. The SSURI would be responsible to the Program Office for all aspects of Utilization Operations.

2.3.4.3 Flight Systems Operations

Flight Systems Operations is an Operations and Maintenance function and is therefore absorbed to a maximum extent within the SSURI organization. The SSURI may therefore elect to contract such support to a SSURI support contractor or, optionally, to contract for such support directly from NASA operations organizations. In either case, the SSURI would be responsible for controlling the level of support provided. NASA may negotiate responsibility for certain GAFs similar to those existing on the SFOC today in order to maintain civil service core skills. These GAFs include flight crew selection and assignment and real-time mission control operations. This is because it is anticipated that the flight crew cadre would remain government employees and because the real-time flight control execution is a critical core skill for NASA in developing future managers. Other activities within this subfunction are anticipated to be CAFs responsible to the SSURI and subject to the process of “insight” management by the SSURI. Indeed, this subfunction is essentially identical to the Center Expertise option since the CAFs in that option already use the process of “insight” management by the government. This role for SSURI employees on CAFs would be one of audit and surveillance of support contractor activities to ensure that certified processes are being followed. The SSURI is responsible to the Program Manager for Flight Systems CoFR.

A principal difference between this option and the Center Expertise option is in contract administration. For the Center Expertise option, the contractor would be a dedicated Flight Systems Operations contractor, and the contract is presumably administered by the Center procurement organization with principal direct technical support by the flight crew operations and mission operations organization. For the Privatized SSURI Prime option, the prime program contractor would be the SSURI and it, in turn, would be supported by either a single support contract or by the implementing center.

2.3.4.4 Logistics and Maintenance Operations

The Logistics and Maintenance Operations function for this option is analogous to that of the Flight Systems Operations function above. It is similar to that of the Center Expertise option, except that the function is absorbed within the SSURI. The SSURI would be responsible to the Program Office for all aspects of Logistics and Maintenance for ISS Flight Systems, ISS multi-experiment facilities, and experiment systems. The SSURI may elect to contract such support directly from a support service contractor or to contract support from the implementing center. NASA may negotiate responsibility for certain GAFs in the interest of maintaining civil service personnel skills. Other functions are anticipated to be CAFs. The NASA role would be functionally the same, that being one of audit and surveillance of contractor performance by the Program Office, because the SSURI would be managed from that level. As with other functions, this option also may not provide the desired synergistic consolidation opportunities of the Center Expertise option because it is part of an all-inclusive program-wide contract. It would, therefore, provide less flexibility to Field Center organizations for implementing their responsibilities.

2.3.4.5 Launch Site Operations

The Launch Site Operations function for this option is analogous to that of the other Operations and Maintenance functions discussed above. The function would be the responsibility of the SSURI. The

SSURI may elect to provide the required support through a SSURI support contract or through the implementing center. The SSURI would be responsible for all aspects of Launch Site Operations, including resupply/return processing, pre-carrier experiment integration and test support, experiment integration and test, launch site support to the PI, and payload-to-vehicle interface tests. As in other Operations and Maintenance functions, NASA may negotiate a role for civil service personnel in order to maintain core skills. The SSURI would be responsible to the Program Manager for the CoFR process.

2.3.4.6 Safety Operations

Safety Operations for this option is similar to that of the Center Expertise option, except that the function is absorbed within the SSURI. Therefore, the SSURI may elect to provide this support through a separate SSURI support contract, through a SSURI general support contract, or through separate implementing center safety contract(s). Functional synergism within the program would be provided by the SSURI general support contract option but may be lost with the other options.

In this option, the SSURI would be responsible for overall payload and Operations and Maintenance safety. The Study Team envisioned that the SSURI would implement approved NASA safety processes under NASA audit and surveillance. The SSURI would be responsible to the Program Manager for all related CoFRs. NASA would be responsible for certifying that the SSURI and its support contractors follow approved processes, as well as for the overall CoFR.

2.3.4.7 Sustaining Engineering and P3I

Sustaining Engineering and P3I for the ISS systems under this option are generally the responsibility of the program with support of the SSURI organization. Sustaining Engineering, in the sense of supporting the maintenance of the as-delivered capability of the flight systems and avoiding obsolescence, would be primarily a SSURI responsibility within this overall function. The SSURI may elect to provide this support through a SSURI support contract(s) or by implementing a center contract for assigned systems. For this subfunction, the Study Team generally envisioned NASA's role as one of audit and surveillance, i.e., one of "insight." However, control of requirements for P3I would be a NASA responsibility, in concert with the SSURI, because the ISS is a government-owned facility with international commitments. Development and implementation of approved P3I would be performed by the SSURI.

2.3.4.8 How the Privatized SSURI Prime Option Works

Operations Concept. This option can be implemented only if all transportation and logistics processes have operated for several years without significant problems. The ISSPO delegates responsibility to the SSURI in performing all normal Operations and Maintenance functions. The analysis and manifesting activities are supported by Sustaining Engineering, and safety support comes from the appropriate SSURI support contractor. The ISSPO is responsible for contract "insight" monitoring and for arranging transportation services. The SSURI assumes management of ground flight, and logistics and safety operations. The SSURI Utilization Operations functions are similar to those discussed in the Center Expertise option.

Organization. The structure is similar to Single Prime option. It uses the current Lead Center approach with direct support provided by the SSURI as the prime contractor with NASA "insight" responsibility. All Operations and Maintenance and Utilization activities are assigned to the SSURI.

Contracts. The program uses a prime contract to the SSURI to support all ISSPO and Operations and Maintenance Utilization. The Utilization payload development function is supported by the prime contract or by new contract competitions.

***Authority*.** The SSURI manager is responsible for day-to-day operations. The ISSPO Program Manager is the point of authority for all ISSPO out-of-family Operations and Maintenance functions. The ISSPO manager resolves conflicts related to safety-of-flight issues, as required, and manages the overall ISS configuration.

***Funding*.** The ISSPO NASA directly funds all ISS development and operations contracts and Utilization development and operations. NASA Headquarters funds the PIs.

***Budget*.** The OSF obtains funding based on requests developed by the ISSPO and the Utilization codes for ISS research development. The ISSPO Program Manager is the advocate for the total budget. PI funding is advocated by the NASA Headquarters Utilization codes.

2.3.5 Dedicated Commercial Option: Private Corporation Has Obtained Rights to and Interests of the ISS and Operates It for Profit

Figure 2-11 shows the organizational funding flow for the Dedicated Commercial option.

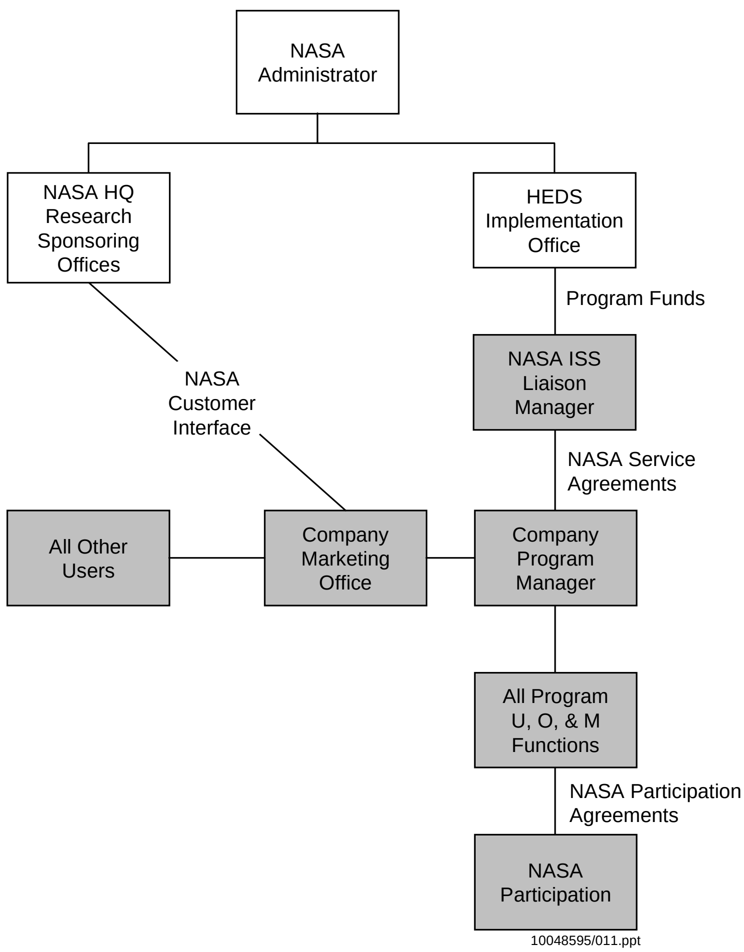

Figure 2-11. Dedicated Commercial Option Organization Funding Flow

2.3.5.1 Program Management

The Dedicated Commercial option is generally characterized as eliminating NASA participation in the ISS program except as a customer, if the program is commercially self-sustaining. Because the Study

Team did not believe this to be the case, NASA would continue to play a small but significant management role in this option. In particular, NASA Headquarters is envisioned to be responsible for advocating the interests of the program and acquiring government funding subsidies as needed to support the program infrastructure that is supplied by a commercial entity. NASA Headquarters would also continue to lead the government effort in coordinating international partner participation in the overall endeavor and ensuring U.S. compliance with the terms of the various inter-governmental agreements. And, because the program is not totally self-supporting, NASA would play a role in developing program strategic planning and in program public affairs. These latter two roles are envisioned to be mainly policy establishment. NASA would participate on the Board of Directors for the commercial enterprise operating the ISS as long as government subsidies are applied.

NASA would also play a supporting role in Flight Systems Operations and Safety Operations under the assumption that the flight crew (at least partially) would continue to be supplied by NASA and that the Flight Systems Operations supporting facilities would be operated in a “host” mode by NASA. This is reasonable, given that the facilities are shared between the ISS and Space Shuttle. Because of this role, NASA would also support safety activities, including specification of safety requirements and safety assessments. The Study Team envisioned direct agreements between the commercial enterprise and the affected NASA line organizations for this support.

2.3.5.2 Utilization Operations

The commercial enterprise responsible for the operation of the ISS would also be responsible for all aspects of Utilization Operations. As such, it would be responsible for outreach, pricing, contract establishment with users, integration processes, and payload operations accommodations and support. Whether an organization similar to the SSURI would be employed, or not, would be a prerogative of the commercial enterprise. In either case, it is envisioned that Utilization would be market driven and subject to the normal regulations of U.S. commerce activity.

NASA’s role in Utilization Operations would be that of a user. NASA Headquarters would still select the research to be supported by NASA funding and provide the funding. The Study Team envisioned that the Center RPOs, the various NASA-sponsored research institutes, or the Commercial Space Centers (as appropriate to the selected research) would support implementation.

2.3.5.3 Flight Systems Operations

Flight System Operations would generally be the responsibility of the commercial enterprise in this option. However, the Study Team envisioned that NASA would continue to supply at least part of the flight crew in order to maintain that core skill. Similarly, NASA would retain key positions associated with real-time mission control and flight crew training operations. The team also envisioned that many of the Flight System Operations ground support facilities would be operated in the “host” mode since the facilities are shared with other programs. Under these assumptions, NASA would support the commercial enterprise with flight crew selection and training; real-time operations planning and execution; and ground facility operations. The commercial enterprise would essentially contract for these services as a constraint to NASA awarding it the ISS “franchise.” The commercial enterprise would remain accountable and responsible for all aspects of the operation, including NASA support. NASA would maintain a small cadre of technical personnel in support of the above activities. It would be comprised of flight crew members, supported by medical personnel and flight controllers and training instructors.

2.3.5.4 Logistics and Maintenance Operations

Logistics and Maintenance Operations in this option would be the entire responsibility of the commercial enterprise.

2.3.5.5 Launch Site Operations

Launch Site Operations in this option would be the responsibility of the commercial enterprise, but it was envisioned that some of the KSC support facilities might still be required and be operated by NASA in the "host" mode. The Space Station Processing Facility (SSPF) would continue to be needed to support turnaround processing of ISS carriers. Other facilities would also be required to support propulsion module servicing and crew return vehicle servicing. This facility support would be purchased from the responsible NASA implementing center by the commercial enterprise. The implementing center may negotiate NASA personnel participation in these activities in the interest of maintaining NASA technical skills.

2.3.5.6 Safety Operations

Implementation of Safety Operations would be the responsibility of the commercial enterprise in this option. However, because of continuing NASA participation in providing some of the crew members, NASA would continue to participate in the Safety Operations processes. In particular, NASA would be responsible for program safety requirements and audit and surveillance of commercial enterprise practices to ensure that proper safety processes are being followed. However, responsibility for the CoFR process would belong to a commercial enterprise.

2.3.5.7 Sustaining Engineering and P3I

Sustaining Engineering and P3I would be responsibilities of the commercial enterprise for this option. NASA would support planning for P3I, as part of ISS strategic planning support, as long as the ISS program receives government subsidies, but the commercial enterprise would be responsible for P3I implementation, even if NASA funds P3I.

2.3.5.8 How the Dedicated Commercial Option Works

Operations Concept. A private corporation operates the ISS in support of corporate objectives. This option can be implemented only if all transportation and logistics processes have operated for several years without significant problems. NASA supports the corporation in selected areas (e.g., safety, transportation, and flight crew support functions), consistent with negotiated service agreements. The corporation assumes responsibility for all Operations and Utilization functions, while NASA participates only as a customer. The corporation assesses the needs, establishes the manifest, conducts the increment operations, and provides resources for all activities.

***Organization*.** This would be a corporate option. NASA would maintain small liaison offices to deal with international partner agreements and corporation-negotiated services. NASA Headquarters would be an advocate for funds and work with the international partners to maintain agreements.

***Contracts*.** None specifically. Service agreements would be put in place for NASA support.

***Authority*.** The corporation would assume all Utilization responsibility.

Funding. The corporation directly funds all ISS development and operations activity. NASA Headquarters funds the PIs and associated hardware development.

***Budget*.** The OSF obtains any government subsidies to be applied to this endeavor. The Headquarters Utilization codes advocate for the NASA PI research and development budget.

2.3.5.9 General Comments on the Dedicated Commercial Option

This option assumes that the ISS is "obtained," in some manner, by a commercial enterprise and is operated in a profit-seeking mode under company risk. NASA involvement, other than as a customer, is very little. It could be none at all, except for retention of flight crew and flight controller critical skills participation and management participation resulting from the need to manage subsidy provisions. Also, pursuit of a viable research program onboard the ISS would be entirely subject to market conditions, although it would be reasonable for NASA to insist on favorable treatment in partial exchange for releasing the ISS to the commercial enterprise for utilization and operations.

2.4 Comparison of Function Allocations for the Five Architecture Options

Tables 2-2 through 2-6 show, for each option, the allocated functions in terms of

- Organizational responsibilities
- Supporting contractor roles

The notations “P” and “S” stand for “Prime” and “Support” responsibility. The notes following Table 2-6 describe respective contractor responsibilities.

Table 2-2. Center Expertise Option Function Allocations

Function	Responsible Party			Implementation Responsibility			
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor
A. ISS Program Management							
1. Advocacy and Funding Acquisition	P	S	S	P		S	
2. Program Policy, International Partner Management	P	S		P			
3. Program Public Affairs	P	S	S	P		S	
4. Program Integrated Strategic/Requirements and Planning	P	S	S	P		S	
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S	P	S	P		S	
6. Budget/Business Management		P		P			
7. Safety Requirements		P		P			
8. Configuration Management		P		P			
B. ISS Utilization Operations							
1. Utilization/Education Outreach	S		P	S		P	S(B1)
2. Utilization Policy Support	P		S	P		S	S(B1)
3. Research Selection	P		S	P		S	S(B1)
4. Utilization Strategic Planning and Requirements	P		S			P	S(B1)
5. Utilization Tactical Planning and Requirements			P			P	S(B1)
6. Experiment Development			P			S	P(Bn)
7. Experiment Results Analysis and Dissemination			P			S	P(PI)
8. Experiment-to-Experiment Facility Integration		S	P		S(C1)	P	S(B1)
9. Utilization Operations Integration Planning			P			P	S(B1)
10. Experiment Crew Training		S	P		S(C1)	P	S(B1)
11. Utilization Operations Real-Time Execution			P			P	S(B1)
C. ISS Flight System Operations							
1. System Availability Planning		P		S	P(C1)		
2. Payload/Experiment Analytical Integration		P	S	S	P(C1)	S	S(B1)
3. Increment System Planning and Requirements		P		S	P(C1)		
4. Increment Integration Planning		P	S	S	P(C1)	S	S(B1)
5. Flight Crew Selection and Assignment		P	S	P		S	
6. System and Integration Crew Training		P	S	S	P(C1)	S	S(B1)
7. Real-Time System Operations Execution		P		P	S(C1)		
D. ISS Logistics and Maintenance Operations							
1. ISS Flight Systems							
On Orbit		P		S	P(Gm)		
Ground		P		S	P(Gm)		
2. Multi-Experiment Facilities							
On Orbit		S	P	S	P(Gm)		S(B1)
Ground		S	P	S	P(Gm)		S(B1)
E. ISS Launch Site Operations							
1. Resupply/Return Processing		P	S		P(E1)		S(B1)
2. Pre-Carrier Experiment Integration and Test Support		S	P		P(E1)		S(B1)
3. Experiment Integration and Test			P	S	P(E1)		
4. Site Support to SSURI/PI			P			S	P(SC)
5. Payload-to-Vehicle Interface Test		P	S		P(E1)		S(B1)
F. ISS Safety Operations							
1. Experiment-to-Experiment Facilities			P			P	S(B1)
2. ISS Flight Systems		P		P	S(F1)		
3. Integrated Safety Assessment		P	S	P	S(F1)	S	S(B1)
G. ISS Sustaining Engineering and P3I							
1. Multi-Experiment Facilities		S	P	S	S(Gn)	P	S(Gn)
2. ISS Systems		P	S	P	S(Gm)		

Table 2-3. Program Evolution Option Function Allocations

Function	Responsible Party			Implementation Responsibility			
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor
A. ISS Program Management							
1. Advocacy and Funding Acquisition	P	S		P			
2. Program Policy, International Partner Management	P	S		P			
3. Program Public Affairs	P	S		P			
4. Program Integrated Strategic/Requirements and Planning	S	P		P			
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S	P		P			
6. Budget/Business Management		P		P			
7. Safety Requirements		P		P			
8. Configuration Management		P		P			
B. ISS Utilization Operations							
1. Utilization/Education Outreach	S	P		P	S(B1)		
2. Utilization Policy Support	P			P			
3. Research Selection Recommendation/Approval	P	S		P	S(B1)		
4. Utilization Strategic Planning and Requirements	P			P	S(B1)		
5. Utilization Tactical Planning and Requirements		P		P	S(B1)		
6. Experiment Development		P		S	P(Bn)		
7. Experiment Results Analysis and Dissemination		P		S	P(PI)		
8. Experiment-to-Experiment Facility Integration		P		P	S(C1) S(B1)		
9. Utilization Operations Integration Planning		P		P	S(B1)		
10. Experiment Crew Training		P		P	S(B1) S(C1)		
11. Utilization Operations Real-Time Execution		P		P	S(B1)		
C. ISS Flight System Operations							
1. System Availability Planning		P		S	P(C1)		
2. Payload/Experiment Analytical Integration		P		S	P(C1) S(B1)		
3. Increment System Planning and Requirements		P		S	P(C1)		
4. Increment Integration Planning		P		S	P(C1) S(B1)		
5. Flight Crew Selection and Assignment		P		P			
6. System and Integration Crew Training		P		S	P(C1) S(B1)		
7. Real-Time System Operations Execution		P		P	S(C1)		
D. ISS Logistics and Maintenance Operations							
1. ISS Flight Systems							
On Orbit		P		S	P(C1)		
Ground		P		S	P(D1)		
2. Multi-Experiment Facilities							
On Orbit		P		S	P(C1) S(B1)		
Ground		P		S	P(D1) S(B1)		
E. ISS Launch Site Operations							
1. Resupply/Return Processing		P		P	S(E1) S(B1)		
2. Pre-Carrier Experiment Integration and Test Support		P		P	S(E1) S(B1)		
3. Experiment Integration and Test		P		P	S(E1) S(B1)		
4. Site Support to SSURI/PI		P		P	S(E1) S(B1)		
5. Payload-to-Vehicle Interface Test		P		P	S(E1) S(B1)		
F. ISS Safety Operations							
1. Experiment-to-Experiment Facilities		P		P	S(B1)		
2. ISS Flight Systems		P		P	S(F1)		
3. Integrated Safety Assessment		P		P	S(F1)		
G. ISS Sustaining Engineering and P3I							
1. Multi-Experiment Facilities		P		P	S(Gn)		
2. ISS Systems		P		P	S(Gm)		

Table 2-4. Single Prime Option Function Allocations

Function	Responsible Party			Implementation Responsibility			
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor
A. ISS Program Management							
1. Advocacy and Funding Acquisition	P	S	S	P		S	
2. Program Policy, International Partner Management	P	S		P			
3. Program Public Affairs	P	S	S	P		S	
4. Program Integrated Strategic/Requirements and Planning	S	P		P			
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S	P		P			
6. Budget/Business Management		P		P			
7. Safety Requirements		P		P			
8. Configuration Management		P					
B. ISS Utilization Operations							
1. Utilization/Education Outreach	S		P			P	S(B1)
2. Utilization Policy Support	P		S	P		S	S(B1)
3. Research Selection	P		S	P		S	S(B1)
4. Utilization Strategic Planning and Requirements	P		S	P		S	S(B1)
5. Utilization Tactical Planning and Requirements			P			P	S(B1)
6. Experiment Development			P			S	P(Bn)
7. Experiment Results Analysis and Dissemination			P			S	P(PI)
8. Experiment-to-Experiment Facility Integration		S	P			P	S(B1)
9. Utilization Operations Integration Planning			P			P	S(B1)
10. Experiment Crew Training		S	P			P	S(B1)
11. Utilization Operations Real-Time Execution			P			P	S(B1)
C. ISS Flight System Operations							
1. System Availability Planning		P		S	P(SPC)		
2. Payload/Experiment Analytical Integration		P	S	S	P(SPC)	S	S(B1)
3. Increment System Planning and Requirements		P		S	P(SPC)		
4. Increment Integration Planning		P	S	S	P(SPC)	S	S(B1)
5. Flight Crew Selection and Assignment		P	S	P		S	
6. System and Integration Crew Training		P	S	S	P(SPC)	S	S(B1)
7. Real-Time System Operations Execution		P		P	S(SPC)		
D. ISS Logistics and Maintenance Operations							
1. ISS Flight Systems							
On Orbit		P		S	P(SPC)		
Ground		P		S	P(SPC)		
2. Multi-Experiment Facilities							
On Orbit		S	P	S	P(SPC)		S(B1)
Ground		S	P	S	P(SPC)		S(B1)
E. ISS Launch Site Operations							
1. Resupply/Return Processing		P	S		P(SPC)		S(B1)
2. Pre-Carrier Experiment Integration and Test Support		S	P		P(SPC)		S(B1)
3. Experiment Integration and Test			P	S	P(SPC)		S(B1)
4. Site Support to SSURI/PI			P			S	P(SC)
5. Payload-to-Vehicle Interface Test		P	S		P(SPC)		S(B1)
F. ISS Safety Operations							
1. Experiment-to-Experiment Facilities			P			P	S(B1)
2. ISS Flight Systems		P		P	S(SPC)		
3. Integrated Safety Assessment		P	S	P	S(SPC)	S	S(B1)
G. ISS Sustaining Engineering and P3I							
1. Multi-Experiment Facilities		S	P	S	S(SPC)	P	S(SPC)
2. ISS Systems		P	S	P	S(SPC)		

Table 2-5. Privatized SSURI Prime Option Function Allocations

Function	Responsible Party			Implementation Responsibility			
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor
A. ISS Program Management							
1. Advocacy and Funding Acquisition	P	S	S	P		S	
2. Program Policy, International Partner Management	P	S		P			
3. Program Public Affairs	P	S	S	P		S	
4. Program Integrated Strategic/Requirements and Planning	S	P	S	P			
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S	P	S	P			
6. Budget/Business Management		P		P			
7. Safety Requirements		P		P			
8. Configuration Management		P		P		S	S(SC)
B. ISS Utilization Operations							
1. Utilization/Education Outreach	S		P			P	S(SC)
2. Utilization Policy Support	P		S	P		S	S(SC)
3. Research Selection	P		S	P		S	S(SC)
4. Utilization Strategic Planning and Requirements	P		S			S	S(SC)
5. Utilization Tactical Planning and Requirements			P			P	S(SC)
6. Experiment Development			P			S	P(Bn)
7. Experiment Results Analysis and Dissemination			P			S	P(PI)
8. Experiment-to-Experiment Facility Integration		S	P			P	S(SC)
9. Utilization Operations Integration Planning			P			P	S(SC)
10. Experiment Crew Training		S	P			P	S(SC)
11. Utilization Operations Real-Time Execution			P			P	S(SC)
C. ISS Flight System Operations							
1. System Availability Planning		P				S	P(SC)
2. Payload/Experiment Analytical Integration		P	S			S	P(SC)
3. Increment System Planning and Requirements		P				S	P(SC)
4. Increment Integration Planning		P	S			S	P(SC)
5. Flight Crew Selection and Assignment		P	S	P		S	
6. System and Integration Crew Training		P	S			S	P(SC)
7. Real-Time System Operations Execution		P		S		P	S(SC)
D. ISS Logistics and Maintenance Operations							
1. ISS Flight Systems							
On Orbit		P				S	P(SC)
Ground		P				S	P(SC)
2. Multi-Experiment Facilities							
On Orbit		S	P			S	P(SC)
Ground		S	P			S	P(SC)
E. ISS Launch Site Operations							
1. Resupply/Return Processing		P	S			S	P(SC)
2. Pre-Carrier Experiment Integration and Test Support		S	P			S	P(SC)
3. Experiment Integration and Test			P			S	P(SC)
4. Site Support to SSURI/PI			P			S	P(SC)
5. Payload-to-Vehicle Interface Test		P	S			S	P(SC)
F. ISS Safety Operations							
1. Experiment-to-Experiment Facilities			P			P	S(SC)
2. ISS Flight Systems		P		S		P	
3. Integrated Safety Assessment		P	S	S		P	S(SC)
G. ISS Sustaining Engineering and P3I							
1. Multi-Experiment Facilities		S	P	S		P	S(SC)
2. ISS Systems		P	S	S		P	S(SC)

Table 2-6. Dedicated Commercial Option Function Allocations

Function	Responsible Party			Implementation Responsibility	
	NASA HQTRS	NASA Centers	Commercial Enterprise	Civil Servant	Commercial Enterprise
A. ISS Program Management					
1. Advocacy and Funding Acquisition	P	S	S	P	
2. Program Policy, International Partner Management	P	S	S	P	
3. Program Public Affairs	S	S	P	S	P
4. Program Integrated Strategic/Requirements and Planning	S		P	S	P
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S		P		P
6. Budget/Business Management			P		P
7. Safety Requirements		P	S	P	S
8. Configuration Management			P		P
B. ISS Utilization Operations					
1. Utilization/Education Outreach	S		P		P
2. Utilization Policy Support	S		P		P
3. Research Selection Recommendation/Approval	P		S	P	S
4. Utilization Strategic Planning and Requirements			P		P
5. Utilization Tactical Planning and Requirements			P		P
6. Experiment Development			P		P
7. Experiment Results Analysis and Dissemination			P		P
8. Experiment-to-Experiment Facility Integration			P		P
9. Utilization Operations Integration Planning			P		P
10. Experiment Crew Training			P		P
11. Utilization Operations Real-Time Execution			P		P
C. ISS Flight System Operations					
1. System Availability Planning			P		P
2. Payload/Experiment Analytical Integration			P		P
3. Increment System Planning and Requirements			P		P
4. Increment Integration Planning			P		P
5. Flight Crew Selection and Assignment		S	P	S	P
6. System and Integration Crew Training		S	P	S	P
7. Real-Time System Operations Execution		S	P	S	P
D. ISS Logistics and Maintenance Operations					
1. ISS Flight Systems					
On Orbit			P		P
Ground			P		P
2. Multi-Experiment Facilities					
On Orbit			P		P
Ground			P		P
E. ISS Launch Site Operations					
1. Resupply/Return Processing			P		P
2. Pre-Carrier Experiment Integration and Test Support			P		P
3. Experiment Integration and Test			P		P
4. Site Support to SSURI/PI			P		P
5. Payload-to-Vehicle Interface Test			P		P
F. ISS Safety Operations					
1. Experiment-to-Experiment Facilities			P		P
2. ISS Flight Systems		S	P	S	P
3. Integrated Safety Assessment		S	P	S	P
G. ISS Sustaining Engineering and P3I					
1. Multi-Experiment Facilities			P		P
2. ISS Systems			P		P

Notes for Tables 2-2 through 2-6

Table 2-2 Notes: Center Expertise Option

1. P = Prime; S = Support
2. (B1) = SSURI Support Services Contractor; (Bn) = SSURI Experiment Systems Development Contractor(s)—maybe through Research Program Office (RPO)
3. PI = Principal Investigator
4. (C1) = ISS Flight Systems Operations Contractor
5. (E1) = ISS Launch Site Operations Contractor
6. (F1) = ISS Safety Operations Contractor
7. (Gn) = Multi-Experiment Facilities Development Contractor(s)
8. (Gm) = ISS P3I Development Contractor(s)
9. (SC) = SSURI Support Contractor

Table 2-3 Notes: Program Evolution Option

1. P = Prime; S = Support
2. (B1) = ISS Utilization Operations Contractor; (Bn) = Experiment Systems Development Contractor(s)—possibly through Research Program Office (RPO)
3. PI = Principal Investigator
4. (C1) = ISS Flight Systems Operations Contractor
5. (D1) = ISS Logistics and Maintenance Contractor
6. (E1) = ISS Launch Site Operations Contractor
7. (F1) = ISS Safety Operations Contractor
8. (Gn) = Multi-Experiment Facilities Development Contractor(s)
9. (Gm) = ISS P3I Development Contractor(s)

Table 2-4 Notes: Single Prime Option

1. P = Prime; S = Support
2. (B1) = SSURI Support Services Contractor; (Bn) = SSURI Experiment Systems Development Contractor(s)—maybe through Research Program Office (RPO)
3. PI = Principal Investigator
4. (SPC) = Single Prime Contractor
5. (SC) = SSURI Support Contractor

Table 2-5 Notes: Privatized SSURI Prime Option

1 P = Prime; S = Support

2. (SC) = SSURI Support Contractor
3. (Bn) = SSURI Experiment Systems Development Contractor(s)—perhaps through Research Program Office (RPO)
4. PI = Principal Investigator

Table 2-6 Notes: Dedicated Commercial Option

1. P = Prime; S = Support

Section 3. Architecture Evaluations and Cost-Benefit Analysis for the Recommended Option

3.1 Overview

The Study Team evaluated all five architecture options for the early years of ISS Operations. The team selected the Center Expertise option as the one that would best meet NASA's overall goals contained in the *Human Exploration and Development of Space (HEDS) Strategic Plans* and the specific goal of improving the quality and quantity of science and technology on the ISS. Section 3.2 discusses the results of these evaluations. In addition to best meeting the above-mentioned goals, the Center Expertise option offers the least composite risk of all the options considered. Section 3.3 describes the risk assessment performed on the options. After selecting the Center Expertise option, the Study Team performed a cost-benefit analysis (CBA) on it. The full CBA can be found in Section 3.4; in essence, it posits that the tangible and intangible benefits would outweigh the costs if the Center Expertise option were implemented. However, costs would precede benefits because of creating the SSURI.

All the options had strengths and weaknesses, and some of the benefits described here could be achieved by the current (Program Evolution) option, e.g., reducing the time to integrate payloads into the ISS if NASA decided to pursue those benefits. The Study Team drew on the experience of the Hubble Space Telescope Science Institute (STScI) in its assessments and on the expertise of the team members, who felt strongly about the benefits for developing center expertise. The team understands that NASA will be required to spend some money and experience some disruption in creating the SSURI, but team members believe that, in the long run, benefits will greatly outweigh near-term costs. The Center Expertise option offers NASA a path to significantly enhance and focus its already excellent research capability; maintain civil service expertise for new programs; take advantage of Field Center leadership and expertise; reduce costs due to increasing contract competition on a local basis; and generate a true Customer-Supplier relationship between the SSURI and the ISSPO. That relationship would work to remove roadblocks to success and find ways to streamline processes. In addition, the path also enables a gradual phaseover to a more privatized approach after stable operations have existed for a few years, if NASA so desires. A privatized entity would allow the civil service work force to migrate to new, large-scale human spaceflight programs.

The following paragraphs present the detailed evaluations, beginning with the ability of the options to meet NASA's goals as contained in the HEDS Strategic Plans.

3.2 Evaluation of the Five Options' Ability To Achieve the Goals of the HEDS Strategic Plans

The goals in the HEDS Strategic Plan are to

- Enable Humans To Live and Work Safely in Space
- Facilitate the Expansion of Scientific Knowledge
- Foster the Commercial Development of Space
- Facilitate the Exploration of the Space Frontier
- Foster Sharing the Experience and Benefits of Discovery

For each strategic goal, NASA defined subgoals to assist in understanding the initiative area. These subgoals were added to the strategic plan goals above and then ranked on a 1-through-7 basis. See

Table 3-1 at the end of Section 3.2. Scores of 1 through 7 are based on the degree of emphasis each architecture places on the NASA primary objective, e.g., a rating of 7 means that this given objective will be a primary focus of the option; a rating of 4, a secondary focus and a lesser objective and even lower score. To achieve a score of 7, evidence that this is a primary objective of the option would be confirmed by multiple attributes that contribute to the achievement of the objective. Scoring at the secondary-objective level would require at least one significant attribute to achieve a score of 4. A score of 1 indicates no significant attributes relative to this objective. Before this numerical evaluation, each of the five options was discussed in terms of its advantages and disadvantages. Option 2 received an overall ranking of 6.20, followed closely by Option 3 with 5.60. Option 4 received a 5.30; Option 1, a ranking of 4.58; and Option 5, a ranking of 2.48.

3.2.1 Option 1: Program Evolution

Advantages

- Causes less impact to ongoing program activities focused on ISS Assembly; is less disruptive to an already complex process
- Is a clear advantage to ISS Assembly focus
- Makes primary focus on the ISS facility
- Provides NASA an opportunity to grow “smart buyers” in both ISS Utilization and Operations and Maintenance areas
- Retains and uses established government and contractor program and systems

Disadvantages

- Makes utilization planning (Operations era) less of a priority to program than Assembly
- Shifts funds to the right
- Lacks program focus on end-to-end Utilization process; no single individual feels responsibility to implement a user-friendly Utilization system
- Fragments Utilization responsibility across NASA Headquarters and Lead/Support Centers
- Drives current payload integration timelines and processes based on 3-year integration templates
- Uses only minimal planning to take full advantage (timeline/cost) of excellent ISS science tools and facilities
- Lacks sense of ownership by science and commercial users

3.2.2 Option 2: Center Expertise

Advantages

- Strengthens focus on ISS Utilization
- Strengthens sense of ownership by science and commercial customers, with an intent to broaden U.S. science and commercial involvement/support of space science and commercial research

- Achieves best U.S. science and commercial research through broadening of U.S. support and involvement base
- Ensures highest quality and quantity of science
- Improves outreach and opens program to a wider range of participants
- May offer additional funding through broader constituency
- Enhances Field Center participation and sense of ownership and responsibility within the program
- Provides NASA an opportunity to grow “smart buyers” in both ISS Utilization and Operations and Maintenance areas by retention of NASA Field Center expertise
- Retains and uses established government and contractor program and systems

Disadvantages

- Could result in adding one more element to an already complex utilization process by adding a SSURI
- Seen as being premature or disruptive to focus on Utilization (to this extent) at the present time in Assembly (Program belief)

3.2.3 Option 3: Single Prime

Advantages

- Strengthens focus on ISS Utilization
- Strengthens sense of ownership by science and commercial customers with an intent to broaden U.S. science and commercial involvement/support of space science and commercial research
- Achieves best U.S. science and commercial research through broadening of U.S. support and involvement base
- Ensures highest quality and quantity of science
- Improves outreach and opens program to a wider range of participants
- May offer additional funding through broader constituency
- Provides NASA opportunity to grow “smart buyers” in ISS Utilization areas

Disadvantages

- Could result in adding one more element to an already complex utilization process by adding a SSURI
- Seen as being premature or disruptive to focus on Utilization (to this extent) at the present time in Assembly
- Limits ISS competitive contracting, which could result in higher cost/less efficiency in the long term
- Eliminates participation of a broader base of U.S. industry in ISS Operations and Maintenance, together with the innovation resulting from competition and broader participation

- Limits NASA Field Center participation; diminishes sense of ownership; and impacts the ability to grow “smart buyers” in ISS Operations and Maintenance area
- Limits NASA ability to synergize around functional skill base across multiple programs
- Poses more removed, complicated management of implementation at NASA Field Centers

3.2.4 Option 4: Privatized SSURI Prime

Advantages

- Provides strongest possible ISS focus on Utilization because the SSURI would control all ISS assets
- Strengthens sense of ownership by science and commercial customers, with an intent to broaden U.S. science and commercial involvement/support of space science and commercial research
- Achieves best U.S. science and commercial research through broadening of U.S. support and involvement base
- Could result in more innovative and streamlined user processes, thus optimizing quality and quantity of science
- Improves outreach and opens program to a wider range of participants
- May offer additional funding through broader constituency
- Reduces NASA involvement; could free up resources for other NASA programs

Disadvantages

- May tie up NASA facilities and resources if NASA provides “host” mode support to the SSURI and then the SSURI contracts back to NASA for Operations and Maintenance flight operations
- Could result in same ISS participants (at almost same level) as Center Expertise option, but with a much more complex set of relationships and interfaces
- Could result in adding one more element to an already complex utilization process by adding a SSURI
- Seen as being premature or disruptive to focus on Utilization (to this extent) at the present time in Assembly (Program belief)
- Could limit NASA Field Center participation and ability to grow “smart buyers” in ISS Utilization and Operations and Maintenance areas
- Could limit NASA ability to synergize around functional skill base across multiple programs

3.2.5 Option 5: Dedicated Commercial

Advantages

- Calls for minimal NASA/government involvement in ISS; frees up NASA resources
- Could result in more innovative commercial approaches for utilization community
- Places higher priority on commercial applications in space

Disadvantages

- Still requires extensive government funds, with minimal government oversight
- Provides national resource to a single U.S. company or consortium
- Eliminates competition and potential broader U.S. participation in ISS; could reduce support base/constituency
- May present issues to international partners
- Limits NASA ability to grow expertise and “smart buyers” for future missions
- May still require significant NASA resources to provide STS transportation and flight crew operations
- Could cause loss of synergy in mission operations, mission planning, and analytical integration with the Space Shuttle

Table 3-1. Scoring Likelihood That a Given Option Will Help NASA Achieve the HEDS Strategic Plans (1 of 2)

Evaluation Criterion	Architecture Attributes – Weights	Program Evolution	Center Expertise	Single Prime	Privatized SSURI Prime	Dedicated Commercial	Rationale
Enable Humans To Live and Work Safely in Space	30%						
Provide safe, affordable, and improved access to space	Attributes: --Has strong focus on human spaceflight safety --Reduces cost of getting an experiment on-board --Reduces the time required from selection to flight	7	7	5	4	1	Access to space here is interpreted as the transportation system. Option 5 is ranked below the other three options because it emphasizes the commercial aspects of space utilization, not provision of access.
Operate the ISS to advance science, exploration, engineering, and commerce	Attributes: --Maximizes the resources available to conduct science, exploration, engineering, and commerce --Provides a balanced approach to achieve objectives in all four of the above areas --Maintains the ISS to minimize downtime --Plans system upgrades to improve operation	6	7	4	4	4	Option 2 ranks highest because this objective is one of the primary reasons for establishing an institute. Option 4 may have a clear advantage in the long term as stable, mature operations are reached and funding becomes available from sources other than NASA. However, in the near term, a privatized SSURI may not have exploration and engineering advances as its highest priorities; thus, it gets a slightly lower rank.
Ensure the health, safety, and performance of humans living and working in space	Attributes: --Selects astronauts with good health --Provides generic and specific task-oriented training for crew --Develops procedures for contingencies related to specific experiment malfunctions --Has strong focus on ensuring that ISS facility/systems are operated, maintained, and upgraded to ensure health, safety, and human performance in space, along with strong focus on contingency plans, procedures, and equipment	7	7	7	4	1	Options 1, 2, and 3 fully meet this objective. Option 4 gets a ranking of 4 due to complexity and safety impact. Option 5 ranks lowest because profit motives may inadvertently lead to compromises in crew health and safety.
Meet sustained space operations needs while reducing costs	Attributes: --Fosters development of low-cost launch and return services --Provides user-friendly process for getting research payloads into space --Has proactive focus on reducing cost without impact on safety; examples include lower-cost launch and return services, reduced PI cost, and timeliness while improving on-orbit research environment	5	7	4	4	3	Option 2 ranks highest because of the functional alignment of responsibilities, e.g., logistics and maintenance labor costs are expected to be lower than major aerospace manufacturers' costs due to lower "wrap rates." Options 3 and 4 rank slightly lower than Option 2 because the Single Prime and the Privatized SSURI Prime would likely not place as high a priority on providing low-cost launch-and-return services.
Weighted Average		1.88	2.10	1.50	1.20	0.68	
Facilitate the Expansion of Scientific Knowledge	30%						
Investigate chemical, biological, and physical systems in the space environment, in partnership with the scientific community	Attributes: --Provides a cooperative environment for selection of the highest quality science for chemical systems --Provides a cooperative environment for selection of the highest quality science for biological systems --Provides a cooperative environment for selection of the highest quality science for physical systems --Provides new facilities as required for new ideas that emerge --Maintains and upgrades existing microgravity research facilities	4	7	7	7	1	Options 2, 3, and 4 are ranked highest (7 of 7) because the SSURI will have this objective as its primary mission. Option 5 is ranked lowest due to its emphasis on the "bottom-line" profit motive.
Expand collaborative research on the ISS that will further human exploration of the solar system	Attributes: --Has a major objective of human life sciences relative to long-duration exposure to the space environment and engineering technology advances related to long-duration spaceflight	4	7	7	7	1	Options 2, 3, and 4 have similar SSURI functions not available in Options 1 or 5. Option 1 includes adequate support, which is not an objective of Option 5.
Extend significantly scientific discovery on missions of exploration through the integrated use of human and machine capabilities	Attributes: --Can accommodate dedicated "campaigns" that are oriented to exploration objectives --Encourages international collaboration	4	7	7	7	1	Options 2, 3, and 4 are ranked highest based on the expectation that having a broader industry involvement will stimulate wider participation across the U.S.
Weighted Average		1.20	2.10	2.10	2.10	0.30	

Table 3-1. Scoring Likelihood That a Given Option Will Help NASA Achieve the HEDS Strategic Plans (2 of 2)

Evaluation Criterion	Architecture Attributes – Weights	Program Evolution	Center Expertise	Single Prime	Privatized SSURI Prime	Dedicated Commercial	Rationale
Foster the Commercial Development of Space	20%						
Improve the accessibility of space to meet the needs of commercial research and development	Attributes: --Requires no government funding --Fosters low-cost launch-and-return services --Provides a user-friendly process for getting research payloads into space --Has strong focus on improved accessibility for commercial R&D purposes --Fosters low-cost launch-and-return services at a reduced cost --Provides a user-friendly process for commercial payloads	4	4	4	4	6	No discriminators exist among the options. None are very good in accomplishing this objective.
Foster commercial endeavors with the ISS and other assets	Attributes: --Minimizes government funding required --Provides user-friendly access to ISS --Protects strong focus on commercial R&D, including proprietary protection --Has strong focus on commercial endeavors --Increases priority on commercial applications in space --Has reduced government cost for commercial support	3	5	5	5	7	Options 2, 3, and 4 have commercial development as primary objectives and are therefore ranked higher than the current program. Option 5 is better than current because it is a commercial enterprise and would try to market the ISS for economic purposes.
Weighted Average		0.70	0.90	0.90	0.90	1.30	
Facilitate the Exploration of the Space Frontier	10%						
Invest in the development of high-leverage technologies to enable safe, effective, and affordable human/robotic exploration	Attributes: --Places major emphasis on the development of robotics and automation to minimize crew involvement in routine operational activities --Encourages investment by the private sector in robotic technologies --Minimizes government funding requirements --Encourages private use of low-cost, unmanned launch vehicles	4	4	4	4	1	Options 1 through 4 receive a ranking of 4 because they retain NASA ISSPO involvement in setting the objectives. Option 5 is ranked lowest because it limits U.S. participation to a single company or consortium and would be focused on a “bottom-line” profit motive.
Conduct engineering and human health research on the ISS to enable exploration beyond Earth orbit	Attributes: --Provides crew with both the skills and the willingness to participate in experiments related to understanding human health effects of long-duration spaceflight	4	4	4	4	1	Options 1 through 4 receive a ranking of 4 because they retain NASA ISSPO involvement in setting the objectives. Option 5 is ranked lowest because it limits U.S. participation to a single company or consortium and would be focused on a “bottom-line” profit motive.
Weighted Average		0.40	0.40	0.40	0.40	0.10	
Foster Sharing the Experience and Benefits of Discovery	10%						
Engage and involve the public in the excitement and the benefits of--and in setting the goals for--the exploration and development of space	Attributes: -- Provides press releases on discoveries made on ISS --Obtains funding from non-NASA sources --Has strong outreach to both the U.S. science and commercial communities and the public --Fully engages user community in ISS utilization and capability enhancement	4	7	7	7	1	Options 2, 3, and 4 rank highest against this objective because of the broader involvement of U.S. industry in all aspects of Operations and Utilization. Option 5 is lowest because it eliminates competition and could dramatically reduce base/constituency.
Advance the scientific, technological, and academic achievement of the U.S. by sharing our knowledge, capabilities, and assets	Attributes: --Has strong outreach to U.S. science, engineering, and academic communities; and fully engages these users in ISS utilization and capability enhancement	4	7	7	7	1	Options 2, 3, and 4 have the SSURI with a charter to communicate the achievements of ISS research and technology endeavors and to promote the utilization for scientific, technological, and economic development objectives. Option 1 is “business as usual,” and Option 5 would give very low priority to this objective.
Weighted Average		0.40	0.70	0.70	0.70	0.10	
TOTAL SCORE	**100%**	**4.58**	**6.20**	**5.60**	**5.30**	**2.48**	

3.3 Risk Assessment

The Study Team performed an assessment to determine the risk related to implementing the options. The team considered each option in terms of its impact on safety, research, schedule, cost schedule, operations, and international partners, NASA's liability risk is discussed in Section 4. Table 3-2 summarizes these risk assessments, and this section explains the rationale used to derive descriptive grades.

Table 3-2. Risk Assessment Summary by Factor

Risk Parameter	Option Name				
	Program Evolution	Center Expertise	Single Prime	Privatized SSURI Prime	Dedicated Commercial
Safety	Very low	Low	Low	Moderate to low	Moderate to high
Research	Moderate	Low	Low	Very low	Moderate to high
Cost	Moderate	Low to moderate	Low to moderate	Low to moderate	Low
Schedule	Moderate	Very low	Low	Low	Moderate
Operations	Low	Very low	Low	Moderate	Moderate to high
International Partner	Low	Low to moderate	Moderate	Moderate	Moderate to high
Composite	**Low to moderate**	**Low to moderate**	**Moderate to low**	**Moderate**	**Moderate to high**

3.3.1 Risk Analysis Summary

Little composite risk is linked to any of the first four options, i.e., Program Evolution, Center Expertise, Single Prime, and Privatized SSURI Prime, with regard to flying science payloads. The Center Expertise option has the lowest risk because it is tailored to integrating and flying this kind of payload. The Program Evolution option is more or less "business as usual," which is effective but not efficient in terms of cost, schedule, and concern for research. The Single Prime option has the benefit of a SSURI within its architecture; but it presents at least the risk of less focus on research, and its potential effect on the international partners needs further study.

The Study Team believes that the Dedicated Commercial option should have the least risk with regard to cost, but it has inherent risks to safety, based on the recent results of the U.S. Air Force's Broad Area Review (BAR). In addition, the ways in which this option would deal with and involve the international partners are unclear. The cultural change associated with this option could create problems, some of which would be mitigated as the organization matures.

3.3.2 Safety Risk

As shown in Table 3-2, the Program Evolution option has very low safety risk; the Center Expertise and Single Prime options have low safety risk; the Single Prime option has moderate-to-low safety risk; and the Dedicated Commercial option has moderate-to-high safety risk. The most significant difference among the first four is that responsibility for the experiment and payload parts of the CoFR has been delegated to lower levels in the hierarchy in the Center Expertise and Single Prime options. Some people might believe that the additional levels of review included in the Program Evolution option would also provide added safety. Because this opinion may have some merit, the Program Evolution option was assigned a risk factor of very low compared with the other options. The Single Prime option was assigned a moderate-to-low safety risk because of the loss of relationship with NASA programs and their infrastructures at the Field Centers, e.g., the Shuttle Program. In the opinion of the Study Team, having the SSURI act as a single prime for Operations and Maintenance increases, but not greatly, the safety risks. In the Single Prime option and especially in the Center Expertise option, the long-term relationships among contractors and civil servants with regard to safety is retained. Some of the risk in the Privatized SSURI Prime option could be mitigated with judicious subcontracting. The moderate-to-high risk rating for the Dedicated Commercial option is based on the 1999 findings of the U.S. Air Force BAR team. In the opinion of the BAR team (and the Study Team), a cost incentive in a contract can lead to safety compromises. Maximizing profit would be the principal goal of the Dedicated Commercial option, as it is in any private-sector organization. It would be difficult to mitigate the increased safety risk in the Dedicated Commercial option for long periods because of the conflicting goals of maximizing safety and maximizing profit/minimizing cost.

3.3.3 Research Risk

The Privatized Single Prime option poses low risk because it not only includes a SSURI to ensure that research is emphasized, it also has some ability to ensure that priority is placed on research instead of on the ISS itself. That is, the Privatized Single Prime option can ensure that research is not compromised for ISS product improvement. The Center Expertise and Single Prime options would have low risk because each has a SSURI with goals to ensure the highest quality and quantity of research; broaden participation in research throughout the research communities; and simplify and reduce the processes required to fly payloads, for example. The Program Evolution option has moderate research risk, based on current processes, participation, and so on, or based on a linear evolution of current processes and participation. It was this risk that was partly responsible for commissioning this study. The Dedicated Commercial option would have moderate-to-high risk to research because of what H. D. Action called the “profit motive.” Because it is unlikely that high profits will accrue from research (as opposed to commercial ventures), it is equally unlikely that a dedicated commercial enterprise would spend much time on research. Furthermore, it would be the enterprise, and not PIs, who would determine which research to perform. As with safety, it would be difficult to mitigate the risk to research in the Dedicated Commercial option because of the conflicting goals of maximizing profit and conducting research that might not have immediate commercial applications.

3.3.4 Cost Risk

Here, the profit motive favors the Dedicated Commercial option. Because the goal of this option would be to maximize profits, controlling costs would be one of the few parameters used in building and operating this SSURI option. It would clearly provide the lowest cost risk. The Program Evolution option has moderate cost risk because it is, essentially, a wholly government operation. Low-to-moderate cost risk would accompany the Center Expertise, Single Prime, and Privatized SSURI Prime options. Although there would be some synergism, or economy of scale, related to the Single Prime and Privatized SSURI Prime options, little competition would emerge over the long term to keep costs down. Probably, but not definitely, the Single Prime option would use corporate rates and factors, resulting in a high loaded-labor-rate, whereas the Privatized SSURI Prime option would use tailored, lower loaded rates, much like the STScI. While remaining a government operation, the Center Expertise option would have two benefits: competition among Field Center contractors and local cost-center rates and factors. Another factor that might reduce cost is the “tailored” nature of Field Center contracts; that is, Field Center staff would select and work with contractors selected specifically for the roles and responsibilities of that center, creating greater productivity. The Study Team believes that these two or three factors would overshadow, in the long term, the economy of scale provided by the Single Prime option. Some mitigation of the moderate cost risk in the Program Evolution option could be achieved by shortening the time required to integrate payloads into the ISS and delegating CoFR responsibility as discussed earlier.

However, a cost disadvantage would always be associated with an option that is wholly government in nature.

3.3.5 Schedule Risk

This factor is very low for the Center Expertise option; low for the Single Prime and Privatized SSURI Prime options; and moderate for the Program Evolution and Dedicated Commercial options, *relative to flying payloads on the ISS***.** A primary purpose of creating a SSURI would be to fly the highest quality and quantity of science on the ISS. As discussed in Section 3.4, the Study Team holds that the time required to integrate a typical payload into the ISS can be reduced substantially. As also discussed in Section 3.4, there would be greater expertise and emphasis on "hot" science and research and better prioritization, leading to better products flown in a timely manner if the Center Expertise option were implemented. Because the Single Prime and Privatized SSURI Prime options include SSURIs, many of the same benefits are inherent within them; consequently, they have low schedule risk. They lack somewhat since they do not have the close relationship with the Field Centers that is part of the Center Expertise option. That is, a single prime contractor would never have the relationship with the Field Centers that a contractor specifically selected by the centers would. The Privatized SSURI Prime option, which "subcontracts" launch processing to KSC, mitigates this relationship risk and has less schedule risk than does the Single Prime option.

The Program Evolution option has moderate schedule risk because it is a government operation not oriented toward science, as are the Center Expertise and Single Prime options. The Program Evolution option's schedule risk could be mitigated by a detailed assessment of the time required to integrate payloads into the ISS. The Dedicated Commercial option does not, by the team's assumption, have the same level of bureaucracy of the other three options because it resides in the private sector; however, it still must work with NASA in any area of NASA support. There is synergism within the other three options, especially the Program Evolution option, developed over the last 40 years that a single prime would have difficulty achieving. The Study Team also assumed that its orientation would be commercial and that science would not be its first priority. Of course, the loss of synergism could be mitigated somewhat by hiring NASA and contractor staff familiar with the pertinent areas. The amount of risk also depends on who the commercial organization is.

3.3.6 Operations Risk

This risk is linked to safely flying a payload on time for its intended purpose. The Study Team concludes that the Center Expertise option has very low risk because the SSURI is oriented toward flying payloads quickly and safely on ISS—one important reason for creating the SSURI—and the SSURI allows Field Centers to select contractors specifically oriented toward their needs. The Program Evolution and Single Prime options have low operations risk. The Single Prime option has the benefit of the SSURI, but it has a different culture from the one that currently exists. Its risk, currently low, would be reduced with organizational maturity. The Program Evolution option has 40 years of experience in flying payloads to ensure that its operations risk is low. The Program Evolution does not have the degree of science orientation that the Center Expertise and Single Prime options have. Initially, the Privatized SSURI Prime option would have moderate risk because of the cultural differences discussed above; time is required for a new organization with a science orientation to establish working relationships with the current or remaining infrastructure. Moreover, time would mitigate this risk to some undefined degree. The Dedicated Commercial option has moderate-to-high operations risk because of its cultural differences; its orientation toward commercial ventures instead of science; and its profit motive that could affect safety. As with the Single Prime option, maturity would mitigate the operations risk of the Dedicated Commercial option.

3.3.7 International Partners Risk

The Program Evolution option would have the lowest risk for the international partners. NASA currently has well established and effective working relationships with the partners. The Center Expertise option, which would leave Operations with the ISS and transfer the remainder of the ISS to the SSURI (which reports to a Space Station Program Manager), would have low-to-moderate risk simply because of the fact that with the change to the SSURI, some of the day-to-day relationships with the international partners may be lost. This risk could be mitigated if a sufficient number of NASA and ISS contractors transferred to the SSURI. It should also be noted that ESA has a strong presence in the STScI and could well have a presence in the SSURI. The Single Prime option, which contains a SSURI, has moderate risk because it would require some undetermined, method of formalizing agreements and memorandums of understanding (MOUs). The Privatized SSURI Prime option also has moderate risk for similar reasons: undefined relationships with the international partners and undefined methods of formalizing agreements. The Dedicated Commercial option presents the greatest risk to the international partners for two reasons. It is the greatest departure from the currently successful relationship between NASA and the international partners; and the actual mechanisms for ensuring an effective, efficient relationship between a fully commercial organization and the international partners was unclear to the Study Team at the time of this risk assessment.

3.4 CBA for the Center Expertise Option

This section contains the CBA performed on the recommended architecture, the Center Expertise option. Unlike a traditional CBA in which direct and indirect, tangible and intangible costs and benefits are estimated, discounted to net present value and used to determine a benefit-to-cost ratio, the CBA that follows is primarily qualitative, but it presents significant quantification wherever possible.

3.4.1 Introduction

Clearly, tangible costs would accrue early in the ISS program if the Center Expertise option were implemented, whereas tangible benefits would be difficult to estimate until after implementation. Furthermore, many benefits would be intangible, e.g., a greater acceptance by and participation in the ISS program by the scientific community and commercial organizations, resulting in high-quality research. These intangible benefits would eventually manifest themselves as tangible benefits and cost savings/avoidance, but several years would elapse before the benefits and savings could be quantified. The following paragraphs discuss costs and benefits, both tangible and intangible, direct and indirect. The team used a three-step approach to conduct the CBA.

1. The full Study Team conducted a *macro-evaluation* of the Center Expertise option's costs and benefits. The results are mostly qualitative and represent the best, collective opinions of the team members, who have wide-ranging experience in government, business, and academia. Each factor was discussed, debated, modified, and then included in the macro-evaluation (Section 3.4.3).

2. Each *functional allocation* of the Center Expertise option (see Table 2-2) was evaluated by the entire team, and relative costs were estimated, and benefits were discussed. During this process such benefits as shortening the time from payload selection to flight were discussed, in an iterative process over several occasions, as the list of functional responsibilities evolved.

3. The team used *quantification* wherever possible. The CBA was basically a cost exercise because, as mentioned, it would be several years before an estimate benefits from implementing

the Center Expertise option could be quantified. The Study Team addressed the following questions:

a. What are the costs to establish the SSURI, including the cost at each implementation step, e.g., FY 2002, FY 2004, and FY 2006?

b. What are the tangible costs and benefits of implementing the Center Expertise option?

c. How would costs and people be divided between the ISS and the Center Expertise option (the SSURI) during mature operations?

3.4.2 High-Level Conclusions of the CBA

This section contains highlights of the CBA. Details appear in Sections 3.4.3 through 3.4.6. Both tangible and intangible benefits and cost savings would occur if the Center Expertise option were implemented. Costs would precede benefits, with the costs of creating the SSURI being incurred in the near term. The Study Team believes that these costs would range from approximately $10 million to $40 million per year, depending on the speed of implementation and on the number of current NASA employees and facilities involved. Rough order-of-magnitude (ROM) estimates of these costs follow:

1. The greatest benefit would occur when and if the length of time required to integrate payloads into the ISS is reduced. A ROM estimate for potential savings, which the team calculates to be in the $100 million-per-year range, is described below. The team understands that NASA is investigating such a reduction at this time. This type of streamlining may also occur in the research selection processes.

2. While it is certainly a ROM estimate, the Study Team holds that, at a minimum, $25 million per year could be saved through the use of competitive, focused Field/Support Center-level contracts.

3. Benefits from implementing the Center Expertise option relate to the Center Expertise option architecture itself, which allows for competition among contractors for center-level work; the establishment of local cost centers to reduce cost; and increased productivity from contracts tailored to ISS needs at each center. While these savings are discussed, they have not been quantified.

4. Savings of approximately $2 million per year could be accrued by delegating responsibility for certifying flight worthiness without compromising safety, with an accompanying increase in customer satisfaction.

5. Finally, a myriad of intangible benefits could be gained by implementing the Center Expertise option.

Table 3-3 summarizes the tangible and intangible costs and benefits discussed throughout this section.

3.4.3 Macro-Evaluation of Costs and Benefits of Implementing the Center Expertise Option

This section summarizes, at a macro level, the major costs and major benefits of implementing the recommended Center Expertise option.

Table 3-3. Summary of Cost-Benefit Analysis Results (Annual) for the Center Expertise Option

Consideration	Cost		Benefit	
	Tangible	Intangible	Tangible	Intangible
Implement Center Expertise Option—Create SSURI	▪ New SSURI organization \$10 to 40.0M/year ▪ New SSURI facilities \$2.5M/year	▪ Work force morale ▪ "Just more overhead" ▪ Program vs. Research competition	▪ Customer-Supplier relationship should reduce program-wide costs, e.g., standardized selection and integration could save \$25 to \$100M/year	▪ Highest quality and/or quantity of research ▪ Improved outreach satisfaction ▪ Increase in research funding sources
Implement Center Expertise Option	▪ New distributed ISSPO organization	▪ Increased management complexity	▪ Contract competition savings of about \$25M/year ▪ Synergy with other similar functions at each Field Center	▪ Local tailoring of Field Center contracts (increase in productivity) ▪ Field Center "ownership" in the program

3.4.3.1 Major Costs of Implementing the Center Expertise Option

The following costs relate to implementing the recommended architecture option:

Organizational Costs. These costs are the cost of facilities required for and people assigned to the SSURI. The Study Team's ROM estimate of these costs follows this overall summary.

Transition Costs. Costs linked to such factors as interruption of work, additional personnel, duplicate facilities, and additional overhead are caused by the transition of responsibilities and functions from the ISS to the SSURI. ROM estimates for transition costs follow this summary. The Study Team often discussed the macro costs and benefits of implementing the Center Expertise option, resulting in the lists of costs and benefits.

Impact on Current Work Force. Regardless of whether a large portion of the current ISS civil service staff goes to work for the SSURI or not, a large percentage of the work force, including current ISS contractors who must transition or lose their jobs, could experience morale problems. To some extent, this is already happening as NASA and contractor employees become more familiar with the "NGO study."

Perception of "Just More Overhead." Some people may think that creating the SSURI would be just another example of the belief that "the government can just add, not subtract," that it tries to solve problems by creating another organization. This perception is an intangible cost to NASA that people in the SSURI must dispel by performing well and by demonstrating that a real potential exists for reducing overhead in the program.

Possible Inefficiencies. A possibility of management inefficiencies because of a more complex organization exists. As with any decentralization, the benefits of the new organization must be evaluated in light of the impact of the change to the overall organization.

Cultural Differences. Initially, cultural differences between "program office people" and scientists in the same operating organization are likely to create minor problems. These differences existed, and were overcome, in the STScI, which was the primary analog used in this CBA.

3.4.3.2 Major Benefits of Implementing the Center Expertise Option

The following two major classes of benefits relate to implementing the recommended architecture option.

Benefits linked to the architecture itself follow:

- Reduced costs because of greater competition among contractors and the establishment of local cost centers.
- Increased productivity by contractors and greater customer (NASA) satisfaction because of tailoring Field Center-level contracts (resulting is closer, better relationships between NASA and its contractors). Estimated to be approximately $25 million per year.

Benefits specifically linked to the SSURI follow:

- Shorter time from "science concept" to flight and simplified user interfaces. Estimates of tangible benefits related to this shortened time appear in later paragraphs.
- Highest quality and quantity of science and technology, resulting from simplified access and faster turnaround of experiments. Ability to attract a wider scientific community of users and greater participation by industry and commercial participants. Each year, NASA reports on improvements in the quality and quantity of Hubble Space Telescope science since formation of the STScI.
- Improved outreach and a wider range of participants, resulting in greater satisfaction among the scientific and commercial customers of ISS, would lead to greater participation.
- Additional sources of funding, resulting from greater participation, a broader constituency, and more support for NASA as more people see the value of NASA and the ISS. This should result in funding from new sources, including cost sharing by commercial users, cross-agency transfers, and possible philanthropic contributions.

3.4.4 Evaluation of Costs and Benefits Associated With Functional Responsibilities Assigned to the SSURI

The Study Team evaluated each functional allocation discussed earlier (see Table 2-2) to determine the costs and benefits of assigning these responsibilities to the SSURI. Both costs and benefits are discussed qualitatively. Table 3-4 summarizes the rationale behind the CBA. Note that the "Ref" column here indicates the function from Section 2, Table 2-2. As can be seen from the numbering system in the "Ref" and "Function" columns of Table 3-4, not all of the functional responsibilities are included. The Team assumed that those functions omitted in the table had neither significant costs nor benefits and were assigned to the SSURI because of (1) their relationship to other responsibilities or (2) synergism which was more easily assigned to other functional responsibilities.

Table 3-4. Summary of Cost-Benefit Rationale

Ref	Function	Cost Impact	Benefit
B1	Utilization/Education Outreach	Same cost	Highest quality science, enhanced cross-disciplinary investigations, greater credibility, broader participation, expanded research base, and wider political advocacy.
B2	Utilization Policy-Support	Lower cost	Greater ability within the research community, broader participation, wider advocacy. Feeling by research communities that research policy is in the hands of people who understand research.
B4	Utilization Strategic Planning and Requirements	Slightly lower cost	More knowledge across discipline areas. More responsive to users, more expertise on “hot” topics, better prioritization leading to better products and results.
B5	Utilization Tactical Planning and Requirements	Slightly lower cost	More knowledge across discipline areas. More responsive to users, more expertise on “hot” topics, better prioritization leading to better products and results.
B6	Experiment Development	Lower cost	More competition, broader oversight, greater continuity, data more available to public, better data; the SSURI would be a better buyer of payload systems.
B7	Experiment Results Analysis and Dissemination	Same cost	Greater continuity, better data, lessons learned, better distribution of information to the public.
B8	Experiment-to-Experiment Facility Integration	Significantly lower cost	Shorter review and integration times, easier access to space, does not discourage potential users, process is more simple.
B9	Utilization Operations Integration Planning	Lower cost	More knowledge across research areas, more responsive to the user, more expertise on “hot” topics, better prioritization leading to better products and results.
B10	Experiment Crew Training	Slightly higher cost	Some cost impact due to loss of synergy. Benefits from more productive support to research by crew, career enhancements for crew who wish to continue in the program after flight status. Generally, an integrated source of scientific/academic training for astronauts.
B11	Utilization Operations Real-Time Execution	Lower cost	Lower cost because costs are driven by quality of requirements, which would improve. Benefits are better requirements, better understanding of how the research community works, and one well defined point of contact.
E3	Experiment Integration and Test	Slightly lower cost	Having people with payload and experiment orientations responsible for experimentation and cost. More efficient integration and test. Lower cost from increased efficiency and lower composite rates for both the SSURI and remaining ISS activities.
E4	Site Support to SSURI/PI	Slightly lower cost	Similar to E3. Payload and experiment orientation of the SSURI would increase efficiency and result in greater satisfaction among PIs and others using the ISS. Lower costs due to lower rates for the SSURI and Center Expertise contractors.
F1	Experiment-to-Experiment Facilities Safety Operations	Significantly lower cost	One person for CoFR for all levels of payload and conforming to the ISSPO Safety Process, resulting in much shorter approval cycle.
G1	Sustaining Engineering & P3I for Multi-Experiment Facilities	Lower cost	Finer tuning of research payloads later in the cycle, better decisions on spending money, better adaptation of facilities to research needs, and better payloads.

3.4.5 Quantification of Costs and Benefits

As mentioned earlier, tangible costs can be estimated with some level of confidence at this time, whereas tangible benefits will emerge over the next few years. It was possible to estimate significant benefits in terms of cost savings and cost avoidances. This subsection discusses tangible costs and benefits that could be estimated at this time. At the end of the discussion of tangible costs is a recommendation for phasing these costs during the transition to the SSURI.

3.4.5.1 Tangible Costs

Most costs of implementing the Center Expertise option would be linked to establishing the new SSURI organization and would be incurred well before many of the benefits of the SSURI could be seen. Assumptions, such as offsets for civil servants replaced by the SSURI contractor yet still working for NASA and location of the SSURI, can affect the net costs of implementing the SSURI. Among the costs that would occur as the SSURI is implemented are:

Facility Costs. The Study Team assumed that the SSURI headquarters function could be located at or near a prominent university and that the significant integration and management function would probably be located at or near the NASA Lead Center. It is certain that facility costs would occur by implementing the SSURI, with the proximity of a NASA center influencing the actual degree of cost. Using the STScI and its staff of approximately 520 as an analog, the Study Team assumed a staff of 800, with 300 of the total distributed among the NASA centers, e.g., in the POIC at MSFC. A facility capable of housing 500 people would be required. Assuming a requirement of 90,000 square feet (based on each of the 500 people requiring 150 square feet of space, plus 1,500 square feet for such items are information systems, conference rooms, libraries, and research areas), and assuming an annual cost per square foot of $25, an annual facility cost of $2.25 million results. Assuming a 10% factor for materials, supplies, shared halls and bathrooms, a final annual facility cost of roughly $2.5 million results. This estimate depends greatly on where the Center Expertise option is located and, of course, the actual size and centralization of the Center Expertise option work force. This estimate does not include the cost of laboratory research equipment required by SSURI staff researchers.

Data Processing and Data Hardware Costs. The Study Team assumed that there would be *no cost impact in this area* except for those generically included in the cost of transitioning from the ISS to the SSURI. Some savings should accrue because of the centralization of payload functions, but NASA is a wise buyer of computer hardware and software. In addition, until final decisions are made about the operation of the POIC and other data-intensive facilities during the ISS Operations phase, there is inadequate data for even a ROM estimate.

Labor Costs. This cost is also very assumption driven, and there could be a cost offset if a sufficient number of civil servants now performing efforts being transferred to NASA would accept positions with the SSURI. The Study Team assumed that all of the 500 people mentioned in Facility Costs would be additions to the ISS cost baseline. The team reduced this number to 400, based on the assumption that some of the replacements would be funded by other sources, e.g., universities, and that some synergistic savings would accrue by locating all science in one place. Without being overly specific because of the sensitivity of rate and factor information, a loaded rate of $100,000 per FTE/EP was used. This rate might be slightly low when compared with some of the loaded rates for contractors currently working on ISS. This assumption results in an annual cost of $40 million per year, not considering any offset for current ISS people who might transfer to the SSURI.

Phasing the Tangible Costs. To time-phase the tangible costs discussed above, the team assumed that transition would begin in FY 2002, with full SSURI capability being achieved in 2006. It was further assumed that the transition would be incremental, with an evaluation by NASA after each step to determine if and how the next step should be taken. The steps and associated dates assumed in this cost-benefit exercise appear in Table 3-5; the Study Team used them to estimate transition costs. This data in the table do not comprise a recommended schedule. As mentioned earlier, some of the cost can be offset by subtracting the costs of NASA civil servants who will either work for the Center Expertise option, or be available for other positions at NASA that would otherwise have to be filled by recruiting new employees.

Table 3-5. SSURI Costs and EPs During Transition (Dollars in Millions)

Date	Content of Transition	SSURI Cost	SSURI EPs
2002	■ Utilization/Education Outreach Management ■ Utilization Policy Management (for Post-Assembly) ■ Research Selection Support to Headquarters ■ Utilization Strategic Planning/Requirements (for Post-Assembly) (CUP) ■ Experiment Results Analysis and Dissemination for Newly Selected Experiments/Research ■ Experiment Results Analysis and Dissemination for Newly Selected Experiments/Research ■ Support to Program for Advocacy & Funding Acquisition ■ Support to Program for Public Affairs ■ Multi-Experiment Facility P3I ■ Support Program on ISS Systems P3I ■ Facilities Leased and Staff of 100	$12.5	100
2003	Same content as 2002	$12.5	100
2004	Same content as 2003 plus the following items: ■ Utilization Tactical Strategic Planning Requirements (Manifest Requirements, IDRD Inputs, Increment Science Management,) ■ Experiment-to-Experiment Facility Integration ■ Utilization Operations. Integration Planning (Post-Assembly Operations) ■ Experiment Crew Training Planning/Execution (Post-Assembly Experiments) ■ Support Program Payload Analytical Integration ■ Support Program Increment Integration Planning ■ Support Program Flight Crew Selection/Assignment ■ Support Program System & Integrated Crew Training ■ Launch Site Experiment Integration & Test ■ Launch Site Support to SSURI and Principal Investigators ■ Safety Operations for Experiment-to-Experiment Facilities ■ Support Program for Integrated Safety Assessment	$32.5	300
2005	Same content as 2004 plus the following items: ■ Utilization Operations Real-Time Execution ■ Support Program Logistics & Maintenance of Multi-Experiment Facilities	$32.5	300
2006	■ Full Utilization and Operations Capability	$42.5	400

3.4.5.2 Tangible Benefits

Most benefits of implementing the Center Expertise option would be linked to reducing certain timelines, obtaining more and better science data, reducing the number of reviews, and tailoring contracts to specific Field Center needs.

Reduced Payload Integration and Processing Times. During visits to the NASA Centers, the Study Team met with the ISS Program Office and many payload groups. Conversations soon focused on the very long time (36 months) required to integrate a payload into the ISS. NASA acknowledged this long time period and said it would evaluate proposals to reduce the long timelines through a payload-classification approach. Quantifying the benefits that could be achieved from this shorter integration time was difficult. Yet, the Study Team believes that (1) about $100 million per year could be saved by reducing the time required to integrate payloads into the ISS, (2) the current NASA efforts to shorten payload integration time should be given the highest priority, and (3) the money saved should be used to create the SSURI and increase the amount of science performed aboard the ISS

The $100 million cost avoidance is a true ROM estimate. The Study Team arrived at this number as follows. The point of departure was the ISS Post-Assembly Operations Cost Estimate (PAOCE) and supporting data provided to the team in June 2000, and a potential reduction from 36 months to 12 months for integrating payloads into the ISS, a number discussed with NASA during visits to JSC. From the $1471 million cost total in FY 2006, the Study Team removed the $493 million estimates for Utilization and Research Operations because these cost elements include building of the payloads and the related research. Some cost avoidances would probably occur in these areas, but these costs elements essentially deal with building and using the payloads. The team next removed the $295 million of Program Reserve and P3I. Perhaps some of the Program Reserve could have been left in the base, but the team chose not to do so.

The remaining $663 million would fund efforts that would be affected by shortening the time required to integrate payloads. An operations analysis was performed on this base. The Study Team assumed that 50% of the effort would be fixed, i.e., not impacted by reducing the time required to integrate payloads. The other half (approximately $330 million) would be directly affected by the reduced integration time. Assuming that a 2/3 reduction can be achieved (from 36 to 12 months), a cost avoidance of $220 million results.

The estimate was further reduced for two reasons. First, the 2/3 reduction seemed optimistic. A 50% reduction would result is a cost avoidance of $165 million. The second reason goes back to the initial cost briefing in Washington, DC, in February 2000. NASA stated that cost challenges had already been included in the ISS PAOCE estimate, and the Study Team believes this statement. Taken together, these reasons (the optimistic estimate for reducing payload integration time and challenges in the operations estimate) resulted in the $100 million figure.

Highest Quality and Quantity of Science. Since formation of the STScI, the efficiency of the Hubble Space Telescope has increased 100% or more, depending on the measurement parameter used. Whether some of this increase was caused by maturation of the program instead of formation of the institute is debatable; however, the Study Team believes that much of the efficiency increase came from having the single point of contact and science orientation provided by the institute. According to the report referenced above, data processing efficiency increased from 1991 to 1998 as follows:

Date	Observations (Thousands Per Year)	Calibrated Science Data Obtained (Gb per Day)	Labor (Number of Persons Per Shift Per Week)
1991	13.64	0.5	70
1999	95.4	5.4	14

The Study Team made no attempt to translate these productivity increases in the STScI into similar improvements in the ISS. The team does believe that implementing the Center Expertise option would result in greater ISS productivity, lower costs, and both tangible and intangible benefits, much as creation of the institute did for the Hubble.

Single Person Responsible for CoFR for Experiments at the Facility Level and Below. The NASA ISS Science Facility Manager is the party most capable of ensuring that facility experiments to be flown fully meet ISS CoFR and safety review processes. Today, the CoFR and safety review processes require separate reviews at (1) the NASA Field Centers where the responsible RPOs are located and (2) at the program level—all to ensure that the experiment to be installed in the onboard Science Facility fully meets CoFR and ISS safety requirements. If the ISSPO would delegate responsibility to the Field Center Science Facility Manager for the CoFR and safety review processes (for experiments that do not impact the interfaces between the facility and the ISS vehicle), this process could be shortened and become focused on the most responsible NASA party. The program would retain authority by delegation, but it accomplishes this by certifying the review process to be performed at the responsible Field Center and by audit to ensure the integrity of the process.

In the Post-Assembly era, a rough estimate is that approximately 70 facility-class payload experiments will be transported to the ISS. This number was derived as follows:

- Four Mini-Pressurized Logistics Modules (MPLMs) plus 1 pallet flight per year
- Each flight transports 15 mid-deck payloads
- Each of 3 racks on the 4 MPLM flights transports up to 6 more experiments for additional experiments on these flights

This configuration results in the following estimate of experiments flown annually:

Mid-decks	5 x 15 = 75 per year
Transportation	<u>4 x 18 = 72 per year</u>
Total	147 per year

A conservative estimate is that 50% of these experiments, or approximately 70, will be facility-class experiments. Assuming that 2 safety reviews for each experiment can be eliminated, 140 reviews can be eliminated.

Assuming that time spent in preparing for and conducting each review would be four people for 3 days (24 hours), the time spent for each review would be 96 hours. These 96 hours per review multiplied by 140 reviews equal 13,400 hours per year that could be avoided, resulting in savings of about $2 million per year, depending on rates, facility costs, travel, and overhead. The key savings, however, would be simplification of the overall process, with resulting increased satisfaction by experimenters.

Cost Savings/Avoidance and Benefits Resulting from Contracts Tailored to Field Center Needs. A 1988 Office of Management and Budget (OMB) report stated that "competition is the driving force behind quality and productivity in the private sector." W. Edwards Deming said that customer satisfaction is the true measure of quality. These statements taken together, along with the concerns expressed by NASA about the loss of center expertise over the last decade, influenced the Study Team as they considered the Center Expertise option. Competition among contractors bidding for contracts would lead to lower bids; and SOWs tailored to specific center needs would result in greater customer satisfaction, with accompanying higher productivity. An increase in expertise at the Lead/Support Centers would be indirect but tangible. Those contractors not having local cost centers would find themselves in an unfavorable competitive position and would have to adjust to be competitive. Smaller contractors with lower indirect rates would have opportunities to bid on center work. Implementing the Center Expertise option would create greater competition, lower costs, and greater productivity.

The Study Team felt that some estimate of net savings from the increases in efficiency and competition should be made, even though the team did not have data available to do so. The Study Team discussed the contracts that would apply. The large SFOC would not be appropriate until after 2007. The prime contractor would surely be selected for the Sustaining Engineering and P3I activity. The team felt that net savings for the remaining contracts could possibly amount to $25 million per year. In general, the team felt that the $25 million in savings was reasonable, even conservative, given the reasons stated above and mitigated by costs such as additional procurements, contracting personnel, and the possibility of unforeseen contract novations. The $25 million-per-year savings is the Study Team's estimate of the cost savings/benefits associated with the Center Expertise option. That figure is not the total benefits associated with the expertise residing at the Field Centers due to the Center Expertise option and is not the productive and efficient working relationships among government organizations and contractors.

3.4.5.3 Assigning Costs and EPs to the ISS and the SSURI

Introduction. Although it was not an explicit requirement in the SOW, the Study Team felt it both beneficial and necessary to distribute costs, over time, between the ISS program and the SSURI. Even though the SSURI itself would be fairly small in terms of people and dollars spent, it would control substantial budgets for several thousand people, if implemented as the Study Team suggests. The following paragraphs describe the methods used to distribute dollars and people between the ISS program and the SSURI.

First, the ISS PAOCE presentation, given at the initial meeting in Washington, DC, in February 2000, and the supporting cost database were evaluated and found to be satisfactory for the Study Team's purposes. With the exception of the section on Sustaining Engineering, the team found it to be presented with adequate details; and because all or most of Sustaining Engineering would remain with the ISS, the team found that it posed no problem. The Study Team would have preferred better differentiation of the content of "Research Operations" and "Utilization" costs since they contained similar categories, e.g., Microgravity, and were high cost categories. However, the team assumed that the total content of these two categories would be transferred to the SSURI. Furthermore, even though the ISS PAOCE represents a requirements budget, the team felt that the estimate for ISS research and operations resulting from the ISS Program Operating Plan (POP) currently underway would not be significantly higher or lower than the roughly $1.5 billion number, unless a reduction in payload integration time is achieved. Consequently, the team's conclusions would not be significantly influenced by the new POP.

Next, much of the information presented during the team's visits to NASA Centers was broken out in a manner inconsistent with the ISS PAOCE budget. A good example is Logistics and Maintenance; the material presented in Houston late in February 2000, and at KSC in May was excellent, and the level of detail in the ISS PAOCE cost estimate was adequate. Unfortunately, the functions or work breakdown structure (WBS) elements presented at JSC and KSC were the same as the cost elements in the ISS PAOCE. Again, this inconsistency was a minor inconvenience because all of Logistics and Maintenance Operations function was assumed to remain with the ISS, and KSC personnel were cooperative in answering our questions.

The following analysis is intended as an estimation of the cost and personnel impact of implementing the Center Expertise option organizational architecture. It is a very assumption-driven analysis, but the team believes that the assumptions are so clearly stated that readers fully understand the conclusions.

Steady State Operations and the Cost and Personnel Estimates. ISS Operations should become steady state by 2006, with approximately 5300 contractors and 1600 civil servants performing Operations-phase functions. By FY 2006, ISS development and work on the Crew Return Vehicle (CRV) will have been completed, leaving only ISS Operations and Research as cost elements.

Although the team expects the current POP to change the phasing of the numbers shown in Table 3-6, it is notable that the ramp-up to steady-state Operations was scheduled to begin in FY 2000 in the PAOCE exercise. The FY 2000 total for Operations and Research is approximately 88% (see Table 3-7) of the FY 2006 total for these two categories. By then, the ramp-up to steady-state Operations has begun, and there would be a substantial transition involved. The recommendation here is that implementation of the SSURI should begin as soon as possible. Tables E-2 and E-3 show the cost-estimate distributions between the SSURI and the ISS Operations and Maintenance program for the stable-Operations years.

Table 3-6. Total ISS Personnel: Development and Operations Phases

Type of Personnel	Fiscal Year							
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2010**
Contractor EPs	7787	6528	5530	5042	4958	4734	5300	5103
Development	2994	1556	658	183	169	0	0	
Operations	2956	3073	2964	2863	2875	2875	3060	
Research	1747	1689	1679	1796	1764	1709	2240	
CRV	90	210	229	200	150	150	0	
Civil Servant FTEs	2385	2328	2294	2148	2035	1915	1612	1306
Development	897	847	752	620	526	178	0	
Operations	649	670	720	745	762	1008	738	
Research	705	694	704	698	969	678	874	
CRV	134	117	118	85	51	51	0	
Total	10172	8886	7824	7160	6993	6649	6912	6409
Development	3191	2403	1410	803	675	178	0	
Operations	**3605**	3743	3684	3608	3638	3883	**3798**	
Research	**2452**	2383	2383	2494	2460	2387	**3114**	
CRV	224	327	347	285	201	201	0	

NOTE: ISS Post-Assembly Operations Cost Estimates (ISS PAOCE), November 1999

Table 3-7. Steady-State Operations in the ISS PAOCE

Activity	Fiscal Year			
	2000	**2002**	**2004**	**2006**
Operations	3605	3684	3638	3798
Research	2452	2383	2460	3114
Total	6057	6067	6098	6912
% of FY 2006	88	88	88	100

Table 3-8, also based on the PAOCE exercise, displays civil servant FTEs, contractor EPs, and costs in FY 2006 by function. For the rest of this report, EP is used to include both civil servant and contractor personnel. Note that no EPs were assigned to the approximately $300 million of P3I and Reserve; as a result the totals are probably low.

Table 3-8. Summary of ISS FTEs, EPs, and Dollars for FY 2006

Function	Factor			
	Contractor	Civil Servant	Total	$ M
Mission Operations	869	160	1029	160.1
EVA	235	33	268	29.5
Sustaining Engineering	690	125	815	143.5
Logistics and Maintenance	178	0	178	95.5
Research and Operations	1007	324	1331	272.6
Utilization	689	405	1094	221.3
Space and Life Sciences	241	42	283	30.9
Bayload Operations Integration	544	145	689	93.9
Launch Processing	730	228	958	109.3
Program Office	117	150	267	20.0
Reserve				144.6
P3I				150.0
Total	**5300**	**1612**	**6912**	**1471.1**

NOTE: Extracted from the ISS PAOCE

3.4.6 Summary of the CBA for the Center Expertise Option

Although no benefit-to-cost ratio was developed to quantitatively demonstrate that implementing the Center Expertise option would be wise, it is the unanimous opinion of the Study Team that the immediate intangible benefits and future tangible benefits would outweigh any costs associated with implementing the Center Expertise option. Costs would be reduced and avoided by competition among contractors bidding for work at the Field Centers; and local cost centers would be created, thereby reducing costs. The true measure of quality is customer satisfaction. Allowing Field Centers to tailor center-level contracts to their own work would increase productivity, communication, and satisfaction and would also reduce cost.

Furthermore, the Study Team believes that cost savings/avoidance of somewhere around $100 million per year could be achieved by reducing the time required to integrate payloads into the ISS. As a result of this study, the ISSPO has begun efforts to create families of payload templates that could take advantage of standardized planning for standardized payloads. The Study Team assumes that these types of improvements will continue to be found as a result of the new Customer-Supplier relationship proposed in the recommended Center Expertise architecture option. The Study Team also believes that much of this saving should be reprogrammed by NASA to obtain more science and technology. Inherent within this shortened integration time is a decision to delegate safety responsibility for payload-to-payload integration and payload-to-facility integration to the SSURI, including responsibility for the CoFR.

Tangible benefits will certainly result from implementing the Center Expertise option, specifically with the creation of SSURI; these benefits cannot be quantified now, but they can be substantiated by the experience of Hubble Space Telescope, which realized productivity gains of more than 100% after creation of the institute. The team feels that similar benefits in increased productivity would result if the SSURI becomes a reality.

Among the intangible benefits that the Study Team believes would emerge from creating the SSURI are the highest quality and quantity of science; broader participation by the scientific community; enhanced cross-disciplinary investigations; additional sources of funding; a more positive view of NASA and greater credibility in the scientific community; a quicker response time when changes need to be made; and overall, better science. While neither costs nor benefits associated with these factors were quantified, they do represent the opinions of the Study Team, who have extensive expertise in government, industry, and academia.

Section 4. Acquisition Strategy

4.1 Introduction

This section describes the acquisition strategy as the set of processes and steps that the Study Team suggests that NASA use in implementing the recommended Center Expertise option. As part of acquisition strategy, the team addressed the following topics:

- The phasing to put the Operations-era architecture in place
- The high-level contracting strategy to be used for each contract required
- The integrator responsible for each contract acquisition
- Issues that may require legislative action or raise government liability concerns
- International partner considerations

The recommended Center Expertise option involves contractual arrangements that are not different from typical NASA procurements. Therefore, such contractual arrangements do not require special legislative action to be authorized, nor are there liability issues since the contract for the SSURI, the only exceptional element in the architecture, could extend third-party liability coverage from the government.

As part of its task to consider organizational architectures for the ISS Operations phase, the Study Team allocated functions to be performed by the government and functions to be performed by contractors. Section 2 contains those functional allocations. Section 4.2 discusses the team's general phasing recommendations and recapitulates the contracted Operations functions for each architecture evaluated.

The acquisition strategy dates shown are notional and are based on Revision E of the *ISSPO Program Baseline.* The intent is to phase the SSURI acquisition, not interfere with the Assembly phase, but to have it up and running at Assembly Complete. The SSURI would participate with the ISS program from the start and would pick up functionality as each acquisition step is successfully completed.

The Study Team also identified the primary current contracts used by the ISS program and their relationships to the Operations-phase functions; Section 4.3 explains the current contract structure.

Based on information provided in Sections 2 and 3, the team then evaluated the options for structuring Operations-phase contracts for the Center Expertise option and the acquisition schedules associated with these options (Section 4.4). The team similarly evaluated contract-structure options for the alternative architectures to the Center Expertise option (Section 4.5).

Because the SSURI would be a contract organization, the Study Team recommends that NASA ease the transition to the recommended option by considering use of Intergovernmental Personnel Act (IPA) provisions to allow government employees to participate as SSURI members and vice versa. Such action would help to maintain expertise for future HEDS research programs. Sections 4.6 and 4.7 address (1) potential legislative actions and potential government liability issues and (2) potential international partner considerations, respectively.

4.2 General Phasing and Operations-Phase Contracted Functions

4.2.1 General Phasing Considerations

In considering program phasing, the team recognized five fundamental guidelines.

1. ***Safety First.*** The phasing of organizational architecture changes must be undertaken in a way to strengthen, not weaken, ISS program safety. As noted in Section 1, the team believes that an unblemished safety record is essential to program success.

2. ***Non-Interference With Assembly Operations.*** The phasing of organizational architecture changes must be conducted on a non-interference basis with ISS Assembly Operations. Assembly Operations is a difficult and complex sequence of flights and activities, whose successful completion is prerequisite to a successful Operations phase.

3. ***Evolution to Stable Utilization Operations.*** In balance with successful Assembly Operations, the conduct of Utilization Operations during the Assembly phase and the smooth evolution to a stable Operations phase (where utilization is the primary objective and success criterion) are also essential. It is important that early research successes demonstrate the value of the ISS—both to motivate continued public, congressional, and administration support for the ISS program and to motivate potential users. It is also important that the learning process to achieve efficient and effective Utilization Operations phasing be started early and then evolve to maximize ease of use by the research community.

4. ***Expiring Contracts.*** Several existing NASA contracts that are essential to ISS activities expire during Assembly Operations or shortly thereafter. These resources must be replaced in a timely manner to ensure continuity of support.

5. ***Dependence on Space Transportation.*** The ISS depends totally on the Space Transportation System (STS) for crew rotation and resupply. The ISS relies heavily on the U.S. Space Shuttle and also on Russian, ESA, and NASDA Expendable Launch Vehicles (ELVs). The ISS lifetime will exceed the committed lifetime of several of the space transport programs, including the Space Shuttle. Out-year ISS lifetime and operations may depend on the capabilities and costs of the follow-on transportation systems. Figure 4-1 shows an overview of ISS phasing.

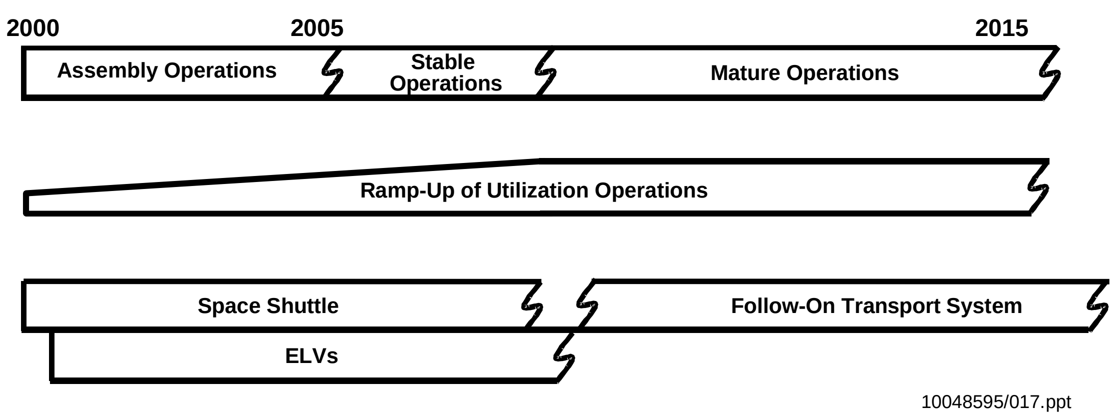

Figure 4-1. ISS Phasing Overview

NASA should consider the initial Utilization phase, i.e., before the time of the ISS stable Operations phase, as a “demonstration” phase with the object of refining the Utilization process. During this period, the current way of operating can function as the SSURI acts in a supporting role to the Field Centers and the RPOs while preparing for the transition to stable Operations. In fact, one could define "stable Operations" as the time when full Utilization Operations authority would transfer to the SSURI. Taking these considerations into account, the team's recommended phasing of functions from the current program architecture to the Center Expertise option would occur as shown in Table 4-1.

Table 4-1. Growth and Evolution of the Recommended Architecture

Function	ISS Program Phase			
	Current 2000	**Assembly Phase 2000-2005**	**Stable Operations 2006-2010**	**Mature Operations 2011-2015**
Program Management	Centralized Program and Projects	Transition to Centralized Program and Distributed Projects	Centralized Program and Distributed Projects	TBD: Based on need selected from options family included in report.
Utilization Operations	Managed by Program Office	Transition to SSURI	SSURI Project	
Flight Systems Operations	JSC Program Support (Line Organization)	Transition to JSC Line Organization Project	JSC Line Organization Project	
Logistics and Maintenance Operations	Program Office	Transition to JSC and KSC Line Organizations	JSC and KSC Line Organization Projects	
Launch Site Operations	KSC Program Support (Line Organization)	Transition to KSC Line Organization Project	KSC Line Organization Project	
Safety Operations	Program Office, Center Safety Offices	Program Office, Center Safety Offices	Program Office, Center Safety Offices	
Sustaining Engineering/P3I	Program Office	Transition to JSC Line Organization Project	JSC Line Organization Project	

As the ISS program progresses through Assembly to stable Operations, the Center Expertise option would be progressively phased in, in a non-interference manner, with Assembly Operations. The Study Team expects that stable Operations may not be achieved at Assembly Complete (the end of the Assembly phase) but may require 1 to 2 more years of transition.

The architecture transition consists of two principal elements: (1) establishment and phase-in of the SSURI and (2) transition of the ISSPO from a single centralized structure to a project structure. The phase-in of the SSURI, which would be a new entity in the ISS program and in NASA, is described more fully in Section 4.4.1. The transition of the ISSPO structure should be synchronized with the establishment of the replacement contracts, which are discussed in Sections 4.4.2 through 4.4.7.

4.2.2 Contracted Functions

Section 2 defines in detail the functions required during the Operations phase and allocates them to government and/or contractor organizations. Table 4-2 summarizes those contracted functions.

Table 4-2. Operations-Phase Contracted Functions

Contracted Functions	Description
SSURI	Management and performance of ISS Utilization functions
Experiment Systems Development	Development of experiment systems
ISS Flight Systems Operations	Planning and conduct of ISS Flight Systems Operations
ISS Logistics and Maintenance Operations	Procurement, storage, and supply of U.S.-provided ISS spares and consumables; depot repair of spares
ISS Launch Site Operations	U.S. launch site support for physical integration, launch, and return of ISS and payload elements
ISS Safety Operations Support	Integrated safety analysis and monitoring across the ISS program
Sustaining Engineering/P3I	Sustaining engineering and product improvement design/development for the ISS and all U.S.-provided ISS elements

4.2.3 Findings and Recommendations

The team makes the following observations and recommendations regarding implementation of the Operations-phase architecture:

1. At least 4 years remain before scheduled Assembly Complete is reached. Planning and experiment definition for Operations after Assembly Complete should be, and are, happening now. The Study Team recommends that an increased focus needs to be placed immediately, within the ISS program, on preparing for the Operations phase.

2. The SSURI is important in effective ISS utilization during the Operations phase. The team agrees that timely acquisition of the SSURI would be the prime factor in achieving a successful Operations-phase program. The SSURI must begin functioning in time to influence systems engineering changes that can be expected during Assembly and initial Operations. A procurement of this magnitude and complexity would normally require 12 to 18 months. Phase-in of the SSURI and transition of functions from currently responsible organizations to the SSURI would require an additional 6 to 12 months.

   SSURI acquisition should begin now. The team recommends that acquisition of the SSURI begin immediately and that the procurement process be expedited to have the SSURI under contract as soon as possible. The SSURI consortium must be formed; universities must be informed about NASA's interest in world-class research; a draft RFP must be issued for comment; and a final RFP must be issued for the procurement.

3. The timing for selecting an operations architecture is important. Each of the Operations and Maintenance-phase functions is currently being performed, in some form, in the ISS development program. The current contracts providing these functions are discussed in Section 4.3. All except the SFOC contract expire before Assembly Complete. Several expire within 1 to 2 years from the current date. Because a replacement contract vehicle or vehicles must be provided before the existing contracts expire to ensure continuity and smooth transition of ISS support, procurement activities must be started in the near term. The Operations-phase organizational architecture must be selected before proceeding with procurement activities. The procurement and transition phase-in of the SSURI would take 18 to 30 months.

Selection of the operations architecture should begin now. The Study Team recommends that NASA select and proceed immediately with implementing the Operations-phase architecture, including appropriate contractual actions.

4.3 Current Contracts

Table 4-3 summarizes the current major contracts related to ISS Operations-phase functions.

Table 4-3. Current Contracts

Current Contract	Related ISS Operations Function	Description	Completion Date
Experiment Development Contracts	Experiment Development	Multiple Experiment Development Contracts	Various
Boeing 50000	Payload Operations Integration Function (POIF)	The Boeing 50000 contract supports the POIF and development of payload equipment; Boeing Company is incumbent prime	9/30/2004
Space Flight Operations Contract (SFOC)	Flight Systems Operations	SFOC provides flight systems operations for STS, STS payloads, and ISS; United Space Alliance (USA) is incumbent prime NAS 9-20000/JSC	9/30/2006 (including two 2-year extensions)
Payload Ground Operations Contract (PGOC)	Launch Site Operations	PGOC provides launch site support for expendable launch vehicles, ISS elements and payloads, and other payloads; Boeing Company is incumbent prime NAS 10-11400	2002
ISS Development Contract	Sustaining Engineering/P3I	Boeing Company is incumbent NAS 15-10000/JSC	12/31/2003
United Space Alliance (USA)	Transportation Services	USA provides STS services and works with the ISSPO to arrange for these services NAS 9-20000	9/30/2006 (including two 2-year extensions)
Consolidated Space Operations Contract (CSOC)	Communications and Operations Support	Lockheed Martin provides the MCC, POIC, and associated networks and data services NAS 9-98100	1/2009

NOTE: The USA and CSOC contract functions are NASA-wide contracts that provide services to all NASA programs but are included here for completeness.

4.4 Contract Structure Options for the Center Expertise Option

The team evaluated contracting options for the Center Expertise option; Table 4-4 shows the recommended structure. This section discusses the approach to each function and contract.

Table 4-4. Recommended Contract Structure

Function	Contract Structure	Date To Initiate Procurement
SSURI	SSURI Contract	November 2000
Experiment Systems Development	Multiple Contracts	Dependent upon flight opportunity
ISS Flight Systems Operations	SFOC	2006
ISS Logistics and Maintenance Operations	Logistics Contract	December 2002
ISS Launch Site Operations	LSOC Contract	December 2000
ISS Safety Operations Support	Safety Contract(s)	By Field Center
ISS Sustaining Engineering/P3I	ISS Engineering Contract	December 2002

4.4.1 The SSURI

The SSURI represents the outsourcing of the utilization management and implementation functions to a research-focussed entity. The challenge of the SSURI contract is to establish an entity that will be recognized and accepted within the U.S. research communities as their leader and agent for research on the ISS. The SSURI must also be accepted and respected by international research communities. This challenge is compounded by the need to attract and represent several scientific disciplines and both technology and commercial development—all three of which would benefit from access to space through the ISS. Because of its unique characteristics, the Study Team recommends that the SSURI be a separate contract.

The SSURI itself must provide, or acquire through other parties, a wide range of services, as delineated in the Architecture function definitions contained in Section 2. This need would require the SSURI to have and to exercise strong project and business management capabilities over a program of some $500 million per year.

The team envisions the SSURI to be a new endeavor established and managed by a nonprofit entity similar to other such entities in the research community. The owning entity may be a new organization or an extension of an existing organization, but is expected to have a strong university academic/research foundation. It would probably be a consortium of interests and skills. The magnitude of the task is not without precedent, but it ranks among the largest of such endeavors.

4.4.1.1 SSURI Acquisition

As recommended in Section 4.2.3, the acquisition process for the SSURI needs to begin immediately. The Study Team projects the required acquisition process as follows, to ensure SSURI phase-in during the time needed to support systems engineering for the ISS Operations phase:

Timeframe	NASA Activity
November 2000	Begin SSURI procurement
January 2001	Issue Draft RFP
June 2001	Issue Final RFP
January 2002	Award contract; SSURI begins phase-in

This schedule is ambitious, but adhering to it is important to support an orderly transition to the Operations phase. For example, the Boeing 50000 contract, which provides the POIF, expires in September 2004. The SSURI needs to be functioning in January 2003 to set up the way in which it would continue to provide the POIF, to negotiate the POIF interface with MSFC, and to initiate a follow-on procurement (directly or through MSFC) in a timely way.

To meet the needed SSURI schedule, NASA should announce its intent to establish the SSURI as soon as possible to allow time for interested parties to establish partnerships and prepare for the procurement.

4.4.1.2 SSURI Functional Phasing

Once the SSURI has been established, it must develop its capabilities in a defined progression to allow the demonstration of those capabilities; support an orderly transition of responsibilities; and minimize risk to the ISS program. The progression of transition, depicted in Table 4-5, must comply with the considerations discussed in Section 4.2.1.

Earlier, Table 4-4 showed the functions allocated to the SSURI in the Center Expertise option, which is discussed in Section 2, with a schedule for the transition of functional responsibilities. In the progression shown, the SSURI would begin its phase-in in FY 2002 by gathering staff and beginning to support selected functions. The earliest selected functions are those requiring the greatest participation from the ISS user community, where the SSURI could be of greatest value to the ISS program and where the SSURI could earliest assume responsibility without impact to Assembly Operations. For example, the SSURI should immediately on its establishment begin program advocacy, with regard to funding, public affairs, and utilization/education outreach. In concert with external advocacy, the SSURI must also assume advocacy for user issues internally within the ISS program organization.

Within a year after its establishment (FY 2003), the SSURI should assume primary responsibility for utilization/education outreach and Utilization policy. At that time, these functions should be focussed on the goals and practices to be used after Assembly Complete, while administering the established baseline policies for Assembly Operations. However, the SSURI should also take a primary role in modifying those policies for Assembly Operations, as appropriate for user needs, opportunities, and operational constraints. In FY 2003, the SSURI should also assume primary responsibility for coordination of experiment results analysis and dissemination; this function is inherently a SSURI function, in cooperation with the PI community, and does not impact Assembly Operations.

Table 4-5. Center Expertise Option Function Allocations (1 of 2)

Function	Responsible Party			Implementation Responsibility				Timing of SSURI Phase-In (By Fiscal Year)						
								Assembly Phase					Operations Phase	
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07
A. ISS Program Management														
1. Advocacy and Funding Acquisition	P	S	S	P		S		A	S	S	S	S	S	S
2. Program Policy, International Partner Management	P	S		P										
3. Program Public Affairs	P	S	S	P		S		A	S	S	S	S	S	S
4. Program Integrated Strategic/Requirements and Planning	P	S	S	P		S								
5. Program Integrated/Tactical Requirements and Planning (Including Manifest)	S	P	S	P		S								
6. Budget/Business Management		P		P										
7. Safety Requirements		P		P										
8. Configuration Management		P		P										
B. ISS Utilization Operations														
1. Utilization/Education Outreach	S		P	S		P	S(B1)	A	S	P	P	P	P	P
2. Utilization Policy Support	P		S	P		S	S(B1)	A	S	P	P	P	P	P
3. Research Selection	P		S	P		S	S(B1)	A	S	S	S	S	S	S
4. Utilization Strategic Planning and Requirements	P		S	P		S	S(B1)	A	S	S	S	S	S	S
5. Utilization Tactical Planning and Requirements			P			P	S(B1)	A	S	S	P	P	P	P
6. Experiment Development			P			S	P(Bn)	A		S	P	P	P	P
7. Experiment Results Analysis and Dissemination			P			S	P(PI)	A	S	P	P	P	P	P
8. Experiment-to-Experiment Facility Integration		S	P		S(C1)	P	S(B1)	A		S	S	P	P	P
9. Utilization Operations Integration Planning			P			P	S(B1)	A			S	P	P	P
10. Experiment Crew Training		S	P		S(C1)	P	S(B1)	A	S	S	S	P	P	P
11. Utilization Operations Real-Time Execution			P			P	S(B1)	A	S	S	S	P	P	P
C. ISS Flight System Operations														
1. System Availability Planning		P		S	P(C1)									
2. Payload/Experiment Analytical Integration		P	S	S	P(C1)	S	S(B1)	A		S	S	S	S	S
3. Increment System Planning and Requirements		P		S	P(C1)									
4. Increment Integration Planning		P	S	S	P(C1)	S	S(B1)	A			S	S	S	S

Table 4-5. Center Expertise Option Function Allocations (2 of 2)

Function	Responsible Party			Implementation Responsibility				Timing of SSURI Phase-In (By Fiscal Year)						
								Assembly Phase					Operations Phase	
	NASA HQTRS	Program	SSURI	Civil Servant	Program Contractor	SSURI Employee	SSURI Contractor	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07
5. Flight Crew Selection and Assignment		P	S	P		S		A			S	S	S	S
6. System and Integration Crew Training		P	S	S	P(C1)	S	S(B1)				S	S	S	S
7. Real-Time System Operations Execution		P		P	S(C1)									
D. ISS Logistics & Maintenance Operations														
1. ISS Flight Systems														
On Orbit		P		S	P(Gm)									
Ground		P		S	P(Gm)									
2. Multi-Experiment Facilities														
On Orbit		P	S	S	P(Gm)		S(B1)	A			S	S	S	S
Ground		P	S	S	P(Gm)		S(B1)	A			S	S	S	S
E. ISS Launch Site Operations														
1. Resupply/Return Processing		P	S		P(E1)		S(B1)							
2. Pre-Carrier Experiment Integration and Test Support		P	S		P(E1)		S(B1)							
3. Experiment Integration and Test			P	S	P(E1)			A		S	S	S	P	P
4. Site Support to SSURI/PI			P	P		S	P(SC)	A		S	S	S	P	P
5. Payload-to-Vehicle Interface Test		P	S		P(E1)		S(B1)							
F. ISS Safety Operations														
1. Experiment-to-Experiment Facilities			P			P	S(B1)	A	S	S	S	S	P	P
2. ISS Flight Systems		P		P	S(F1)									
3. Integrated Safety Assessment		P	S	P	S(F1)	S	S(B1)	A	S	S	S	S	S	S
G. ISS Sustaining Engineering and P3I														
1. Multi-Experiment Facilities		S	P	S	S(Gn)	P	S(Gn)	A	S	S	S	P	P	P
2. ISS Systems		P	S	P	S(Gm)			A	S	S	S	S	S	S

NOTES:
1. P = Prime; S = Support, A = Acquisition Period
2. (B1) = SSURI Support Services Contractor; (Bn) = SSURI Experiment Systems Development Contractor(s)—may be through RPO.
3. PI = Principal Investigator
4. (C1) = ISS Flight Systems Operations Contractor
5. (E1) = ISS Launch Site Operations Contractor
6. (F1) = ISS Safety Operations Contractor(s)
7. (Gn) = Multi-Experiment Facilities Development Contractor(s)
8. (Gm) = ISS P3I Development Contractor(s)

In FY 2004, in anticipation of Assembly Complete, the SSURI should assume primary responsibility for those functions that particularly look beyond Assembly Complete into full Utilization Operations. These functions include utilization strategic planning and requirements, utilization tactical planning and requirements, experiment development, and program responsibility for Sustaining Engineering/P3I for multi-experiment facilities. At this point, the SSURI would have been supporting these functions for 3 years and could be expected to perform the primary responsibility without impact to Assembly Operations.

In FY 2004, the SSURI would also have been establishing its follow-on mode of support for those functions currently performed under the Boeing 50000 contract. Because this contract expires in September 2004 (the end of FY 2004), follow-on support must begin at that time (FY 2005), either through a new contract or other assumption by the SSURI of the functions of Utilization Operations integration planning, experiment crew training, and Utilization Operations real-time execution.

After Assembly Complete in FY 2005, the SSURI would assume primary responsibility in FY 2006 for the remaining assigned functions. These functions in the Center Expertise option are all Center projects, which would then be overseen by the SSURI.

The Study Team envisions this progression blueprint as a dynamic process, to be modified on the basis of SSURI achievements and experience, and one that would be elaborated through a finer-grained analysis of orderly capability transition.

Because it is complex to change existing ISS program processes, roles, and responsibilities during a period of Assembly activity, in particular, it is clear that recommendations linked to a program operations architecture must be thoroughly developed, planned, and managed during implementation. Therefore, the Study Team strongly supports NASA development of a Center Expertise Master Transition Plan that would govern implementation of the phases shown in Table 4-5. The team envisioned that such a plan would be a “partner” effort between the ISSPO and the implementing projects, including the SSURI. Typical contents and considerations would include detailed transition schedules of roles and responsibilities; criteria for effecting transition (e.g., SSURI demonstration of capability and stability of processes); support-facility planning; international partner impact planning; and post-transition, mutual support plans.

To ensure that the SSURI continues to operate in a way that reflects the goals of NASA and the utilization community, the Study Team offers the following recommendations:

- The SSURI should be overseen by a board of directors, chosen from the utilization communities that it serves, to ensure that its decisions are consistent with the goals of NASA in establishing the SSURI.
- SSURI performance should be reviewed annually by the utilization and research communities that it serves. This annual assessment should have a primary influence on the way the SSURI functions.
- NASA should establish a review panel to oversee the SSURI transition process. This panel should measure progress and help management bring about a timely and effective transition.
- Because the SSURI would be a primary way for NASA to exercise its stewardship in providing benefits to the public commensurate with the annual investment in the ISS, NASA should set up a process that measures the achieved and forecast economic benefits delivered to U.S. citizens.

It is assumed that the SSURI would routinely be evaluated by the program as is done for any other contract of this magnitude.

4.4.2 Experiment Systems Development

In building an experiment, which by definition is something that has not been done before, the best capability should be sought for the unique requirements of the experiment. Knowledge, experience, and often specialized equipment are required that are unique to the scientific domain of the investigation. Experiment system development contractors should be chosen for their unique qualifications for each specific experiment or experiment facility development. In some cases, the experiment system developer will most effectively be the PI team; in other cases the PI may need the services of another development organization.

NASA established RPOs to foster the unique capabilities required in each discipline and subdiscipline, in the scientific community, in industry, and internal to NASA. The Study Team believes that the SSURI should work collaboratively with the RPOs to conduct experiment systems development on a case-by-case basis. The schedules for new experiment system development contracts depend on individual flight opportunities.

4.4.3 ISS Flight Systems Operations

The SFOC contract currently supports the Flight Systems Operations function. The SFOC contract provides a unique set of skills related to flight operations and leverages synergism between the Space Shuttle and the ISS programs. The team judges that this synergism is critical to the ISS program and recommends that ISS Flight Systems Operations function remain under the SFOC contract for its duration.

The SFOC contract does expire in 2007. Because ISS Flight Operations will always heavily interact with the Space Transportation System, a decision should be made nearer that time about follow-on Flight Systems Operations support for both the ISS and the STS to be used through the rest of the ISS lifetime.

4.4.4 ISS Logistics and Maintenance Operations

The Logistics and Maintenance Operations function is defined as (1) logistics engineering, (2) logistics on-orbit operations, (3) logistics ground transport operations, and (4) logistics storage and maintenance. Collectively, the first three subfunctions provide logistics support analysis, on-orbit equipment utilization tracking, on-orbit maintenance (including crew training), and transport services between equipment manufacturing/major repair locations and the launch site. The fourth subfunction of logistics storage and maintenance provides warehousing of ISS program spares, maintenance of spares, preparation for launch when required, and limited repair of returned spares. JSC performs the first three subfunctions, and KSC performs the fourth subfunction.

The Logistics and Maintenance Operations contractor is required to provide hands-on support at JSC and KSC, and this support requires capabilities for cost-effective logistics analysis, logistics on-orbit operations, logistics ground transport operations, and logistics storage and maintenance operations. The Study Team believes that these services could be provided by a number of service contractors, with service contractor rate structures, and can therefore be effectively competed.

The Study Team considered but did not conclude that the Logistics and Maintenance Operations subfunctions could optionally be combined with other Center Expertise support contracts. For example, the logistics engineering subfunction could be combined with the Sustaining Engineering/P3I contract. Further, the logistics on-orbit operations subfunction could be combined with the Flight Systems Operations contract. The logistics storage and maintenance operations subfunction could be combined with similar support contracts on other programs. Finally, the ground transport operations subfunction could be combined with the logistics storage and maintenance operations contract. The advantages of such combinations are to reduce the number of contract entities that NASA would be required to maintain, and possibly to achieve cost savings through efficiencies of a larger contract. The principal disadvantage would be the reduction in competition and its effect on cost. The program should evaluate these options for implementation.

Logistics and Maintenance Operations planning and spares acquisition is currently provided by the ISS development contractor. The development contract will be completed in December 2003. Allowing 1 year for procurement of a follow-on contract, the team recommends that an RFP for the Logistics and Maintenance Operations contract be issued in December 2002.

4.4.5 ISS Launch Site Operations

The Launch Site Operations contractor is required to perform hands-on support at KSC. Because the Launch Site Operations support function is largely to act as a "host" to the SSURI and the experiment developers, ISS Logistics and Maintenance Operations, and P3I contractors, the contractor requires an in-depth knowledge of KSC facilities and operational processes, including safety. Many of the facilities and operational processes are common to other payload programs supported at KSC, where similar host services are provided.

The Study Team believes that these services could be provided by a number of service contractors, with service contractor rate structures, and can therefore be effectively competed. The team further believes that the ISS Launch Site Operations function can be performed most cost-effectively through an institutional KSC contract that finds synergism with other KSC programs. The completion date for the current PGOC contract is December 31, 2002. Allowing a 1-year procurement period, the Launch Site Operations follow-on RFP should be issued no later than April 2001.

4.4.6 ISS Safety Operations Support

The Study Team recognizes that safe ISS operation is an essential requirement for ISS success, and an inherent NASA responsibility. The Study Team also recognizes the need for a consistent and simplified safety process as key in helping researchers effectively use the ISS.

The ISSPO retains overall responsibility for safety throughout the ISS program; as part of its responsibility, the ISSPO is responsible for establishing a program-wide safety process that imposes the least burden while maintaining effectiveness at the same time. Under the Center Expertise option, multiple NASA Field Centers and contractors provide the various functions and skills required for ISS operations. Of necessity, each performing organization has inherent responsibility and performing functions with respect to safety. The SSURI, as the ISS program element responsible for Utilization, would also have responsibility for implementing the safety process with researchers in the most effective, efficient manner. As part of the safety structure, a safety organization(s) independent of the ISSPO and its performing elements would be required to monitor and ensure the integrity of the safety process. Most NASA Field Centers have, and will continue to have, an institutional Safety Operations support contractor. The Study Team recommends that the Field Center institutional safety organizations and their contractors continue to support the ISS program in monitoring and ensuring the integrity of the safety process so that no other safety support contractor is required.

4.4.7 ISS Sustaining Engineering/P3I

The Sustaining Engineering/P3I contractor is required to have in-depth knowledge of ISS systems design and integration. A full range of engineering, development, manufacturing, and testing skills is also required. Surge capability beyond the nominal sustaining level of effort is required to protect against unforeseen contingencies. These requirements limit the number of competitors to a few large aerospace companies.

The Study Team also observes that it is very difficult, and possibly without precedent, for a contractor other than the developer to win and execute a sustaining engineering contract for a system as large and complex as the ISS. The knowledge and experience gained by the development contractor and its personnel will be essential to the continued safe operation of the ISS over its lifetime.

Therefore, the team recommends that NASA consider a means other than a competitive procurement to award the Sustaining Engineering/P3I contract. Both government and contractor expense can be saved by not conducting a competitive procurement. Early negotiations with the development contractor are in the best interest of the program to ensure retention of key personnel and to evolve a fair and cost-effective contract.

The completion date for the ISS development contract, held by the Boeing Company, is December 2003. Allowing a 1-year procurement period, the RFP for a follow-on Sustaining Engineering/P3I contract must be issued no later than December 2002.

Because the capabilities of the Sustaining Engineering/P3I contractor imply the relatively high overhead rate that is typical of aerospace development contractors, the Study Team does not recommend combining this contract with any other operations functions.

4.5 Contract Structures for the Alternative Architectures

The Study Team also evaluated possible contract structures for the four alternative architecture options. Table 4-6 shows these contract structures. Under all of these architecture options, the same functions must be performed.

Table 4-6. Contract Structures for the Alternative Architectures

Group or Contract Function	Candidate Architecture Option			
	Program Evolution	Single Prime	Privatized SSURI Prime	Dedicated Commercial
SSURI	SSURI Contract	SSURI Contract	SSURI Contract	Commercial Entity
Experiment Systems Development	Multiple	Multiple	Multiple	Commercial Entity
Flight Systems Operations	SFOC	SFOC	SSURI Contract	Commercial Entity
Logistics and Maintenance Operations	Logistics Contract	Single Prime	SSURI Contract	Commercial Entity
Launch Site Operations	LSOC Contract	Single Prime	SSURI Contract	Commercial Entity
Safety Operations Support	Safety Contract(s)	Safety Contract(s)	Safety Contract(s)	Commercial Entity
Sustaining Engineering/P3I	ISS Engineering Contract	Single Prime	SSURI Contract	Commercial Entity

In the Program Evolution option, the same contract options exist as for the Center Expertise option, and the same evaluations apply.

In the Single Prime option, the Study Team recommends that the SSURI, experiment systems development contractors, Flight Systems Operations contractor, and Safety Operations support contractors be maintained separately from the single prime contract. The Single Prime option contractor would be responsible for Sustaining Engineering/P3I, Launch Site Operations, and Logistics and Maintenance Operations functions. In this case, the single prime contractor would be required to structure its team for these functions.

In the Privatized SSURI Prime option, the SSURI would assume responsibility for all functions. However, the team expects that the SSURI itself would subcontract several of the functions that require distinct capabilities, similar to the evaluations for the Center Expertise option.

In the Dedicated Commercial option, the commercial entity that owns the ISS would be responsible for all functions and would structure its own team to perform all functions.

4.6 Potential Legislative Actions and Government Liabilities

The Study Team recommends the establishment, through a NASA procurement, of a non-governmental entity, hereafter called the SSURI, to manage ISS science operations. The study envisions that the SSURI would undergo an evolution in roles, responsibilities, and perhaps its legal character during the lifetime of the ISS. This section addresses several legal and administrative issues that would affect this evolution.

4.6.1 Background

Because obtaining the SSURI is envisioned to be a procurement action, rather than an independent entity chartered by statute, a direct relationship would exist between the authorities under which this entity operates and NASA's statutory authority. In general, the Space Act provides NASA with ample authority to undertake a wide variety of arrangements.[5] This authority has become particularly important with an emerging emphasis on the privatization and commercialization of space activities and a widespread belief that NASA should divest itself of routine operations to focus on cutting-edge research and development.

Congress has expressed definite interest in Space Station operations, especially its commercial and economic development, and has proposed legislation to address these issues.[6] The role of the SSURI would surely be seen as a part of this development.

4.6.2 Specific Issues

This section specifically addresses issues that may arise while developing a procurement and contract for the SSURI. Although enabling legislation would not seem to be necessary for the organization envisioned by the Study Team, the congressional oversight process suggests that a consensus between the administration and Congress on the basic mission and duties of the SSURI would be needed. In addition, depending on the issues and their resolution, an omnibus piece of legislation encompassing any and all special authorities could prove helpful.

Procurement Strategy for the SSURI. The Study Team recommends that procurement proceed expeditiously. The approach toward procurement could take the form of a direct contract or a cooperative agreement. [7] NASA policy allows the use of a contract when the entity is responsible for delivering prescribed items to NASA. A cooperative agreement is appropriate when the entity is responsible for carrying out a public purpose or delivering a service to the community on behalf of NASA. A cooperative

[5] The Space Act allows NASA to enter into what is known as "other transactions," a provision that has been used as a basis for a wide variety of agreements with other non-government entities.

[6] The Commercial Space Act of 1998 provides for the commercialization of the ISS. A report entitled *Commercial Development Plan for International Space Station* was submitted on November 16, 1998. Another report entitled *Opportunities for Commercial Providers on the International Space Station* was submitted in May 1999.

[7] The Chiles Act P.L. 97-258, (14 CFR Part 1260) prescribes the purposes of contracts vis-a-vis cooperative agreements.

agreement is also appropriate when a commercial, non-governmental entity contributes its own resources to a project and there is substantial government involvement during the performance.

The initial form of the procurement may best fit a contract format. During the transition phase and stable Operations phase, a cooperative agreement may give the most flexibility in allowing the SSURI to meet community needs. The final form, especially if Operations are privatized, would strongly argue for a cooperative agreement. NASA could provide an option after 5 years, and at each subsequent renewal, to convert any initial contract to a cooperative agreement.

No special legislation is needed. NASA's existing authority and its procurement policy are adequate to accomplish the procurement. In fact, NASA has shown extraordinary flexibility and creativity in using its authority in this way.

Indemnification. In the past, NASA has provided indemnification under P.L. 85-804 for hazardous space-related activities carried out by contractors on behalf of the government. Since 1997, however, NASA has narrowed the application of this authority to activities that were demonstrably defense related.

For ISS operations, the SSURI might seek indemnification from government actions in cases of damage to or loss of the ISS or exposure to third-party liability. To some extent, these concerns may be mitigated by cross-waivers entered into by the SSURI and other participating parties on the ISS.[8] However, any contract or agreement with the SSURI that confers on it any responsibility for the health and safety of the ISS or its equipment could be perceived as an unmanageable risk unless the government would provide guarantee of indemnification.

One example of this practice was the indemnification provided to the ELV industry. After the purchase of insurance that would cover the maximum probable loss, a launch entity enjoyed statutory indemnification above this level. Thus, a shared-risk regime for the SSURI would be based on some precedent.

Providing this kind of indemnification would, in fact, require legislation because it exceeds NASA's present authority.

Termination Liability. The Study Team anticipates a final state for the SSURI in which the institute would act entirely as a privatized entity with only program oversight coming from the government. This state would encourage the full economic development of the ISS and would allow the SSURI to act in a manner fully compatible with commercial interests.

In this regime, it would be expected that the SSURI would provide its own resources, draw financing from other investors, and perhaps even share in some of the revenues. It is possible that the SSURI would ask to be reimbursed for all exposure if the government terminated its agreement for convenience. (In the past, private investors have specified this clause as a condition of their participation.) Such termination liability would need to be specifically provided for in law, probably through an appropriations act. Such a provision would require a waiver from the Budget Act under the current "pay-go" rules.

Special legislation would be needed for this authority.

Civil Servant Conversion. When the Hubble Space Telescope Science Institute (STScI) was established, initial staffing came largely from the community, and no special provisions were needed to accommodate a large transfer of civil servants. For the SSURI, however, the highly integrated nature of its activities and interactions with NASA Field Centers may require special authority to transition civil servants

[8] Congress has provided NASA the authority to use cross-waivers, patterned after the Space Shuttle, for Space Station users. This applies to first- and second-party liabilities but not third-party liabilities. Each user must be party to an agreement providing these cross-waivers.

before their eligibility for full retirement benefits. In addition, such personnel would be subject to post-employment restrictions that would inhibit the desired functioning of the SSURI. Finally, many such employees might desire to continue their existing health benefits, especially if the SSURI has no pre-existing health plan.[9]

Thus, special legislation would be required to permit such employees to (1) continue their participation in the Federal Employee Retirement System (FERS) or the Civil Service Retirement System (CSRS) or convert their plans to a new one offered by the SSURI, (2) exempt employees from post-employment restrictions that would otherwise affect the functioning of the SSURI, and (3) continue participation in any health-benefits plan provided by the government.

Special legislation would be needed for this authority.

IPA. An alternative way to utilize civil servant personnel in the SSURI is through the Intergovernmental Personnel Act (5 USC 3371 to 3376). This act provides for the employment of civil servants for up to 4 years[10] of continuous service in an approved non-federal government entity whose main purpose is to offer research or development services to the government. The SSURI would likely qualify as such an approved organization. NASA must approve the organization and determine that an IPA assignment yields some benefit to the government.

A civil servant could be assigned to the SSURI on detail or as an appointment. A detailed employee continues to count against NASA's FTE EP ceiling, continues to receive pay from his/her position,[11] and continues all government benefits and participation in such things as the Thrift Savings Plan and health and life insurance plans. An appointed employee does not count against NASA's FTE EP ceiling, goes on Leave Without Pay, and has the option of retaining retirement coverage and participation in the Thrift Savings Plan and health and life insurance plans.

No legislation is needed for IPA assignments.

International Traffic and Arms Regulations (ITAR) Exemption. ITAR addresses the transfer of technology or defense services to non-U.S. entities. An exemption from ITAR, either through statute or administrative action, could be structured as a part of an overall Memorandum of Understanding (MOU) or Letter of Agreement covering ISS operations. Alternatively, the SSURI would need to seek a Technical Assistance Agreement or an export license for many essential activities it would carry out in dealing with non-U.S. persons.

A statutory exemption is conceivable. However, various administrative paths are available to provide the needed authority.

Other Authorities That NASA May Need. In addition to the authorities that the SSURI may require, NASA itself may need additional authority to ensure the success of the ISS. These authorities would need to be conferred on the SSURI as a part of the contract. Some of these authorities include

- Authority to retain revenues received from commercial users. This approach would offer an alternative to returning such revenues to the Treasury. *Special legislation may be needed.*
- Pricing policy for commercial users. Congress and the administration will need to agree on a pricing regime that recovers taxpayer investment, yet encourages commercial interest at an

[9] Established consortia such as AUI, AURA, and USRA have health plans that have been financed over many years. A new consortium may not have such a mature plan.

[10] After 4 years, the employee must return to the federal agency for 12 months. After this, however, up to 2 years of additional IPA time may be accrued.

[11] The SSURI could reimburse NASA for all or part of the employee's pay.

affordable price. *Special legislation is not needed; however, this authority could been viewed as a policy matter codified in legislation by the Committees of jurisdiction.*

- Financial flexibility. Although the SSURI could act more efficiently if relief from cost accounting standards and Federal Procurement Regulations were provided, such relief is not essential. This financial flexibility is at the discretion of NASA and could be included in the terms of a contract. *Special legislation is not needed. This authority can be addressed as a contractual matter.*
- Authority to supplement and mix appropriated funds with private funds. The SSURI could be able, especially in later years, to supplement grant funding with venture capital, private endowments, royalties, revenues from advertising and other profit-making activities, consortium member dues, and perhaps user fees. *No special legislation is needed; however, NASA would need to ensure appropriations integrity.*
- Authority to protect commercially sensitive data from public access. Although the Space Act requires NASA to provide for the widest practicable and appropriate dissemination of information concerning its activities, it is reasonable to anticipate that full economic development of the ISS would be feasible only if some protections from Freedom of Information Act requests or from other public access were provided. The SSURI would need to sign nondisclosure agreements with most users. *Special legislation may be required.*
- Certain exemptions. To stimulate private investment in potential commercial activities, NASA could seek to make products or inventions from the ISS exempt from federal taxation. *Special legislation is needed.*

4.6.3 Summary

As stated early in Section 4.6, no special legislation is needed to establish the SSURI envisioned in this report. NASA could proceed immediately with its procurement under the authority of the Space Act. However, the successful bidder may seek certain authorities and could make them a condition of a contract. These authorities include indemnification, termination liability, and civil servant conversion. Other authorities and other forms of regulatory and administrative relief could enhance the efficiency and functioning of the SSURI during the Operations phase.

An omnibus piece of legislation could serve valuable purposes in setting forth a clear identity for the SSURI, ensuring clarity in its roles and responsibilities, and providing the full authorities needed for its mission. However, such legislation would be referred to multiple Committees of jurisdiction in both the House and Senate and would probably take more than a year to enact.

Because the actual form and content of the authorities desired may differ from bidder to bidder, the Study Team recommends that NASA proceed with the procurement now and seek any enhancing or enabling legislation at a later stage tailored to the successful bidder's needs.

4.7 Potential International Partner Considerations

4.7.1 Need for Early Involvement

Early involvement of the international partners in the ISS operations architecture options is essential to the overall success of any option carried forward, except the "Program Evolution" option. During the ISS redesign studies at Langley Research Center (LaRC), the partners were invited to participate in briefings on the redesign options being considered, before a final decision was made. Even though they were still somewhat upset at not being made part of the redesign study teams, they did not object to the eventual outcome.

Their involvement in the definition of the SSURI is critical because of the close interaction that will occur naturally among the U.S. and international experimenters in the utilization of the ISS. It is inconceivable that the SSURI, even if not internationalized, would not include international partner representation because of the close cooperation required in planning and executing experiments on board. Recognizing the necessity of this interaction, the Study Team recommends that the international partners be included in the development of the SSURI procurement to either permit their direct participation at the onset or to allow a graceful transition later. The Study Team further recommends that possible internationalization of the SSURI be a high-priority discussion topic immediately within NASA.

There will be some impact on the international partners at tactical and operational levels with options that involve the SSURI. The extent of the impact would depend on such factors as geographic location of the SSURI, functions that are delegated to the SSURI, and contractual relationships between SSURI and NASA entities. For example, the international partners maintain offices near some of the NASA Field Centers. If the SSURI were placed at a location that is not close to one of these centers, additional financial impact may occur to the partners wishing to staff offices within the SSURI. The MOUs require partner participation at the tactical and operational levels and involvement with the SSURI at the strategic level of Utilization integration.

4.7.2 SSURI Involvement in Selecting International Partner Science Payloads

Significant differences exist between the ISS agreements and the STScI agreements regarding research/science selection on an international basis. The Hubble MOU specifically states that the research will be decided on an international competitive basis. The ISS agreements specifically state that international partners will select their own payloads through their own processes (Article 8 of the MOU). However, these agreements also state that NASA has the lead responsibility for tactical- and operation-level planning and that the partners are obligated to staff these functions to appropriate levels for day-to-day interaction.

In the future, it may be desirable to consider a change to the agreements that would provide for cooperation in science/payload selection. An encouraging development in the Life Sciences discipline is that voluntary cooperation exists among the scientists to eliminate duplication and to share scientific findings developed from the Space Shuttle/Spacelab era. A similar cooperative effort is developing in the Microgravity Materials Science discipline. However, it cannot be expected that in commercial endeavors and technology-development research, where there is the potential for economic benefits, a similar desire would exist for cooperation in selecting what experiments would fly.

Appendix A. Statement of Work for the International Space Station Operations Architecture Study

This appendix contains the final Statement of Work (SOW) for the ISS Operations Architecture Study Task.

2.0 Background

1. As construction of the International Space Station (ISS) proceeds and program emphasis shifts from development to research and operations, the Office of Space Flight intends to establish an integrated operations architecture that is consistent with Agency strategic plans. The term 'operations' as applied herein refers to all activities required to conduct research and to maintain the health of ISS systems and crew. This statement of work defines the activities to be undertaken by a consulting contractor in support of ISS operations architecture development.

2. The objective of the operations architecture study is to provide the OSF an independent recommendation for an ISS operations architecture, with justification for the recommended architecture, to include a cost-benefit analysis. The study will also provide a proposed acquisition strategy for the recommended architecture, that details impacts to current government organizations involved with ISS operations as well as impacts to existing ISS program and Agency-wide operations-related contracts.

Period of Performance	Seven Months From Contract Award
Cost	TBD
Place of performance	Contractor's facilities plus travel to: NASA Headquarters, JSC, KSC, MSFC, and LaRC
Contract vehicle	GSA schedule (MOBIS)

2.0 Study Tasks

1. Study team formation and clearances. The contractor shall assemble a team of experts in space flight operations, to include launch site flight hardware processing, and space-based research. The team, as a whole, shall have prior experience with: Space Shuttle and Space Station operations, and space research; experience with non-governmental organizations (NGOs) and/or government corporations; and experience with commercial space enterprises. Experience with corporate re-engineering also desired. Team members will be screened by the contractor to determine that no conflict of interest currently exists, which might bias study results. The results of the screening will be provided to NASA.

2. Development and assessment of possible ISS operations architectures. The contractor shall develop possible ISS operations architectures that consider both recent National Research Council (NRC) recommendations related to ISS research structures and additional guidance provided by the OSF. The contractor shall assess the possible architectures to determine the architecture most likely to achieve OSF and Agency strategic plans. The term 'architecture' as used herein is defined as an integrated organizational structure for space operations and research on-orbit wherein all

components are described in terms of roles, responsibilities, contractual relationships, and regulatory or policy authority.

3. Cost-benefit analysis. The contractor shall provide a cost and benefit analysis for the recommended architecture, using a NASA-provided estimate for ISS operations costs as a comparator.

4. Acquisition strategy development. The contractor shall recommend an acquisition strategy for the recommended architecture to be used as a guide for the implementation of the architecture. The strategy shall address any changes required to the existing ISS and Agency operations contracts structure, and a practical timetable for the implementation of the recommended architecture. The strategy shall also address: the impact of the architecture on the ISS international partners; requirements for legislative action prior to implementation; liability issues that must be addressed prior to implementation; public safely issues arising from new or modified NGO or contractor relationships with the government; and approaches to guarantee an adequate level of government expertise in space flight operations.

5. Report preparation and presentation. The contractor shall provide a midterm briefing to NASA managers, at NASA Headquarters, Washington, DC. The midterm brief shall include the status of the study, an estimate of work to go, a completion schedule, and any outstanding issues or questions to be addressed by NASA. The contractor shall provide a final written report as outlined in Section 3.2 below along with a final briefing on its recommendations to NASA. The time and place for the final briefing will be as negotiated. The contractor shall provide 50 hard copy editions of the final report along with an electronic version in Microsoft Word format. Administrative services required for all study tasks are to be provided by the contractor.

6. Post-report support to NASA Management. The contractor shall support two additional briefings of the final team report to NASA management at times and places to be negotiated.

3.0 Study products

1. Mid-term briefing to NASA OSF management

2. Report of study recommendations

    2.1. Operations architecture options considered by/rejected with accompanying rationale

    2.2. Recommended ISS operations architecture; concept of operations; organizations, roles and responsibilities, contract relationships, and flow of authority and budgetary processes

    2.3. Cost-benefit analysis

    2.4. Recommended acquisition strategy

        2.4.1. Special considerations for the ISS international partners

        2.4.2. Special considerations for Legislative action

        2.4.3. Special considerations for government liability and public safety oversight

2.4.4. Special considerations for ISS pre-planned program improvement

2.4.5. Special considerations for government work force expertise in space flight operations

3. Final briefing to NASA OSF Management

4.0 Government support to the study

1. ISS program status and agency strategic plans. The government will provide the study team an orientation briefing covering the current status of the ISS program, and an overview of Agency and OSF strategic plans. A list of government contacts will also be provided to assist the team in obtaining additional information for the study.

2. Current ISS operations budget profile. The government will provide an operations cost estimate for FY 2006 through FY 2015 with sufficient detail to understand the operations functions to be performed, along with current operations budget ground rules and assumptions.

3. Current ISS program and Agency-wide operations contract structure. The government will provide the study team summaries of existing operations contracts associated with the ISS program. Each summary will cover contract scope, period of performance, existing options, and government interfaces.

5.0 Travel

1. Travel for the study team shall include, at a minimum, visits to the following locations for the purposes cited:

Locations	Purposes
JSC	Research and data collection
KSC	Research and data collection
MSFC	Research and data collection
LaRC	Briefing on NASA commercial activities
HQs	Study team orientation briefing
HQs	Study team midterm briefing
HQs	Study team final report briefing

Appendix B. Biographical Sketches of Team Members

John T. Cox (Study Chair) is currently employed by Computer Sciences Corporation as a Project Director. With over 30 years of NASA experience, he is a former NASA Flight Training manager, Lead Payload Officer, Space Shuttle Flight Director, Space Station Director of Utilization and Operations, and Space Station Program manager. He was team leader on the original Space Station Operations Task Force and a member of the National Research Council (NRC) Committees on Research and Technology for the ISS and the Long-Term Operations of the ISS. Dr. Cox received a B.S. in mechanical engineering from the University of California at Berkeley and an M.S. in aerospace engineering and a Ph.D. in biomedical engineering from the University of Houston.

H. Fletcher Kurtz (Acquisition Strategy Lead) is currently employed by Computer Sciences Corporation, where he has responsibility for five supercomputing facilities that support the DoD and NASA. Mr. Kurtz previously served 32 years at NASA MSFC, where he held positions as Manager of the Mission Operations Office, Deputy Director of the Systems Analysis and Integration Laboratory, and Director of the Mission Operations Laboratory. He was also Program Manager and Chief Engineer of the Huntsville Operations Support Center, which contains the Spacelab Payload Operations Center and the ISS Payload Operations Integration Center. In these roles, he supported many manned and unmanned NASA projects, including the Hubble Space Telescope Science Institute. Mr. Kurtz holds an M.S. in physics from Vanderbilt University and has completed graduate studies at the University of California at Berkeley and the University of Alabama, Huntsville.

W. Eugene Rice (International Partner Lead) currently supports FAA National Airspace System Modernization at Adsystech, Inc. Mr. Rice has over 25 years' experience in developing manned spacecraft for NASA. At NASA JSC, he served in several senior management positions on projects from Apollo to the Space Shuttle to the ISS. He was the senior technical member of the Space Station Freedom negotiating team that forged agreements with the European Space Agency, the Japanese National Space Development Agency, and the Canadian Space Agency. After leaving NASA, Mr. Rice joined the Grumman Aerospace Corporation as Director of System Engineering and Integration, where he was responsible for overall Space Station architecture, system requirements definition, system safety risk assessment, and design convergence. Mr. Rice completed B.S. and M.S. degrees in aeronautical engineering at the University of Oklahoma and Southern Methodist University, respectively, and has pursued graduate studies at the University of Colorado.

Ronald Sega (Utilization Lead) is a former astronaut and U.S. Air Force pilot, who is currently Dean of the Department of Engineering and Applied Science at the University of Colorado at Colorado Springs. He has also served as Research Associate Professor of Physics at the University of Houston, where he was affiliated with the Space Vacuum Epitaxy Center and is currently an Adjunct Professor. Dr. Sega is a Co-Principal Investigator on the Wake Shield Facility (WSF), which flew on STS 60 and STS 69. Dr. Sega flew as a Mission Specialist on STS 60, the first joint U.S./Russian Space Shuttle mission where he operated the WSF and performed various biological materials science, Earth-Observation, and life science experiments. He also served as Mission Specialist on STS 76 where he was Payload Commander. He was also the NASA Director of Operations at Star City, Russia. Dr. Sega has an M.S. in physics from Ohio State University and a Ph.D. in electrical engineering from the U.S. Air Force Academy.

Carl B. Shelley (Organization and Operations Architecture Lead) currently supports ISS efforts as an employee of JAMSS America. At NASA JSC, Mr. Shelley worked for 20 years in flight operations on all of the manned spaceflight programs beginning with Gemini and continuing through Apollo 12, Skylab, Apollo-Soyuz Test Program, and the Space Shuttle. During this time, he was active in all facets of flight operations, with special emphasis in flight crew and flight controller training, flight control team operations, crew procedure development, flight planning, and payload operations. Mr. Shelley served as the Deputy Director of the MOD before joining Space Station Freedom program management in 1985. There, he managed program utilization activities. He also co-chaired the Space Station Operations Task Force study and was Deputy Project Manager of the JSC Space Station Project Office for 5 years. He completed his career at JSC in Space Shuttle program management where he was instrumental in program management planning and implementation for the Space Flight Operations Contract. Mr. Shelley received a B.S. in electrical engineering from Auburn University and has pursued graduate studies at the University of Southern California and other institutions.

Robert Sieck (Safety Lead), formerly with NASA for 35 years, is a consultant for the Aerospace Safety Advisory Panel. While at NASA KSC, he was a Spacecraft Test and Launch Operations Lead Engineer in the Gemini and Apollo programs. During the Shuttle Approach and Landing Tests at Dryden Flight Research Center, he was Engineering Manager for the NASA Ground Operations team. As Shuttle Launch Director, Mr. Sieck developed a new government/contractor launch team, restructured the Launch Mission rules and procedures, and was Launch Director for 52 missions. Recently, while he was Director of Shuttle Operations, he managed the transition of ground operations to the Spaceflight Operations Contractor. Mr. Sieck received a B.S. in electrical engineering from the University of Virginia and has done postgraduate work at Texas A & M and the Florida Institute of Technology.

H. Wayne Whittington (Cost Business Analysis/Budget Lead) is currently an Executive in Residence at the University of Houston, Clear Lake, where he teaches Government and Public and Private Management. Dr. Whittington retired from NASA in 1994 after having served as Manager of Space Station Program Control (Business Management) at NASA JSC. Earlier, he held various management positions at JSC including Space Station Resources Manager and Manager of Space Station Plans and Schedules. Before coming to NASA, Dr. Whittington worked for the Boeing Company in Houston, Texas, and was a Captain in the United States Air Force. Dr. Whittington received a B.S. and M.S. in mathematics and biology from Texas A&M, Commerce, followed by an M.S. in systems management from the University of Southern California. Dr. Whittington also earned a Ph.D. in management information systems from the University of Colorado.

Stephen Bales (Core Team, Human Flight Operations) currently heads a chemicals firm in New Jersey. As a former NASA Flight Controller, and Division Manager, he directed a wide range of Mission Operations and preparation activities. He managed the NASA Operations and telecommunications resources. He also achieved cost-reduction goals by (1) working with NASA contractors to voluntarily consolidate ports of existing contracts, (2) working with customers to alter selected requirements, and (3) consolidating computing requirements across all NASA centers. He was the chief architect, developer, and operator of NASA JSC’s Mission Control Center and Astronaut Training Facility. Mr. Bales received a B.S. in aerospace engineering from Iowa State and an M.B.A. from the University of Houston.

Thomas Betterton (Space Assets Acquisition Expert) is currently a member of the U.S. Air Force Scientific Advisory Board and a fellow of the American Institute of Aeronautics and Astronautics (AIAA). He has served as member of the Advisory Committee on the ISS. Mr. Betterton is a retired Rear Admiral from the Navy, who served 35 years as a naval officer. For more than 16 years, he focused on the definition, development, and operation of major space-based systems. Since his retirement, he has been retained as a consultant by several aerospace firms. He has a wide variety of experiences in material acquisition and life-cycle support of naval weapons systems. Rear Admiral Betterton earned a B.S. degree in electrical engineering from the University of Notre Dame. He also received an M.S. degree in aeronautics and astronautics and an Engineer of Aeronautics and Astronautics, both from the Massachusetts Institute of Technology.

John T. Conway (Core Team, Payload Integration) has been a private consultant since 1996 to a number of aerospace companies. As a former Director of Payload Processing at NASA KSC, he managed a 2400-government/contractor team for Space Shuttle payload processing and served as Technical Manager of the Payload Ground Operations Contract. In this capacity, Mr. Conway worked closely with payload customer teams throughout NASA and the world and with payload-to-carrier and payload-to-launch vehicle integration processes. His responsibilities included developing the KSC launch site capability to test and integrate elements and payloads of the ISS and NASA oversight of expendable launch vehicles and systems, including the launch decision. Previously, Mr. Conway served as Director, Information Systems, responsible for developing, installing, and operating computer, communications, and instrumentation systems used for preflight preparation, testing, checkout, and launch of the Space Shuttle at KSC. Mr. Conway has a B.S. and M.A. in mathematics from Florida State University and the College of William and Mary, respectively.

Harold Draughon (Core Team, Program Contract Consolidation) currently serves on two independent assessment teams: one team is for the Hubble Space Telescope to ensure flight safety and mission success; the other team is for the Space Shuttle avionics upgrade effort. He retired from NASA after 25 years, which included service as a Flight Controller in the Gemini and Apollo programs, a NASA Flight Director in the Space Shuttle program, and a Deputy Manager for Operations in the Space Shuttle program office. He served for 10 years with Rockwell and the United Space Alliance (USA) as Program Manager for the Space Flight Operations Contract and then as Vice President for Flight Operations. During this period, he managed the consolidation of major Space Shuttle operations contracts into the Space Operations Contract; he subsequently managed the consolidation of that contract into the Space Flight Operations Contract. Mr. Draughon received a B.S. in electrical engineering from North Carolina State University at Raleigh.

Owen Garriott (Flight Science Crew Multi-Program Utilization Expert) currently holds a Research Professorship at the University of Alabama. He is a former NASA astronaut with extensive hands-on experience in Skylab and Spacelab plus Space Station design and utilization planning experience. After leaving NASA, he consulted for various aerospace companies and served as a member of several NASA and National Research Council Committees. Later, he was Vice President of Space Programs at Teledyne Brown Engineering. Dr. Garriott became a NASA scientist-astronaut in 1965 and was science pilot for Skylab-3, the second manned Skylab mission. He served as Director of Science and Applications at NASA JSC and then as Mission Specialist on STS-9/Spacelab-1, the maiden flight of the European Space Agency-developed laboratory. Dr. Garriott also served as Program Scientist for the Space Station program. He belongs to numerous professional associations. Dr. Garriott received an M.S. and Ph.D. in electrical engineering from Stanford University.

Stan Goldberg (Utilization Integration Expert) is currently a Director at Universal Technology Corporation of Colorado, where he provides strategic and technical consulting to such clients as the Air Force and NASA. For the Space Station program, Mr. Goldberg served as Deputy Director, Utilization and Operations, where he defined NASA factors required to support user integration ground and space infrastructure requirements. He integrated utilization and operations elements of international partners into a single Utilization and Operations Plan for Space Station Freedom. As Director, International Programs, Mr. Goldberg managed all activities to resolve international technical and programmatic issues associated with Space Station Freedom. For the Office of Commercial Programs, he developed NASA-wide programs to structure cooperative relationships with U.S. firms interested in exploiting the low-gravity environment available on the Space Station. As Senior NASA representative and liaison to the Air Force, Mr. Goldberg was the principal architect in establishing a Partnership Council that coordinates strategic planning and leverages technologies of common interest. Mr. Goldberg received a B.S. in mathematics from Southern Methodist University and an M.S. in applied mathematics from the University of Colorado.

Robert Gussin (Current Commercial Research Expert) was previously Corporate Vice President for Science and Technology at the Johnson & Johnson Company for whom he now provides consulting services. In this post, he was responsible for corporate strategic planning research and development and the introduction of new biotechnologies and pharmaceutical products for the health care industry. Dr. Gussin also served on the NASA Advisory Committee on the International Space Station. In this capacity, he led a task group to devise recommendations for improving NASA's approach to encouraging commercial development of ISS applications. Dr. Gussin received a B.S. in pharmacy from Dusquesne University and an M.S. and Ph.D. in pharmacology from Dusquesne University and the University of Michigan Medical School, respectively.

Michael Katovich (Core Team, Current Space Research) is currently a Professor in the Department of Pharmacodynamics at the University of Florida. His research focuses on hypertension, diabetes (with emphasis on gene therapy approaches), temperature regulation, and the renin-angiotens system, specifically dealing with blood pressure measurements (direct and indirect), vascular smooth muscle preparations, metabolic measurements, and in vivo and in vitro assessment of adrenergic function. He is a member of numerous professional societies, including the International Society for Gravitational Physiology, of which he is currently serving as president (1999-2000). Dr. Katovich received a B.S. in zoology and an M.S. and Ph.D. in physiology from the University of California at Davis.

Tom Kelley (Multi-Program Management Expert) is retired president of Grumman Corporation's Space Station Integration Division. Mr. Kelly worked for Grumman for 40 years, where he directed Grumman's engineering work on the Apollo Lunar Module and worked on the Space Shuttle and Space Station Freedom programs. He is a member of the National Academy of Engineering, a fellow of the American Astronomical Society, the American Society of Mechanical Engineers, and the American Institute of Aeronautics and Astronautics. Mr. Kelly was a member of National Research Council (NRC) Committee on the Use of the Space Station for Engineering Research and Technology Development and the Committee on Space Station Meteoroid/Debris Risk Management, and the Chair of the NRC Committee for Long-Term Operations of the ISS. He holds a B.S. in mechanical engineering from Cornell University, an M.S. in industrial management from the Massachusetts Institute of Technology, and an M.S. in mechanical engineering from Columbia University.

Glynn Lunney (Multi-Program Management Transition Expert) is a former Apollo Flight Director and Program Manager, Associate Administrator for Space Flight, and Space Shuttle Program Manager. Dr. Lunney managed Space Shuttle flight operations for Rockwell and later managed United Space Alliance (USA) acceptance of Space Shuttle operations responsibility, which transitioned from NASA in the Space Flight Operations Contract. He successfully developed the USA program support architecture, structure, and processes to support this activity. He has participated in several key strategic planning studies for NASA. Mr. Lunney has a B.S. in aeronautical engineering from the University of Detroit.

Keith McClung (Core Team, Program Operations) has over 35 years of experience in the space program with Boeing and predecessor companies. His roles have been in engineering, mission operations, program management. He has been involved in every manned space program since Apollo. For the Consolidated Space Operations Contract, Mr. McClung helped define and propose a new approach to contracting for ground systems/operations services for all of NASA and JPL's space missions. Earlier, he was Program Director, Commercial and International Programs, to develop technology products. He captured contracts with the Canadian Space Agency for support to the ISS and developed proposals to the Brazilian Space Agency, which resulted in contracts to support Brazil's participation in the Space Station. Previously, Mr. McClung directed Facility Operations, including maintenance, operations, and sustaining engineering for the Mission Control Center. He was also Deputy Program Manager, Space Operations Contract. Mr. McClung coordinated consolidation of the Space Transportation System

Operations Contract and Operations Support Contract. He received a B.S. in physics from Oklahoma University.

Robert Naumann (Space Research Expert) is currently Professor of Materials Science at the University of Alabama and Associate Director of the Alliance for Microgravity and Materials Science and Applications, a cooperative agreement between the university, the United States Research Agency, and NASA MSFC. He has held numerous positions at NASA Headquarters and MSFC in the physics and science areas related to all fields of Materials Science. Dr. Naumann is also a consultant to many space-related companies and was a Principal Investigator for the Japan-U.S. Thermal Science Accelerometer Project (STS-95); Organics Separation Experiment (Spacelab 2); and three Glovebox Experiments in the U.S. Microgravity Laboratory (USML)–1. He is also a Co-Investigator on the Protein Crystal Growth Experiment and on several other human- and non-human-tended space-based experiments. He is a member of numerous societies and various committee working groups. Dr. Naumann has a B.S., M.S., and Ph.D. in physics from the University of Alabama.

G. Paul Neitzel (Core Team, Current Space Research) is a professor in the George W. Woodruff School of Mechanical Engineering at Georgia Institute of Technology. His research interests include hydrodynamic stability of steady and unsteady flows, fluid mechanics of materials processing, flow control, vortex breakdown, and bioreactor fluid mechanics. He is a fellow of the American Physical Society and associate fellow of the American Institute of Aeronautics and Astronautics. He is a former member of the NASA Space Station Utilization Advisory Subcommittee. Dr. Neitzel received a B.S. in mathematics and physics from Rollins College. He also has an M.S. in numerical science and a Ph.D. in fluid mechanics, both from The Johns Hopkins University.

Cornelius Pings (Utilization Institute Expert) is President Emeritus of the Association of American Universities, and a member of the National Academy of Engineering. He is a former professor of Chemical Engineering and Chemical Physics, Vice Provost, and Dean of Graduate Studies at California Institute of Technology. He is the recipient of numerous awards, former chair of the National Research Council (NRC) Committee on Science, Engineering and Public Policy, and chair of NRC Task Group on Institutional Arrangements for Space Station Research. Dr. Pings earned a B.S. degree in applied chemistry and a Ph.D. in chemical engineering from the California Institute of Technology.

William Smith (NASA Legislation Expert) is currently President of the Association of Universities for Research in Astronomy, the consortium that has responsibility for the science operations of the Hubble Space Telescope through Space Telescope Science Institute. He is a former congressional staff member with oversight of the NASA budget. As Staff Director of the House Subcommittee on Space, he was responsible for a wide variety of legislative issues dealing with space commercialization and innovative approaches to implementing NASA programs. He also worked for 8 years in the Federal Aviation Administration and held various technical and regulatory positions. Dr. Smith received a Ph.D. in chemistry from Texas A&M University.

Stanley Sobieski (Core Team, Hubble Space Telescope Science Institute and NGO) is currently employed as a Senior Systems Engineer with Swales Aerospace, where he leads the Operations and Ground Systems Group, which develops mission operations requirements, concept definitions, network plans, and various procedures for the EOS, Landsat-7, and GOES missions. He also serves as HST Vision 2000 reengineering facilitator for the HST operations system to improve performance, lower costs, and improve operator and observing/archival scientist interfaces. As the NASA GSFC HST Interface manager, Dr. Sobieski managed overall science operations, oversaw the operation of the HST Science Institute, and managed grant provisions to HST observers. He recently managed a NASA study on Options for Managing Space Station Utilization, in which several types of non-government organizations were evaluated. Dr. Sobieski received an M.S. and Ph.D. in astrophysics from the University of Pennsylvania.

Appendix C. Meeting Agendas for NASA Center Visits

This appendix contains the meeting agendas for the Study Team's fact-finding visits to

■ NASA Headquarters, Washington, DC	February 2–4, 2000
■ Johnson Space Center, Houston, TX	February 22–25, 2000
■ Marshall Space Flight Center, Huntsville, AL	April 3–6, 2000
■ Kennedy Space Center, Kennedy Space Center, FL	May 8–10, 2000

During these visits, Study Team members listened to presentations, engaged in discussions, and gathered information to help them in their task. The team also held closed deliberations at each site to discuss what they had learned, crystalize their thoughts on candidate architectures, and design "homework" assignments for the next meeting.

NASA Headquarters, Room 9H40
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Wednesday, February 2, 2000

(Morning session - open to Study Team only)

8:00 a.m.	*Refreshments*	
8:30 a.m.	Opening remarks	J. Cox
8:45 a.m.	Get acquainted (Bias, Goals, Expectations)	All
9:30 a.m.	Study Team kickoff briefing	J. Cox
10:00 a.m.	*Break*	
10:15 a.m.	Non-Governmental Organizations (NGOs)	S. Sobieski
11:00 a.m.	Evaluation criteria	All
12:00 noon	*Lunch*	

(Afternoon session - open)

1:00 p.m.	Welcome and remarks	J. Rothenberg, NASA
1:15 p.m.	Enterprise Strategic Plans	J. Mankins, NASA
	Program overview and status	M. Hawes, NASA
2:45 p.m.	*Break*	
	Program organization and operations contracts	D. Koupash, NASA

(Closing session - open to Study Team only)

4:00 p.m.	Discussion and identification of additional data needs	All
4:15 p.m.	Bios, report plan, teams, meeting dates	J. Cox, All
4:45 p.m.	*Adjourn*	All

NASA Headquarters, Room 9H40
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Thursday, February 3, 2000

(Morning session – open to Study Team only)

8:00 a.m.	*Refreshments*	
8:30 a.m.	Discussion of Day 1 presentations	All
	Identify additional data needed	
8:45 a.m.	Institutional Arrangements for Space Station Research	C. Pings
9:45 a.m.	Evaluation criteria and level of detail	All
10:15 a.m.	*Break*	
10:30 a.m.	Challenges to Long Term Operations of the ISS	T. Kelly
11:15 a.m.	Evaluation criteria discussions by team	Teams
12:00 noon	*Lunch*	

(Afternoon session – open)

1:00 p.m.	Program Operations Budget Estimate	D. Koupash, NASA
	Operations Budget Estimate Trace to OPAT II	D. Koupash, NASA
2:45 p.m.	*Break*	
3:00 p.m.	OSF Operations Architecture Options	D. Koupash et al., NASA

(Closing session – open to Study Team only)

4:30 p.m.	Discussion and identification of additional data needs	All
	Friday morning discussion focus	
4:45 p.m.	*Adjourn*	All

NASA Headquarters, Room 9H40
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Friday, February 4, 2000

(Morning session – open to Study Team only)

8:00 a.m.	*Refreshments*	
8:30 a.m.	Discussion of Day 2 option presentations	Teams
	Evaluation template	
	Initial evaluation thoughts	
	Identify additional data needed	
9:45 a.m.	Meeting dates	J. Cox
10:00 a.m.	*Break*	

(Mid-Morning session – open)

10:15 a.m.	NGO Concepts	M. Uhran, NASA
	Follow-on Questions on OSF Architecture Options	NASA
	Team Visits to OSF Centers; Additional Research and Information Requirements	D. Koupash et al., NASA
12:30 p.m.	*Lunch*	

(Closing session – open to Study Team only)

1:15 p.m.	Team discussion results	Team Leads
	Preparation for Houston meeting	
2:00 p.m.	*Adjourn*	All

Johnson Space Center
Conference Room 214, Regents Park III
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Tuesday, February 22, 2000

(Afternoon session – open to Study Team only)

1:00 p.m.	*Arrival*	All
	Review evaluation criteria homework select topics	
	Revise bios and send to Michele Bissonette mbissone@csc.com	
	Review study team exercise 2 plan for the week	
	Agree on reference configuration for this week's activity	

(Afternoon session – open)

2:00 p.m.	Institutional Arrangements for Space Station Research	C. Pings
3:00 p.m.	**ISSP Presentation**	
	Briefings introduction	T. Holloway
	Study Team charge	J. Cox
	Projected Post-Assembly Complete Environment	M. Kennedy
3:30 p.m.	*Break*	
3:40 p.m.	ISS Program Office Briefings (Continued)	
	Overview of ISS Systems/Capabilities	K. Reiley
	Overview of Research Traffic and Ops Model	J. Kite
	Commercial Prospects for ISS	M. Uhran
	Potential add-on topic (1 hour)	
6:30 p.m.	*Adjourn: end of open session*	

(Closing session – open to Study Team only)

6:45 p.m.	Discussion; identification of additional data needed	All
	Homework, Plan for Day 2	
7:00 p.m.	*Adjourn*	All

Johnson Space Center
Conference Room 214, Regents Park III
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Wednesday, February 23, 2000

(Early morning session – open to Study Team only)

8:00 a.m.	*Arrival*	All
8:15 a.m.	Start JSC architecture exercise	J. Cox, All
9:45 a.m.	*Break*	

(Mid-morning session – open)

10:10 a.m.	**ISSP Presentation - Continued**	
	Overview of Key Support Facilities/Tools	
	ISSP - Key Support Facilities/Tools	M. Raftery
	JSC - Key Support Facilities/Tools	L. Davis
	KSC - Key Support Facilities/Tools	T. Corey
	MSFC - Key Support Facilities/Tools	T. Inman
	CSA - Key Support Facilities/Tools	C. Hatfield
	RSA - Key Support Facilities/Tools	K. Shireman
	Overview of ISS Operations Functions	J. Delheimer
12:30 p.m.	*Lunch*	
1:15 p.m.	**JSC/ISSP Implementers Presentation**	
	Principles Required To Safely, Effectively, and Efficiently Perform Functions	M. Kennedy
	ISS Operations Architecture (ISSP Perspective)	M. Kennedy
	Summary/Action Items	M. Kennedy
2:15 p.m.	**JSC/ISSP Implementers Presentations**	
	IP Agreements and Coordination	K. Doering
	Configuration Management	A. Lindenmoyer
	Budget and Business Management (if necessary)	C. Claunch
3:15 p.m.	*Break*	
3:30 p.m.	ISS Safety	J. Wade
	Program Planning and Manifesting	K. Schmalz
	Logistics and Maintenance	T. Butina
5:15 p.m.	*Adjourn: end of open session*	

(Closing session – open to Study Team only)

5:30 p.m.	Discussion; identification of additional data needs Homework, Plan for Day 3	All
6:00 p.m.	*Adjourn*	All

Johnson Space Center
Conference Room 214, Regents Park III
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Thursday, February 24, 2000

(Early morning session – open to Study Team only)

8:00 a.m.	*Arrival*	All
8:15 a.m.	Part 2 of JSC Architecture Exercise	J. Cox, All
9:45 a.m.	*Break*	

(Mid-morning session – open)

10:00 a.m.	**JSC/ISSP Implementers Presentations - Continued**	
	Cargo Integration	G. Johnson
	Mission Operations	L. Davis
	Sustaining Engineering	L. Anderson
12:00 noon	*Lunch*	
12:45 p.m.	User Integration	
	Payload Integration Management	J. Scheib
	Research Planning	N. Penley
	Engineering Integration	D. Hartman
2:00 p.m.	ISSP discussion of NRC NGO Recommendations	R. Nygren
3:30 p.m.	*Break*	
3:45 p.m.	***Contract Discussions***	
	Boeing	
5:15 p.m.	*Adjourn: end of open session*	

(Closing session – open to Study Team only)

5:30 p.m.	Discussion; identification of additional data needed
	Homework, Plan for Day 4
5:45 p.m.	*Adjourn*

Johnson Space Center
Conference Room 214, Regents Park III
ISS Operations and Utilization Architecture Study
Study Team Meeting Agenda

Friday, February 25, 2000

(Early morning session – open to Study Team only)

8:00 a.m.	Part 3 of JSC Architecture Exercise	J. Cox, All
9:00 a.m.	*Break*	

(Mid-morning session – open)

9:15 a.m.	**Contract Discussions – Continued**	
	SOMO Presentation	NASA
	CSOC Presentation	NASA
	SFOC Presentation	NASA
	Follow-up action responses	NASA
12:15 p.m.	*Adjourn*	

(Closing session – open to Study Team only)

12:30 noon	*Lunch*	
	Exercise summary, next meeting @ MSFC	All
	Draft report development	
1:15 p.m.	*Adjourn*	All

Marshall Space Flight Center
Building 4610, Room 1054
ISS Operations Architecture Study
Study Team Meeting Agenda

Monday, April 3, 2000

(Afternoon session – open to Study Team only)

1:00 p.m.	*Arrival*	All
	Review Study Team plan for the week	
	Review architecture tool	
	Develop reference configuration	
	Revise bios and send to Michele Bissonette mbissone@csc.com	

(Afternoon session – open)

2:00 p.m.	Welcome/Introduction	A. Roth
2:10 p.m.	MSFC Organization and ISS Responsibilities	T. Inman
2:30 p.m.	End-to-End Payload Integration	J. Scheib
	Rack level from PDR to launch	
3:20 p.m.	EXPRESS Integration - Rack, Pallet, and WORF	P. Gilbert
4:15 p.m.	*Break*	
4:30 p.m.	Payload Operations and Integration Function (POIF)	R. Cissom
5:30 p.m.	Payload Planning	J. Hagopian
6:30 p.m.	*Adjourn: end of open session*	

(Post-afternoon session – open to Study Team only)

6:35 p.m.	Recap/findings from discussions	All
	Identify any new information needs	
6:45 p.m.	*Adjourn*	All

Marshall Space Flight Center
Building 4610, Room 1054
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Study Team Meeting Agenda

Tuesday, April 4, 2000

(Open session)

8:00 a.m.	Payload Operations Integration Center (POIC)	D. Bailey
	Remote Users/Remote Operations	C. Lapenta
9:30 a.m.	Telescience Resource Kit (TreK)	M. Schneider
10:15 a.m.	*Break*	
10:30 a.m.	Research Institutes and Research Program Offices	
	How they work, direction, funding	M Uhran
11:00 a.m.	Commercial Programs	M Uhran
11:30 a.m.	Microgravity Research	R. Henderson
12:30 p.m.	*Lunch*	
1:15 p.m.	Fundamental Biology	G. Jahns
2:15 p.m.	Space Biology/Biomedical Research and Countermeasures	C. Stegemoeller
3:15 p.m.	*Break*	
3:30 p.m.	Earth and Space Sciences	B. Park
4:30 p.m.	Engineering Research and Technology	C. Parra
5:30 p.m.	ISS Vehicle Support at MSFC	MSFC
6:15 p.m.	*Adjourn*, start facility tours	MSFC

Marshall Space Flight Center
Building 4610, Room 1086
ISS Operations Architecture Study
Study Team Meeting Agenda

Wednesday, April 5, 2000

(Session open to Study Team only)

8:00 a.m.	*Gather*	
8:15 a.m.	Discussion of previous days' findings	All
	Joe Rothenberg and Mark Uhran update	
8:30 a.m.	Report development	J. Cox
	Outline review	
	Findings	
	What is an architecture?	
	Architecture options discussion	
	Evaluation Criteria	
9:30 a.m.	Findings exercise	2 Teams
10:00 a.m.	Architecture option development	2 Teams
	Primary option	
	Secondary options	
11:15 a.m.	*Break*	
11:30 a.m.	Findings and architecture presentations	2 Teams
	20 minutes each team	
	Differences and similarities	All
12:15 p.m.	*Lunch*	
1:00 p.m.	Cost-benefit orientation	W. Whittington/All
	Example	
	Exercise for top two architectures	2 Teams
2:00 p.m.	How it works	J. Cox
	Orientation	
	Exercise – one Ops, One Util	2 Teams
3:00 p.m.	*Break*	
3:15 p.m.	How it works: presentations	J. Cox
4:00 p.m.	Consensus on recommendation for architecture?	All
4:45 p.m.	Thursday activity	J. Cox
5:00 p.m.	*Adjourn*	All

Marshall Space Flight Center
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Thursday, April 6, 2000

8:00 a.m.	*Gather*	
8:15 a.m.	International Partners discussion	G. Rice
	Impact for US activity	
	Impact if evolved to International Role	
8:45 a.m.	Safety considerations	B. Sieck
	Transfer of work to contractors	
	Process, limits, concerns	
	ISSI P/L safety concerns	
9:45 a.m.	Phasing discussion for preferred architecture	J. Cox/All
10:15 a.m.	*Break*	
10:30 a.m.	Draft document development	
	Preferred architecture	C.Shelley/R. Sega
	How it works	C.Shelley/R. Sega
	Evaluations	C.Shelley/R. Sega
	Findings and rec's (should show up in "Arch'" or "How it works")	C.Shelley/R. Sega
	CBA for options developed	W. Whittington
	Acquisition	F. Kurtz
12:00 noon	*Lunch*	
12:30 p.m.	Next Meeting – Mid Term Report	J. Cox
	Date	
	Attendees	
	Format	
	KSC/LaRC estimates	
1:00 p.m.	Turn in rough drafts and agree to improved draft revision date	Leads
2:00 p.m.	*Adjourn*	All

Kennedy Space Center
SSPF, Room 3006A
ISS Operations Architecture Study
Study Team Meeting Agenda

Monday, May 8, 2000

(Open session)

8:00 a.m.	*Gather*	All
8:30 a.m.	KSC Space Station Processing	
	Introduction	T. Talone
	KSC 2000 Reorganization Overview	
	Roles and Responsibilities	
	Program Interfaces	
	Budget	
10:00 a.m.	*Break*	
	PGOC Contract	B. Keith
	Logistics	C. Lodge/W. Roy
	ISS Resupply and Return	T. Corey
	ISS Utilization	M. Smith
	Summary	T. Talone
12:00 noon	*Lunch*	
1:00 p.m.	OZ Action-Item Closure	
	Post-Assembly Complete Traffic Model	N. Penley
	Integration Templates for Subset of Above	J. Scheib
2:30 p.m.	SSPF Tour	
	SSPF Offline Lab	C. McFadden
		L. Brawn
	Intermediate Bay (Rack integ, PTCS, Attached P/L)	M. Smith
	High Bay (MPLM -> CITE -> Elements)	Mission Managers
	Rack Foam Cutting and Packing Area	T. Corey

(Session open to Study Team members)

4:30 p.m.	Discuss briefings, review plans for 5/9, 5/10	All
5:00 p.m.	*Adjourn*	All

Kennedy Space Center
SSPF, Room 2048
ISS Operations Architecture Study
Study Team Meeting Agenda

Tuesday, May 9, 2000

(Session open to Study Team only)

8:00 a.m.	Architecture functions review and agreement on "base option"	C. Shelley
	Goal: agree with list and function assignments	
	Architecture options	All
	Goal: Agree with option set of identified deltas to base option	
	Architecture depiction	Cox
	Goal: Agree with method to depict options to management	
10:00 a.m.	*Break*	
10:15 a.m.	Transitions	
	Develop a phased approach to implement Architecture	
	Opportunity gates, program and contract milestones	
12:00 noon	*Lunch*	
12:45 p.m.	Transition (continued)	
	Goal: Agree on phasing approach - each function – capture rationale	
1:30 p.m.	Transition phasing depiction	J. Cox/All
	Goal: Agree on method to depict the phased transition	
2:45 p.m.	*Break*	
3:00 p.m.	Commercial Science Centers Teleconference	All
	Questions handout as guide	
	Frank Schowengerdt – Colorado School of Mines	
	Louis Stodieck – Bioserve Space Technologies	
	Goal: List of architecture items to improve commercial opportunities	
5:00 p.m.	*Other tours/Adjourn*	All

Kennedy Space Center
SSPF, Room 2048
ISS Operations Architecture Study
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Wednesday, May 10, 2000

(Session open to Study Team only)

8:00 a.m.	Architecture evaluation	J. Cox/All
	Goal: Modified criteria & completed base option score card	
	Architecture Options	
	Complete scorecard for other options	
	Goal: Agree on representative scorings	
10:00 a.m.	*Break*	
10:15 a.m.	Cost-benefit discussion	W. Whittington/All
	Review revised CBA package	
	Relate to new architectures	
	Goal 1: Agree on CBA for base option	
	Goal 2: Identify CBA differences across options	
12:00 noon	*Lunch*	
12:45 p.m.	Acquisition strategy	All
	Goal: Set of responses for each topic below	
	Changes to existing ISS and Agency operations contracts structure	
	List the changes	
	Practical timetable for implementation	
	Describe	
	Impact of architecture on International Partners	
	Describe	
	Legislative action needed prior to implementation of architecture	
	Describe	
	Liability issues that must be addressed prior to implementation	
	List	
	Public safety issues arising from new or modified NGO or contractor relationships	
	List/Describe	
	Approach to guarantee adequate government expertise level in space flight ops	
	(Note: Ops includes utilization for this study)	
	Describe	
3:00 p.m.	*Adjourn*	All

Appendix D. People Who Provided Guidance

This appendix acknowledges the people who provided special guidance to the Study Team and the presenters who gave the team information during its visits to the various NASA Centers.

- **NASA Headquarters**
  - Joseph Rothenberg
  - Arnauld Nicogossian
  - Stacy Edgington
  - Mike Hawes
  - Doug Koupash
  - Mark Uhran
- **Marshall Space Flight Center**
  - Caroline Griner
  - Axel Roth
  - Robin Henderson
  - Thomas Inman
  - Mark Null
  - Bill Ramage
- **Kennedy Space Center**
  - Roy Bridges
  - Tip Talone
  - Wayne Bogle
  - Todd Corey
  - Maynette Smith
- **Johnson Space Center**
  - George Abbey
  - Thomas Holloway
  - John Rummel
  - Bill Bennett
  - Jack Boykin
  - Jim Costello
  - Jon Harpold
  - Maurice Kennedy
  - Rick Nygren
  - Blake Ratcliff
  - Dave Schurr
  - Charles Stegemoeller
- **Hubble Space Telescope Science Institute**
  - James Jeletic
  - Steve Beckwith
  - Charlie Wu
- **Ames Research Center**
  - Gary Jahns

In addition, the Study Team thanks the following individuals and offices, who, as external reviewers, provided special expertise and a point of view that helped the team during final preparation of the report: Donna Bartoe, John-David Bartoe, Jack Kerrebrock, Dick Kohrs, John O'Neill, the ISS program office, and the Space Station program office.

The following individuals presented information to the Study Team during its visits to the various NASA Centers. The team appreciates the time and effort given by the individuals in providing insight about their respective roles and responsibilities.

Last Name	First Name	Topic
Ames Research Center		
Jahns	Gary	Fundamental Biology Program
Glenn Research Center		
Ostrach	Simon	Microgravity Research on Fluids and Combustion Institute
Goddard Space Flight Center		
Campbell	John H.	Hubble Space Telescope Program, Code 440
Jeletic	James	Space Telescope Science Institute
Park	Betsy	Space and Earth Science Research Program Office

Last Name	First Name	Topic
Headquarters		
Hawes	Mike	Program Overview and Status
Koupash	Doug	Program Organization and Operations Contracts
Koupash	Doug	Program Operations Budget Estimate
Koupash	Doug	Operations Budget Estimate Trace to OPAT II
Koupash et al.	Doug	OSF Operations Architecture Options
Koupash et al.	Doug	Visits to OSF Centers; Additional Research and Information Requirements
Mankins	John	Enterprise Strategic Plans
Rothenberg	Joseph	Welcome and Remarks
Uhran	Mark	NGO Concepts
Uhran	Mark	NASA Research Institutes
Uhran	Mark	Commercial Space Center Program Definitions and Scope
Johnson Space Center		
Anderson	Lorraine	Sustaining Engineering
Boykin	Jack	SFOC Overview
Butina	Tony	Logistics and Maintenance
Costello	Tom	SOMO Technology
Creasy	Susan	Mission Management Functions
Davis	Larry D.	MOD ISS Operations at Station Complete
Davis	Larry D.	MOD ISS Facilities
Delheimer	Joella	Overview of ISS Operations Functions
Doering	Kim	International Partner Agreements and Coordination
Grounds	Dennis J.	Biomedical Research and Countermeasures Program Office
Hartman	Dan	Payload Hardware/Software Engineering Integration
Hatfield	Caris A.	CSA Provided Facilities
Holloway	Thomas	ISSPO Perspective on NGO Architecture
Holloway	Thomas	Principles Required To Safely, Effectively, and Efficiently Perform Functions
Johnson	Gary	Functional Flow for Resupply/Return Flights
Kennedy	Maurice	ISS Program Presentation to ISS Operations Architecture Study Team
Lee	Richard	Configuration Management Post-Assembly Complete
Lueders	Kathy	One Day in the Future: Depot/OEM Operations
Nygren	Rick	ISS Payloads Office
Nygren	Rick	ISS Response to NRC – NGO Recommendations (Preliminary)
Parra	Carlos	Engineering Research and Technology Research Program Office
Penley	Ned	Research Traffic and Operations Model
Piatek	Irene M.	JSC Engineering Directorate Facilities for ISS
Raftery	Michael L.	ISS Program’s Laboratories and Test Facilities
Reiley	Keith	Overview of ISS in 2007
Roe	Lisa	CoFR Process

Last Name	First Name	Topic
Scheib	Jim	ISS Payload Mission Integration
Schell	Rich	CSOC/IOA Briefing
Schmaltz	Karen	Program Planning and Manifesting
Seyl	Jack	SOMO/CSOC Presentation
Shireman	Kirk	Russian Facilities
Shurr	David	ISS Prime Contract
Stegemoeller	Charles	National Space Biomedical Research Institute
Uri	John	Research Mission Management
Wade	Jim	ISS Safety and Mission Assurance/Program Risk
Walters	Britt	Space and Life Sciences Directorate Facilities for ISS
Penley	Ned	Assembly Complete Research Traffic
Scheib	Jim	End-to-End Payload Integration
Scheib	Jim	End-to-End Payload Integration (Subrack-Level Payloads)
Kennedy Space Center		
Beardall	Joseph	CoFR Process
Corey	Todd	Launch Site Capability Post-Assembly Complete
Corey	Todd	KSC ISS Resupply and Return Post-Assembly Complete
Dollberg	John	Safety Process
Keith	Bryant	PGOC Contract Overview
Lodge	Cindy	Logistics Division: Interfaces and Roles
Nordeen	Ross	CoFR Process
Roy	William	Logistics Division: Interfaces and Roles
Schierf	Roland	CoFR Process
Smith	Maynette	KSC ISS Utilization Post-Assembly Complete
Talone	Tip	KSC Space Station Processing: Introduction and Overview
Marshall Space Flight Center		
Bacskay	Allen	EXPRESS Pallet Engineering Integration
Bailey	Darrell	Payload Operations Integration Center (POIC) Payload Data Services System (PDSS)
Cissom	Rick	Payload Operations Overview
Croomes	Scott	ISS Vehicle Support at MSFC
Gilbert	Paul	EXPRESS Rack/WORF Hardware/Software Engineering Integration
Hagopian	Jeff	ISS Payload Mission Planning
Henderson	Robin	Microgravity Research Program
Inman	Tom	Overview of Key MSFC ISS Support Facilities/Tools/Functions
Lapenta	Cathy	Remote Operations
McNair	Ann	Utilization and Mission Support Contract Overview
Schneider	Michelle	Telescience Resource Kit (TReK)
Vanhooser	Teresa	Boeing 50K Contract Overview

Appendix E. Cost-Benefit Analysis Supporting Data

This appendix contains data that supports and further explains the data in Section 3, *Architecture Evaluations and Cost-Benefit Analysis for the Recommended Option*. Section E.1 contains detailed cost and equivalent persons (EPs) data. Section E.2 contains the ground rules and assumptions for assigning cost and EPs between the ISS program and the Space Station Utilization and Research Institute (SSURI).

E.1 Detailed Cost and EP Data

The tables in Section E.1 contain detailed and phased cost and EP data for the ISS and the SSURI. As with other costs and EP data in this section, this information was taken from or derived from the *ISS Post-Assembly Operations Cost Estimate (PAOCE)*. The notations “CON” and “CS” stand for contractor and civil servant, respectively.

Several points should be made about Table E-1. The distribution will change somewhat after the current Program Operating Plan (POP) is finalized. In addition, the fact that more that 3000 EPs were assigned to the SSURI (not including most of the 500 discussed in Section 3.4.5.1) does not mean that the SSURI would have nearly this many people in it. In fact, the Study Team believes that most of the work would be contracted out to NASA organizations. What the distribution in this table does indicate, however, is the team’s belief that the SSURI would have budget responsibility for approximately half of the operations/research activities currently in the ISS PAOCE estimate.

Table E-1. Distribution of Costs and EPs for the ISS and the SSURI—FY 2006

Function	ISS				SSURI			
	$M	EPs			$M	EPs		
		CON	CS	Total		CON	CS	Total
Mission Operations	160.1	869	160	1029				
Extravehicular Activity (EVA)	29.5	235	33	268				
Sustaining Engineering	143.5	690	125	815				
Logistics and Maintenance	95.5	178	0	178				
Research Operations					272.6	1007	324	1331
Utilization					221.3	689	405	1094
Space and Life Sciences	30.9	241	42	283				
Payload Operations Integration					93.9	544	145	689
Launch Site Processing	109.3	730	228	958				
Program Office	20.0	117	150	267	(20.0)	(267)	0	(267)
P3I	75.0				75.0			
Reserve	72.3				72.3			
Total	**736.1**	**3060**	**738**	**3798**	**735.1**	**2507**	**874**	**3114**

Tables E-2 and E-3 contain annual phasings of ISS and SSURI costs, based on the assumptions contained in Section E.2.

Table E-2. Distribution of ISS Cost and EPs by Fiscal Year—Based on the ISS PAOCE

Cost Element		Fiscal Year							
		2006	2007	2008	2009	2010	2011	2012	2013
Mission Operations	$	160.1	147.0	147.8	148.9	154.2	156.5	157.9	160.4
Contractors		869	836	793	793	793	793	793	793
Civil Servants		160	155	155	155	155	155	155	155
Total EPs		1029	991	948	948	948	948	948	948
EVA Projects	$	29.5	31.3	33.2	35.2	37.3	38.4	39.8	41.2
Contractors		235	240	245	251	255	255	255	255
Civil Servants		33	29	23	18	13	13	13	13
Total EPs		268	269	268	269	268	268	268	268
Sustaining Engineering	$	143.5	148.2	153.0	158.0	163.2	168.8	174.2	176.8
Contractors		690	700	710	710	710	710	705	685
Civil Servants		125	110	80	70	64	64	64	75
Total EPs		815	810	790	780	774	774	769	760
Logistics and Maintenance	$	95.5	93.6	97.5	98.1	100.9	102.6	106.0	112.9
Contractors		178	170	170	170	170	170	170	170
Civil Servants		0	0	0	0	0	0	0	0
Total EPs		178	170	170	170	170	170	170	179
Space and Life Sciences	$	30.9	33.6	34.2	33.6	34.7	38.0	37.8	38.0
Contractors		241	241	241	241	241	241	241	241
Civil Servants		42	42	42	42	42	42	42	42
Total EPs		283	283	283	283	283	283	283	283
Launch Site Processing	$	109.3	113.4	121.5	119.1	129.0	127.4	131.9	138.7
Contractors		730	755	800	804	737	738	786	700
Civil Servants		228	228	228	228	228	228	228	228
Total EPs		958	983	1028	1032	965	966	1014	928
Program Office	$	20.0	20.7	21.4	22.1	22.8	23.6	24.4	25.2
Contractors		117	117	117	117	117	117	117	117
Civil Servants		150	150	150	150	150	150	150	150
Total EPs		267	267	267	267	267	267	267	267
P3I	$	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
Contractors		0	0	0	0	0	0	0	0
Civil Servants		0	0	0	0	0	0	0	0
Total EPs		0	0	0	0	0	0	0	0
Reserve	$	72.3	73.5	73.9	74.5	77.1	78.3	78.9	80.2
Contractors		0	0	0	0	0	0	0	0
Civil Servants		0	0	0	0	0	0	0	0
Total EPs		0	0	0	0	0	0	0	0
TOTAL	$	736.1	736.3	757.5	764.5	794.2	808.6	825.5	848.6
Contractors		3060	3059	3076	3086	3023	3024	3067	2961
Civil Servants		738	714	678	663	652	652	652	663
Total EPs		3798	3773	3754	3749	3675	3676	3719	3624

Table E-3. Distribution of SSURI Cost and EPs by Fiscal Year

Cost Element		Fiscal Year							
		2006	2007	2008	2009	2010	2011	2012	2013
Research Operations	$	272.6	262.1	234.3	224.2	221.9	216.7	210.6	197.6
Contractors		1007	976	953	944	806	816	804	781
Civil Servants		324	283	272	244	214	210	207	205
Total EPs		1331	1159	1225	1188	1020	1026	1011	986
Utilization	$	221.3	240.7	255.3	264.4	273.3	285.6	288.9	296.7
Contractors		689	704	706	722	733	743	743	749
Civil Servants		405	408	406	389	379	377	372	369
Total EPs		1094	1112	1112	1111	1112	1120	1115	1118
Payload Operations Integration	$	93.9	97.6	97.6	97.6	97.6	97.6	97.6	97.6
Contractors		544	541	541	541	541	541	541	541
Civil Servants		145	141	141	141	141	141	141	141
Total EPs		689	682	682	682	682	682	682	682
P3I	$	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
Contractors		0	0	0	0	0	0	0	0
Civil Servants		0	0	0	0	0	0	0	0
Total EPs		0	0	0	0	0	0	0	0
Reserve	$	72.3	73.5	73.9	74.4	77.1	78.2	78.8	80.2
Contractors		0	0	0	0	0	0	0	0
Civil Servants		0	0	0	0	0	0	0	0
Total EPs		0	0	0	0	0	0	0	0
TOTAL	$	735.1	748.9	736.1	753.6	744.6	753.1	750.9	747.1
Contractors		2240	2221	2200	2207	2080	2100	2088	2071
Civil Servants		874	832	819	774	734	728	720	715
Total EPs		3114	2953	3019	2981	2814	2828	2808	2786

E.2 Ground Rules and Assumptions for Assigning Cost and EPs Between the ISS Program and the SSURI

Each of the cost elements in the ISS PAOCE (e.g., Sustaining Engineering, Research Operations) was assessed using the detailed data provided by NASA. Following that, a subset of the Study Team met with NASA officials at JSC to further understand the content of the elements. Tables E-4 through E-13 contain the ground rules and assumptions used in assigning cost and EPs to the ISS and the SSURI. As was the case earlier, none of the tangible benefits (cost savings) were considered in order to ensure traceability between the numbers in Section E.2 and the ISS PAOCE.

Table E-4. Mission Operations Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
MOD Projects	14.4			
Flight Operations	9.2			
Portable Computer System	0.1			
Vehicle Mockups	5.1			
CSOC	30.7			
Integrated Planning System	5.8			
Mission Control Center	24.9			
SFOC	115.0			
Crew Return Vehicle (CRV)	1.9			
Utilization Support	1.2			
Ground Operations	111.9			
Total	160.1	869	160	1029

Ground Rules and Assumptions—ISS PAOCE

1. Three work centers (controllers and planners) reduced by 25% per year through FY 2008 based on past experience; others considered at or below minimum staffing levels.
2. Civil servant staffing reduced 34% from FY 2000 through FY 2007 consistent with Core Competency Study.
3. Equipment upgrades on 5-year centers. This, plus off-nominal operations, results in an FY 2010 cost spike (6%) real growth.

SSURI Assumptions—All of this effort remains with the ISS.

Table E-5. EVA Projects Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
NBL Operations	11.5			
Vehicle Operations/Safety	2.6			
EMU Sustaining Engineering	4.9			
EVA Sustaining Engineering	4.4			
EVA Tools	1.5			
SSATA Training Runs	0.7			
Safer Sustaining Engineering	0.8			
IP EVA Mission Assurance	2.1			
RMS VR Simulator	1.0			
Total	**29.5**	**235**	**33**	**268**

Ground Rules and Assumptions—ISS PAOCE

1. Contractor work force up to 80% of total or better by FY 2010.
2. Total work force constant after FY 2010.
3. 2.7% real cost growth for hardware development.

SSURI Assumptions—Only ISS personnel perform EVA. All of this effort remains with the ISS.

Table E-6. Sustaining Engineering Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs
Contractor	117.3	690
Civil Servant		125
Special Failure Analysis	26.2	
Total	**143.5**	**815**

Ground Rules and Assumptions—ISS PAOCE

1. NASA Headquarters Placeholder; estimate based on small civil service work force supported by up to 710 contractors.
2. EPs and additional funds for special failure analysis and outsourced work.

Work Breakdown Structure Elements (extracted from “Sustaining Engineering,” Lorraine Anderson, February 24, 2000):

1. Sustaining Engineering is the design engineering, technical, and programmatic support needed after the development of the hardware/software items are completed and these items have been delivered (DD250).
2. Sustaining Engineering also includes pre-DD250 tasks such as developing planning documentation, maintaining testbeds/facilities, Mission Evaluation Room (MER) and

Engineering Support Room (ESR) training, and critical skill-retention activities (e.g., cross-training, design knowledge capture).

SSURI Assumptions—All of this effort remains with that ISS. A grassroots estimate of ISS Sustaining Engineering is needed. It was the team's understanding that, while the above estimate is a placeholder, it was intended to include only prime contractor hardware, not sustaining hardware, for Government-Furnished Equipment.

Table E-7. Logistics and Maintenance Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Post-Production Support (Prime)	71.8			
Other Repair	17.9			
Boeing Core Systems	9.5			
GFE	0.5			
IP/US	3.0			
Common HW HAB	4.9			
Crew Provisioning	5.8			
Crew Health Care Systems	1.7			
Analysis and Spares	0.2			
Flight Crew Equipment	2.6			
Food	1.3			
Total	**95.5**	**178**	**0**	**178**

Ground Rules and Assumptions—ISS POACE

1. Work force is constant for all but the first and last years.
2. The Reliability and Maintainability Assessment Tool is used to project depot repair actions.
3. Cost growth variable (0.6% to 4%) depending on projected maintenance load.

SSURI Assumptions—All of this effort remains with the ISS.

Table E-8. Research Operations Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Gravitational Biology	75.5			
Operations	19.2			
Facilities	56.3			
Biomedical Research	23.0			
Operations	17.8			
Facilities	5.2			
Microgravity Research	116.4			
Operations	33.4			
Facilities	83.0			
Space Product Development	3.1			
Operations	3.1			
Engineering Technology	4.6			
Operations	4.6			
Earth Observation Systems	0.5			
Operations	0.5			
Flight Multi-User Support	49.5			
Operations	20.9			
Facilities	28.6			
Total	**272.6**	**1007**	**324**	**1331**

Ground Rules and Assumptions—ISS POACE

1. Contractor work force up to 80% of total by FY 2009.
2. 10% cost decline each year through FY 2008; then 2% to 6% per year reductions each year afterward.
3. Annual facilities support costs (materials and repairs) decline by 63% starting in FY 2008 (after the final microgravity racks are delivered).
4. Expect updates to schedules and resources after ongoing research programs are completed.

SSURI Assumptions—The budget for all of this activity would be transferred to the SSURI, as well as the 1331 billets associated with the effort. Determining how the budget would be used and where the billets would be located would be a SSURI responsibility.

Table E-9. Utilization Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Gravitational Biology/Ecology	11.5			
Biomedical Research and Countermeasures	6.0			
Advanced Human Support Technology	15.0			
Microgravity Research	144.4			
Space Product Development	17.2			
Engineering Technology	26.3			
Earth Observation Systems	0.2			
Flight Multiuser Hardware and Support	0.7			
Total	**221.3**	**689**	**405**	**1094**

Ground Rules and Assumptions—ISS PAOCE

1. Real growth in cost (to 6%) and contractor work force (less than 2%) through FY 2011; declining growth in remaining years (5% to 1% per year).
2. Slight annual decline (1-2%) in civil servant work force starting in FY 2009.

SSURI Assumptions—The budget for all of this activity and the associated billets would be transferred to the SSURI.

Table E-10. Space and Life Sciences Costs and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Medical Operations	9.3			
Crew Health Care System Hardware	1.4			
Stowage Integration	8.4			
Human Engineering	1.1			
Food Systems	1.3			
Analytical Labs	3.8			
Image Analysis	1.2			
Radiation Support	0.6			
Orbital Debris	2.4			
Life Sciences Integration	1.4			
Total	**30.9**	**241**	**42**	**283**

Ground Rules and Assumptions—ISS PAOCE

1. Contractor staffing at 80% from the start.
2. Civil servant staffing at or below desired levels with no relief assumed.

3. Investigating a more integrated approach to ISS support: internal review effort started in November 1999.

SSURI Assumptions—All of this effort remains with the ISS.

Table E-11. Payload Operations Integration Costs and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
POIC	93.9			
Total	**93.9**	**544**	**145**	**689**

Ground Rules and Assumptions—ISS PAOCE

1. Costs and work force flatlined from FY 2007 through program complete.

SSURI Assumptions—From discussions with ISS personnel, it appears that all of the above dollars and people would support Space Station payload operations in the Payload Operations Integration Facility (POIF) at MSFC; therefore the team assumed that all would be transferred to the SSURI.

Table E-12. Launch Site Processing Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Launch Support	31.9			
Support Equipment	5.6			
Facilities	16.9			
Logistics	27.9			
Test Control and Monitoring System	3.2			
Payload Integration	14.1			
Launch Site Analysis and Integration Team	9.9			
Total	**109.2**	**730**	**228**	**958**

Ground Rules and Assumptions—ISS PAOCE

1. Significant contractor work force reductions (up to 24%) before FY 2006.
2. Civil servant work force reduced by 32% (to 228 FTEs) by FY 2005.
3. Limited facilities and support equipment upgrades.
4. Assumes Vertical Processing Facility and Operations and Checkout vacuum chamber operational to support CRV.

SSURI Assumptions—All of this effort remains with the ISS.

Table E-13. Program Management Cost and EPs for FY 2006, Real-Year Dollars in Millions From ISS PAOCE

Task	$M	EPs		
		Contractor	Civil Servant	Total
Program Management	20.0	117	150	267
Total	**20.0**	**117**	**150**	**267**

Ground Rules and Assumptions—ISS PAOCE

1. NASA Headquarters placeholder; based on 117 EP contractor support adjusted for inflation; current support, 170 EP.

Work Breakdown Structure Elements

- Mission Management
- International Partner Agreements and Coordination
- ISS Configuration Management
- Commercialization (Management)
- ISS Safety
- ISS Budget and Business Management

SSURI Assumptions—The above estimate, as indicated, is a NASA Headquarters placeholder; consequently, it is difficult to determine the absolute amount of money and number of people required to manage the ISS. It seems reasonable to assume that management of an international program with an annual value of $1 billion would require $20 million annually. All of this effort remains with the ISS.

Acronyms

AIAA	American Institute of Aeronautics and Astronautics
ARC	Ames Research Center
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ATP	Authority To Proceed
BAR	Broad Area Review
CAF	Contractor Accountable Function
CBA	cost-benefit analysis
CDR	Critical Design Review
CO	Contracting Officer
CoFR	Certificate of Flight Readiness
COTR	Contracting Officer's Technical Representative
CRV	Crew Return Vehicle
CSA	Canadian Space Agency
CSC	Computer Sciences Corporation
CSOC	Consolidated Space Operations Contract
CSRS	Civil Service Retirement System
ELV	Expendable Launch Vehicle
EPs	Equivalent Persons (similar to Full-Time Equivalents (FTEs))
ESA	European Space Agency
ESR	Engineering Support Room
EVA	Extravehicular Activity
FCOD	Flight Crew Operations Directorate (JSC)
FERS	Federal Employees Retirement System
GAF	Government Accountable Functions
GSA	General Services Administration
GRC	Glenn Research Center
HAB	Habitation Module
HEDS	Human Exploration and Development of Space (Strategic Plans and Alliance)
IGA	Intergovernmental Agreement
IPA	Intergovernmental Personnel Act
ISS	International Space Station
ISSPO	International Space Station Program Office
ITAR	International Traffic and Arms Regulations

JSC	Johnson Space Center
KSC	Kennedy Space Center
L&M	Logistics and Maintenance
LaRC	Langley Research Center
MER	Mission Evaluation Room
MOBIS	Management, Organizational and Business Improvement Services (a GSA contract vehicle)
MOD	Mission Operations Directorate
MPLM	Mini-Pressurized Logistics Module
MS&A	management system and architecture (ISSPO)
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NGO	non-governmental organization
NIH	National Institutes of Health
NRA	NASA Research Announcement
NRC	National Research Council
OEM	original equipment manufacturer
OMB	Office of Management and Budget
ORU	orbital replacement unit
OSF	Office of Space Flight (NASA)
OTF	Operations Task Force
PAOCE	Post-Assembly Operations Cost Estimate
P3I	Pre-Planned Program Improvement
PDR	Preliminary Design Review
PDSS	Payload Data Services System
PGOC	Payload Ground Operations Contract
PI	Principal Investigator
POIC	(ISS) Payload Operations Integration Center
POIF	(ISS) Payload Operations Integration Function
POP	Program Operating Plan
PSR	Pre-Ship Review
PUP	(U.S.) Partner Utilization Plan
RDR	Requirements Definition Review
RFP	Request for Proposal
ROM	rough order-of-magnitude

RPO	research program office
RSA	Russian Space Agency
SCR	Science Concept Review
SFOC	Space Flight Operations Contract
SOW	Statement of Work
SSATA	Space Station airlock test article
SSPF	Space Station Processing Facility
SSURI	Space Station Utilization and Research Institute
STS	Space Transportation System
STScI	(Hubble) Space Telescope Science Institute
TBD	to be determined
USA	United Space Alliance
USOC	United States Operations Center
WBS	work breakdown structure