PRO ORBIS®

MANAGEMENT INNOVATIONS

REFERENCE MODEL

FOR THE

INTERNATIONAL SPACE STATION

U.S. NATIONAL LABORATORY

International Space Station
U.S. NATIONAL LABORATORY
Advancing Science in Space

EXECUTIVE SUMMARY

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Prepared By: ProOrbis, LLC

Commissioned By: NASA

THIS IS AN EXECUTIVE SUMMARY OF THE REFERENCE MODEL FOR THE ENTERPRISE TO MANAGE THE UTILIZATION OF THE U.S. SHARE OF THE INTERNATIONAL SPACE STATION (ISS) BY ORGANIZATIONS OTHER THAN NASA. IT IS A DISTILLATION OF APPROXIMATELY 110 PAGES OF BACKGROUND RESEARCH, FINDINGS, AND DESIGNS. FOR MORE INFORMATION, PLEASE REFER TO THE FULL REPORT.

ISS U.S. NATIONAL LABORATORY

Study Background and Approach

- Goal: Design an enterprise that maximizes the value to the American people of investments made in the International Space Station (ISS).
- Approach: 1) Identify the valuable uses of the unique ISS environment (tangible and intangible)
  2) Analyze the current capabilities of the ISS and its supply chain (payload development, transportation, labs, funding, etc)
  3) Identify the missing capabilities that are preventing value creating utilization
  4) Design the optimal enterprise to deliver those capabilities

The NASA Authorization Act of 2005 designated the U.S. segment of the ISS as a national laboratory to be made available for use by U.S. public and private entities. NASA requested an independent study to formulate a reference model for an enterprise to manage these uses. NASA's objective for this project was to obtain a model organization designed to maximize the value of the national investments in ISS. ProOrbis has proprietary methodologies that are uniquely suited to building such a model and was tasked by NASA to conduct the study using the ProOrbis® Method with an objective, independent perspective.

This report reflects the results of a 90 day study in which ProOrbis used its methods combined with independent research, NASA working sessions and, over 200 interviews with current and previous managers and users of ISS including: academic, industrial and government scientists, payload developers and integrators, research organizations, astronauts, NASA personnel, education experts and potential funding sources (both private and philanthropic). Participants were provided confidentiality for their input to this report to facilitate an open dialog.

The ProOrbis® Method is advanced management science that includes a comprehensive strategic framework and economic techniques for maximizing the tangible and intangible value of investments (see Appendix A for more information). All points in the model have been tested for practicality using proprietary ProOrbis® Applications*. We introduce ***method terms*** throughout the document, noted in bold, blue italics.

Maximizing value is a common objective for profit-making firms. Governmental organizations generally have the task of accomplishing a specific mission within a budget constraint. The *value* of the mission, if articulated, is rarely calculated and is not usually the functioning objective to which the organization is held accountable.

This is an original model built specifically for the intended purpose of maximizing the value of the investments in ISS, making this, from the outset, an unusual assignment. ISS is a unique physical asset operating in an environment with which most R&D organizations have little or no experience. Given the unique nature of the asset and the unusual nature of the assignment, it may not be surprising that the result of this study is an innovative design. As with all innovations, a certain amount of resistance and skepticism may be expected. However, because something has not been done before, does not mean that it cannot be done. Leaders recognize the challenges of innovation. Our intent with this report is to enable leadership by describing both the vision and the practical design of a new enterprise for a new frontier of science.

Innovation is as important in management as it is in science or technology. The objective of this study is to maximize the value (both tangible and intangible) to the American people of the investment in ISS. We have identified a myriad of complex management challenges which have been solved in this project using advanced management science. The result is an original, specially purposed enterprise designed to be implemented practically and with the highest return for the public investment required to support the initial years of operation.

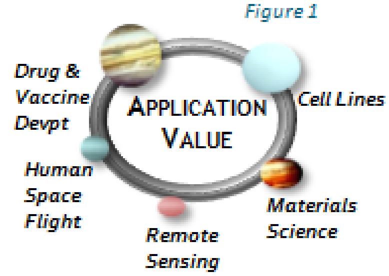
**This study was commissioned and prepared for broad publication and does not include proprietary or confidential material.*

ISS Capabilities and R&D Opportunities

Advantages of the International Space Station (ISS) for science and technology development:

- Microgravity - Microgravity, or more precisely weightlessness, is a naturally occurring phenomena that results from the combined forces of angular acceleration and Earth's gravity
- Extreme Conditions - Extreme heat and cold cycling, ultra-vacuum, atomic oxygen, and high energy radiation
- Vantage Point - 350 km altitude in low Earth orbit and orbital path over 90% of the Earth's population

Figure 1



R&D Opportunities: ISS is a unique environment for advancing scientific understanding of physics, chemistry, and biology. The following is a brief summary of the opportunities for the applications identified (Figure 1) based on the implications of findings to date and possibilities for significant outcomes.

- **Drug Design and Vaccine Development:** Results indicate that the microgravity environment facilitates an array of alterations in microbial gene expression which have been linked to pathogenicity of some bacteria. By examining the differences in gene expression of microbes grown in microgravity relative to the 1G environment of Earth, it is possible to identify the genes important for infection of the host. The ISS platform can uncover and accelerate new targets in organisms which can lead to the successful development of new vaccines or therapeutics. An example of this approach is currently in work for *Salmonella* and methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria. The microgravity environment also facilitates better macromolecular crystal growth enabling crystals to grow larger with higher quality. This new, three-dimensional structure can lead to an enhanced ability to target drugs very specifically, which can minimize off-target side effects.

  Research Possibilities: Development of accelerated vaccines or therapeutic development protocols which could be used to address issues such as pandemic illness.

- **Cell Lines:** Research results indicate cells can exhibit large changes in gene expression as many genes are observed to be up or down regulated in their expression when exposed to microgravity. This altered gene expression may allow for the development of new varietals of plants and crops to suit environments previously considered hostile and to increase production and quality of product. This could be achieved by exposing cells to microgravity as a unique stressing factor that alters gene expression, which could encourage the change in characteristics desired. The acceleration of changes in plants could provide valuable survival tools for the future (disease and pest resistance; tolerance for temperature and moisture conditions).

  Research Possibilities: Formulation of accelerated cultivar development protocols for plants that can be adapted to various environmental conditions.

- **Material Science:**
  - **External (exposure to extreme conditions):** Research using the external platforms of ISS has been performed through a series of materials experiments known as the Materials on International Space Station Experiment ("MISSE"). The external platforms allow for the testing of combined environments at one time. The testing conditions include exposure to extreme heat and cold cycling, ultra-vacuum, atomic oxygen, and high energy radiation. Testing and qualification of materials exposed to these extreme conditions has provided data to enable the manufacturing of long-lived, reliable spacecraft and satellite components.
  - **Internal (exposure to microgravity):** The absence of gravity leads to an absence of thermal convection, sedimentation, buoyancy, hydrostatic pressure and the gradients inherent in these one-G phenomena. It also reveals other mechanisms which would not be apparent under one-G conditions, such as Marangoni and capillary forces. Finally, it allows the measurement of critical thermo-physical properties that cannot be measured under one-G conditions. This research has lead to improved alloys of high-strength glassy metal materials which are now being used in consumer electronics applications.

  Research Possibilities: Thermo-physical properties measurement could be used to address issues in metals, ceramics, electronic and electro-optic materials, such as optimizing alloy properties to produce superior characteristics.

- **Remote Sensing**: ISS has a unique vantage point due to its 350 km altitude in low Earth orbit and orbital path over 90% of the Earth's population. This can provide improved spatial resolution, but also variable lighting conditions compared to the sun-synchronous orbits of typical Earth remote sensing satellites. The ISS can be a valuable platform to test advanced sensor technologies due to its vantage point and resource support as a crewed station.

Research Possibilities: Develop a hyper-spectral sensor suite that could enable advances in environmental monitoring, geologic exploration and mining, urban and regional planning, or oceanographic measurements.

- **Human Biomedical Science (non-NASA application)**: Exposure of humans to the reduced gravity environment of space accelerates some changes in the body, including bone loss, muscle wasting and balance disorders. This provides the unique opportunity to take advantage of microgravity conditions as a screening test for therapeutics with applications in both space and on Earth. This was part of the strategy used by Amgen to test its anti-bone wasting drug Prolia™ (denosumab), which was approved by the FDA in June 2010 to treat patients at risk for osteoporosis.

The NPO would not have a biomedical research pathway for human performance in space, but the value of this NASA research could be maximized by coordination of research synergies for other applications.

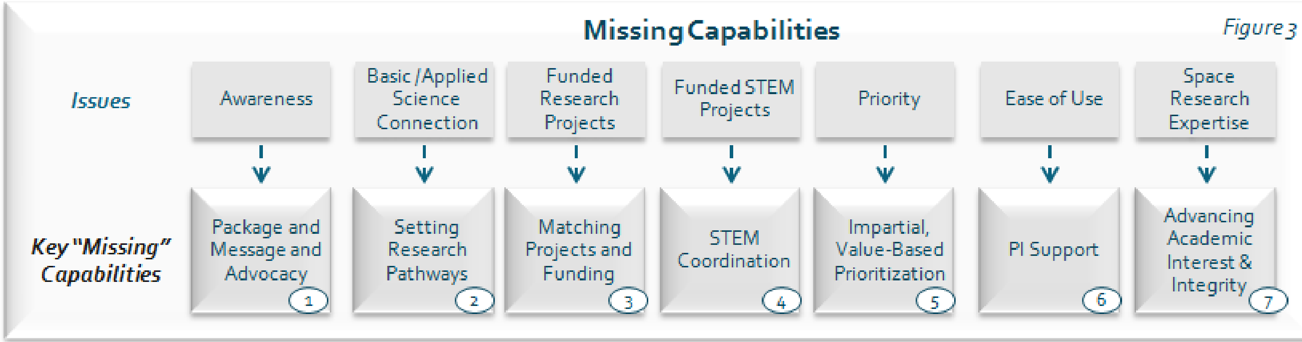
There is clearly interest and support amongst potential users including major firms, principal investigators, academic institutions, and government agencies for exploring research and development opportunities in space. However, because of the nature of the findings to date, scientists involved in the study have had a wide range of perspectives on both the findings and their implications. The general consensus is that ISS offers unique opportunities to explore a new frontier of science and significant value can be gained, but that certain missing capabilities are needed to take advantage of these opportunities.

Capabilities

The ISS is a physical asset located in low Earth orbit. The current network of providers required to utilize ISS is experienced and robust with the notable exception of transportation. The capabilities of the current ISS supply chain, experience of previous users and interests of potential users provide the foundation of understanding for what missing capabilities are needed to maximize value. A high level, simplified view of the network is depicted in Figure 2.

Figure 2

The findings from extensive interviews illuminated key issues to be addressed by a new entity, which are outlined in Figure 3.



1 ***Package, Message and Advocacy***. Addresses the issue of broad lack of awareness amongst the potential ISS constituency groups of the advantages of performing science in space by communicating this information in formats and forums that meet the unique needs of each audience. In addition, identifies advocates from the private and public sectors and formulates comprehensive strategies to access those advocates. This requires deep insight into the interest of a broad constituency and expertise in external relations, outreach and program development.

2 ***Setting Research Pathways***. Addresses the issue of diverse and sometimes competing, scientific interests in utilizing the ISS by bridging basic science with industrial R&D applications through the development of research pathways. These pathways would connect basic and applied research along a continuum rather than treat them as independent activities. This requires a multidisciplinary environment that allows fundamental and applied scientists to collaborate and extend beyond their current disciplinary areas without requiring either group to abandon their principle mission.

3 ***Matching Projects and Funding***. Addresses the issue of an unreliable funding channel, which has contributed to a diminished project pipeline; by creating a mechanism to match potential projects with interested investors. This requires an understanding of the unique needs for each of these groups as well as the applicable rules and regulations governing the potential arrangements between parties (such as intellectual property, federal funding, established agreements, etc).

4 ***STEM Education Coordination***. Addresses the abundance of interest in Science, Technology, Engineering, and Mathematics (STEM) project opportunities for ISS and lack of consistent funding by creating a mechanism for matching projects with interested funding sources. Projects could include education programs, education distribution channels, curriculum opportunities, and related ground-based projects. The matching capability described in #3 would serve a similar function for ISS education projects. This would require the ability to coordinate amongst the existing STEM project opportunities available from a wide variety of sources in order to maximize the existing project pipeline and not proliferate or create confusion for education consumers.

5 ***Value-Based Prioritization***. Addresses the concern that non-NASA users are treated fairly by providing a reliable, impartial, transparent prioritization process that balances a diverse portfolio of research disciplines and stages of research. This requires a process that can consider a wide variety of tangible and intangible value and can account for the magnitude of the value impact on the U.S. In addition, users need feedback to understand why a project was not selected so that they could choose to improve the design to create more value. This requires in-depth scientific and economic multi-disciplinary knowledge that can capture the values of the diverse research potentials for ISS utilization.

6 ***Principal Investigator Support***. Addresses the concerns of previous, current and potential new users who are intimidated by, or apprehensive about the process for getting research to ISS by providing a mechanism for a seamless support system for the entire process. This requires facilitating users throughout the process from contract negotiation through payload development and implementation and post-flight support by leveraging experience and close working relationships with extended enterprise partnerships (such as implementation partners) and NASA to assist investigators, which can improve both their experience and project efficiency. This activity is more direct and hands-on in the beginning, especially for those completely new to the process, and becomes more of a support resource for the principal investigator in later stages where NASA or implementation partners are generally more involved.

7 ***Advancing Academic Interest & Integrity***. Re-build the cadre of scientists with expertise in the low Earth orbit environment by developing the skills and sparking interest in the next generation of leaders in STEM disciplines, which is essential to improving the management of the knowledge base for conducting science in space. A myriad of mechanisms will be required such as scientific forums, formulation of academic curricula, and dissemination of findings through published results. From the highest levels of scientific discovery to the introduction of topics to young children, the translation of findings and promise of the low Earth orbit environment will need to be made available in a way that is accessible and inspiring.

*The "missing capabilities" are the foundation for the activities to be designed into this enterprise. Completing the supply chain leverages the existing infrastructure by enabling the entire system to produce more **Throughput** (output that has value), which improves the value of the entire network. In this way, relatively small investments in precisely the right capabilities can leverage cumulative investments of the network, thereby creating significantly improved returns.*

Enterprise Design

A ***Capabilities Architecture*** is the highest level of design for the operating model for the enterprise. The design of the capabilities set forth the requirements for the design of the organization as well as the resources required to deliver those capabilities (human capital, physical capital and technology capital assets).

Figure 4 depicts the capabilities architecture to deliver the "missing capabilities" to complete the ISS supply chain. A more complete description of the capabilities is contained in the full report. Because of the design innovation in this model, certain capabilities were selected to be developed in more detail to ensure both operability and to identify the nuances of execution and are highlighted as follows:

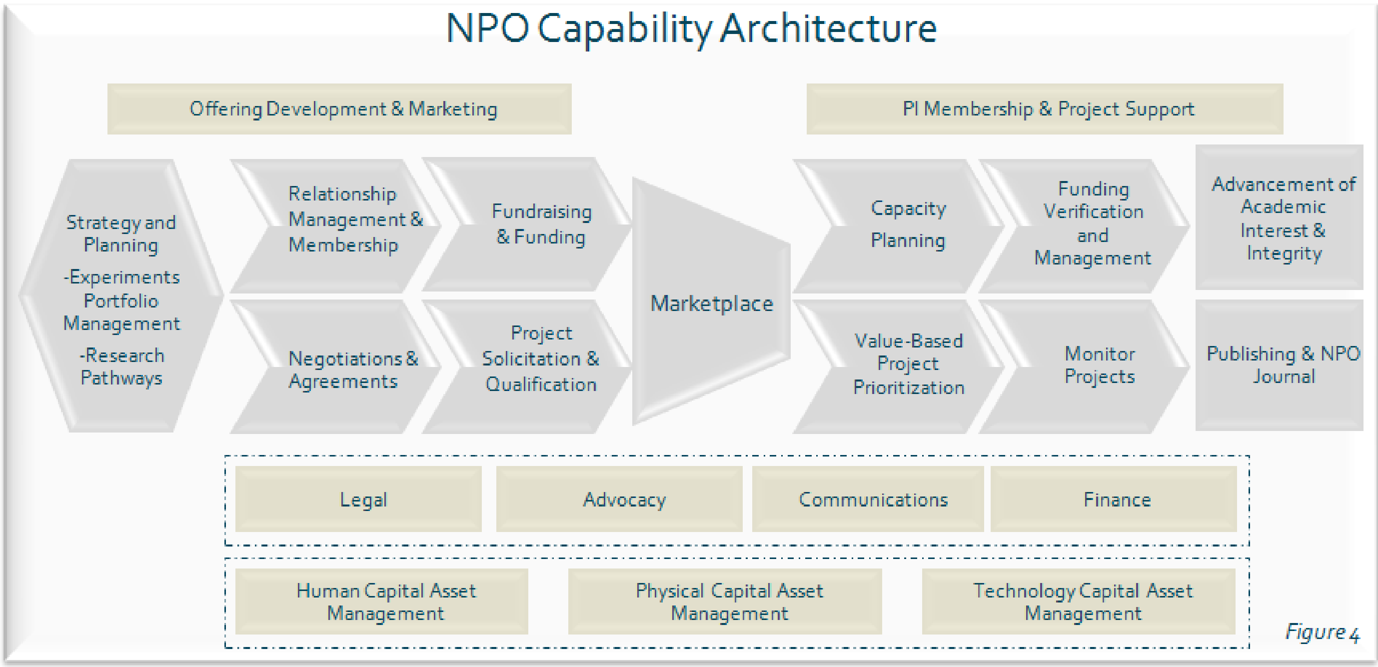


Figure 4

RESEARCH PATHWAYS - Basic scientific research is often thought of as being separate and distinct from applied or industrial research. Our studies have illustrated the rift that sometimes exists between more fundamental scientists who view commercial activity as a bit "unseemly and ignoble" and industrial researchers who feel that basic research activity is more like a "hobby" and disconnected from the "real world". Although it is always dangerous to over generalize, in the extreme, the applied researcher only cares *that* something happens, not necessarily *why*. The basic scientist is interested in *why* something happens, but less in *what* it would be useful for when applied.

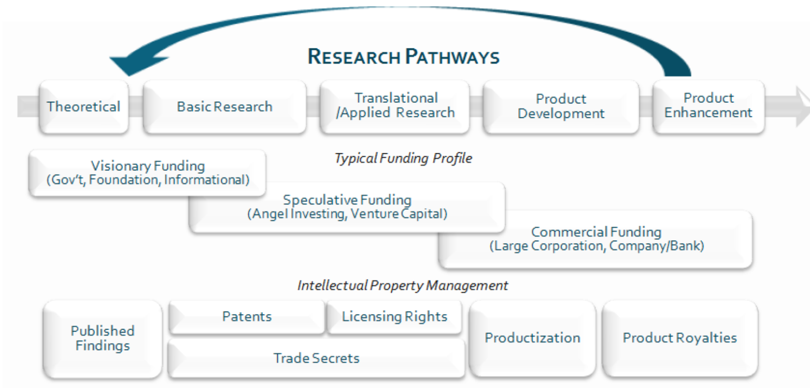


Figure 5

In actuality, of course, fundamental research is on a continuum with applied research. In this study, this is termed a *research pathway*. Pathways begin with the formation of a theory and conclude with the creation of value. Late stage enhancements can generate discoveries that may indicate the need for more basic research.

Each stage is associated with a typical funding profile and an intellectual property strategy which are essential to understanding how projects are funded throughout the pathway (see Figure 5).

Figure 6 graphically depicts a scenario whereby basic research understandings open up several opportunities for market applications. Projects can enter the process in any phase of a pathway. Later stage projects may produce findings that lack theoretical underpinnings. By going back and conducting more basic and theoretical research, additional opportunities for market applications may be opened.

There have been projects conducted in low Earth orbit in every stage of a research pathway, but not all of the steps of each project's pathway have been completed. There are a myriad of findings in which we know *that* things happen but not *why*. A key capability of this new entity is to manage the research pathways for a broad range of science conducted in low Earth orbit by leveraging the portfolio of completed research, formulating pathway options, and leading the coordination of the science community in the design and consideration of projects for the future. Projects can also be solicited by the NPO to "fill in" research pathways, especially in the theoretical and basic research categories. In this way, grant funding that is made available through the NPO can "open up" research pathways.

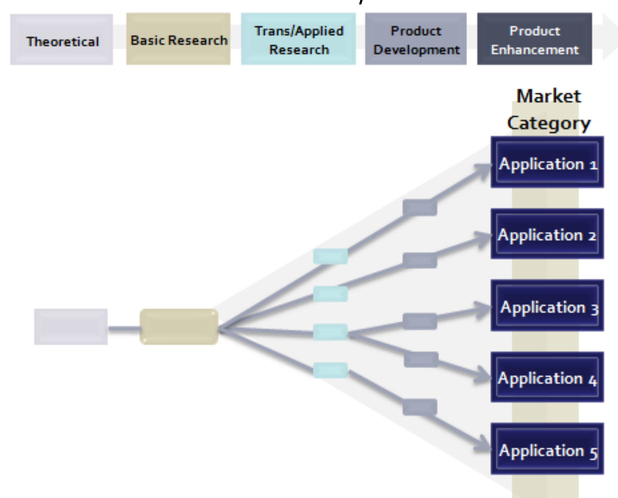


Figure 6

Research pathways are the key to valuing fundamental science. They put R&D projects in their "value context" and help to establish what we know, what we don't know and what it might be worth to know it. In this way, they provide the strategic frame for both building a more robust underpinning for applied research and the relevancy for basic research. Articulating what value could be derived from a discovery and formulating a pathway to that value creates the opportunity for more targeted investment that shortening the cycle time between discovery and practical application. Improving national returns on R&D investments and articulating the value created could lead to dramatic increases in funding for basic research and more efficient use of funds available.

MARKETPLACE - The purpose of the marketplace capability is to match R&D and STEM education projects with funding, creating a market mechanism to improve both efficiency and the success rate of funders and principal investigators. This capability requires standard frames and rules for marketplace participants to facilitate a more orderly and efficient process and create a more professional experience. To establish these guidelines, up front, the model has employed the concept of membership. Members of the marketplace would agree to the rules and only members could participate. Members would have a profile (both for projects and funding interests) and the marketplace would match their interests through management of data and creation of forums for interaction. The intellectual property considerations are complex and addressed in some length in the full report.

- **Funding Sources**: Public sources include the federal government, state governments, public universities, and quasi-governmental organizations. Private sources include private foundations, private universities, venture funding, corporations and high net worth individuals/angel investors.
- **Projects:** Both R&D and STEM education projects could be presented to the NPO as fully funded, partially funded or completely un-funded. Projects that require funding would be put into context of a research pathway to determine the nature of the appropriate funding. Funded projects are placed on research pathways for the purpose of valuation, but because they do not require funding they proceed directly to prioritization.

VALUE-BASED PROJECT PRIORITIZATION – The marketplace capability creates a stream of funded projects, but the valuation would be done in the prioritization process. The model employs a sophisticated, comprehensive valuation frame. In general, the term intangible value refers to value created by the entity that does not flow "through" the entity – in other words value that is not received directly by an entity, such as revenue. Note that intangible value is not incalculable or "feel good" value. Intangible value (in general) builds on practical applications thereby expanding value (see Figure 7), and considers factors well beyond simply commercial value. The value is the ***Throughput*** of the supply chain (see Figure 2).

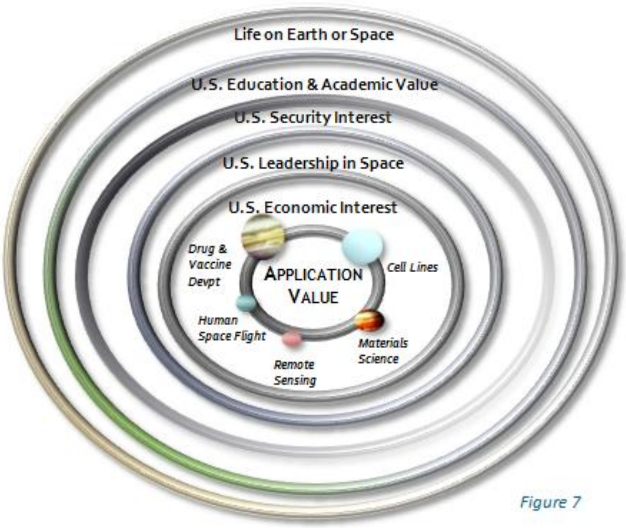


Figure 7

- **Value Criteria -** Projects are evaluated and articulated within the common valuation frame including dimensions such as:
  - **Life on Earth or Space** - Advances in science and technology are ultimately about changing the experience of life. Innovations can impact humans, animals, plants, climate, and resources now or in the future (the value of sustainability). Value estimates can include factors such as fewer deaths, fewer sicknesses, healthier livestock, a more abundant food supply, the protection of endangered plant or animal species, reduction in pollution, etc.
  - **U.S. Education and Academic Advancement** – One of the most valuable assets of a nation is its human capital. Investments in education are like any other investment, and the value is measured in the concept of human capital stock. For a country, the stock of human capital is the productive capability of its people. Quality education in STEM disciplines creates larger pools of scientific talent. Although STEM as a concept is typically associated with K-12 education, this study has broadened it to include all levels of development. Research projects develop scientists (the ultimate "on the job" training) for both industrial and university roles. Publishing scientific advances enables developments in science by allowing researchers to build on each other's work and provides content for educational curricula.
  - **U.S. Economic Interest** - The national interest in innovation is rooted in the advances that can be made in products and services. New medicines, vaccines, materials, information, and services benefit both the companies that offer them and the consumers that purchase them. These improvements are measured in

terms of GDP, additional jobs, productivity and thereby in the increased tax revenue generated from those activities. Improvements can also decrease government spending (i.e. better vaccines can lead to lower healthcare costs).

- **U.S. Security Interest** - The U.S. presence on ISS provides the opportunity to understand the conditions of this environment and to ensure we remain competitive with other nations including considerations of the defensive implications of the capability to operate in low Earth orbit and the impact of ISS R&D advances on the nation's ability to avoid or mitigate aggression or destruction.

- **U.S. Leadership in Space** - To the extent that there is a national interest in pursuing other planets for humans to inhabit, tapping resources, or other expansions of our world, then knowledge that will enhance space exploration such as: 1) improvements to the design of spacecraft, 2) mitigation of the effects of microgravity or radiation on humans, and 3) advancements in the understanding required to develop replenishable food sources in space would have mission-oriented value.

- **Special or Preferential Treatment.** In the absence of a value frame, special allocations or prioritization for certain interests might be needed. This study finds that agencies that fund ISS research understand their mission interests very well and there is no reason to believe these projects would not compete in a value-based frame. However, it has been suggested that the principal investigators be engaged in the beginning of any solicitation, from the NPO or any other government agency, to ensure they recognize the importance of the full value frame within which their project will be evaluated so that they design their projects to generate the highest value.

- **Research Priority.** Government organizations have research agendas set by agencies that determine national priorities for research and reflect the most urgent needs as perceived by policy-makers. The prioritization process modeled for the NPO identifies the highest value research pathways that can be pursued in the low Earth orbit environment. Specific government grant funding for projects can be tied to a particular objective and national research agendas may inform the value implications of topics, but no additional agenda should be required.

- **Modeling Considerations.** The proprietary models built for establishing this valuation frame use established mathematical techniques of economics, operations research, and principles of finance (such as periodicity match, reliability or relevance) and are designed carefully to inform comparisons, which are the core of a prioritization decision. Building models that attempt to "boil the ocean" will usually result in an overload of information that impairs decision-making rather than informing it.

  Value frames are not the same as numerical compilations of individual assessments, which are inherently subjective. Valuation may involve estimates (i.e. how much of a particular crop gets a particular disease and what are the chances a discovery will mitigate the disease), but that is different than a numerical rating of a subjective assessment (i.e. the intellectual merit of a proposal on a scale of 1-10). Subjective assessments rely on the opinion of experts to judge against criteria whereas fact-based frames require the articulation and dimensionalization of the value criteria and the components of investment. Fact-based frames are more often used when the organization is accountable for return on investment (ROI) and transparency. With proper structuring and feedback, these frames can be improved over time with experience and can be used to create higher value projects.

A broad value frame enables a more fact-based and transparent discussion of prioritization. This eliminates the need for a research agenda to be established based on anything other than value to the American citizenry. Fact-based frames both inform the structure of the research (since research projects can be designed to create more or less value) and the level of investment required to create that value. As the ISS is a relatively expensive asset to utilize, dimensionalizing value is critical to managing its use for ROI.

The Establishment of an Entity

Several previous studies have established the need for a separate organization other than NASA to manage the national laboratory uses of ISS. According to the 2009 Augustine report:

> "The committee believes that an organization is needed to mediate between NASA operations managers and the broad stakeholder community. This could facilitate access to ISS assets by a disparate user community (with widely varying levels of sophistication about spaceflight activities), and could help organize the multiple demands of the users into more unified requirements. Without a mediated dialogue between [NASA] operations managers and users, it will be difficult to realize operational efficiencies."[1]

This study would concur with these findings and we have not identified an existing entity that is designed to execute these missing capabilities. Therefore, we recommend the design of a new organizational entity referred to hereinafter as the NPO.

THE NPO PURPOSE AND FEATURES - There are certain key strategies the NPO would need to employ to deliver the missing capabilities. These are the attributes of the ***Positioning***:

- **Long-term Focus**. To provide confidence and stability to investors and researchers to make the investments necessary to move to this new research platform, we recommend the adoption of a longer-term focus for the NPO, which is to advance research and development in space. This concept is referred to as "advancing science in space". By creating an enterprise that builds a community of interest in this type of research, ISS could become a stepping stone to future space-based assets which bridges a major concern about the life span of ISS. This longer-term focus would enable the community of users to pool their resources and influence to promote a longer-term presence in low Earth orbit if it proved valuable and worthwhile.

- **Caliber and Accessibility.** The NPO needs to be both a world-class enterprise and a national establishment. By carrying the respect and prestige required to accomplish its objective while operating as a responsive, flexible and sufficiently sophisticated and innovative enterprise, the NPO will be able to attract a wide array of participants from venture financiers and major companies to leading universities, foundations and school children. To support these interests, we believe the NPO should be an organization that can be "joined", supporting the membership model and creating an atmosphere of inclusiveness, accessibility and collaboration. This collegial concept is well established in a host of analogs from industry consortiums, academic societies to national science museums. Although not a concept used in the management of other national laboratories, the breadth of mission interests of the users and their active participation in the use of the lab are well-suited to a membership model.

  To demonstrate "establishment support" and provide time for the building of awareness and space research capabilities, some government appropriations will be required. The NPO can raise funds for projects and charge fees for value-added services (discussed further in the Sources of Funds section), but a community of interest and demonstration of value will take time to develop. Given the projections in the financial analysis (outlined in the Budget section), the NPO could reasonably be expected to be self-supporting in about 5 years.

  To accomplish the NPO's objective, it will be necessary to employ a world-class and effective management structure with as little constraints as possible. Federal government regulations, especially for contracting and employment, are designed for a different type of entity (one with a mission and a budget) with no expectation of self-sustainment. Managing this as a government entity would significantly increase unnecessary cost, adding to the budget requirements and potentially impairing the organization's performance.

- **Impartial and Un-conflicted.** It is essential that this organization have a singular and un-conflicted goal. Both the fact and appearance of impartiality is an absolute requirement to give users confidence in the reliability of the organization's decisions. Conflicted interests are also the concern of the Administration staff and Congress. The use of ISS for profit-making ventures without due consideration, using the power to prioritize projects to penalize competitors, or advancing one agenda over another have all been expressed as critical flaws to be avoided.

NASA COMMITMENT - One of the most challenging areas of the model is the commitment and allocation of resources for ISS accommodations and transportation. There is capacity available for research that falls into three categories 1) NASA sponsored research to support its mission interests, 2) international partner accommodations and 3) national laboratory projects sponsored by organizations other than NASA.

A firm commitment of ISS accommodations (physical payload sites) and resources (up-mass/down-mass, crew time, power/thermal, data transmission, etc.) is essential to the success of the NPO and, more importantly, to achieving objective value-based productivity of the national asset. Ideally, this would be directly and clearly addressed with a directive such as guidance from the NASA Administrator in consultation with the White House, and subject to applicable Congressional statutes. Such clearly documented executive guidance would add to the establishment credibility and would allay broad concerns over prioritization. The NPO could be accommodated like the international partners (who receive an up-mass, down-mass, and crew time allocation). In all cases the safety of the crew and the maintenance of the ISS are the top priorities and it appears that NASA has workable procedures for equitably allocating resources should there be maintenance interruptions.

NASA AND NPO INTERFACE - The assistance most requested in the interviews conducted was a mechanism that enabled a seamless support system for external users. The NPO should aim to provide this support while leveraging the existing capabilities within NASA and the various implementation partners.

AGREEMENT WITH NASA (COOPERATIVE AGREEMENT, CONTRACT OR GRANT) - The choice of legal instrument can have a significant impact on the value creation and return on investment in the enterprise – both enabling its ability to execute its purpose and providing the most efficient organizational model. Instruments were evaluated using three main criteria: permissibility, suitability, and best fit for the desired relationship between NASA and the NPO.

The analysis concluded that a cooperative agreement is the best fit for an instrument that would add the least administrative burden and cost overhead. It provides for the needed government oversight and serves as a strong foundation for managing the collaborative relationship between NASA and the NPO.

NON-PROFIT ORGANIZATION (NPO) - Given the nature of this activity and requirements of operation, the analysis of organizational forms identified a 501(c)(3) public charity as the best fit instrument. Key factors included the ability to: 1) be designed to support a special and uniquely purposed enterprise, 2) raise and receive funds from public and private entities and use proceeds for education and research, 3) support membership models, 4) accommodate a vast array of interests (mission oriented and private), 5) be set-up in a timely fashion, 6) be relatively flexible to change to a different legal entity if needed in the future, and 7) be managed by appropriate rules for a mission-oriented organization. The tight fit of this form enables management and control for the least amount of additional cost.

The management of an enterprise requires investment, and like all investment can be designed to maximize return (ROI). However, this requires the design to be more of a technical matter than an exercise in power or control. It is important that the purpose of the NPO be set forth clearly and that its duties are to create value for the American people through its users. An unsuitable instrument or organizational form, even if permissible, could have a significant deleterious impact on the results and create a non-mission focused administrative burden for NASA.

Conflict of interest is one of the major concerns in use of a non-governmental entity and therefore the establishment of a de novo enterprise is recommended to ensure a specially purposed organization that has a singular objective, effective governance structure and efficient resourcing.

Sources of Funds

The following valuable services, ***Offerings***, have been identified that could be sources of funds to create a self-sustaining NPO. In keeping with the concerns of policy-makers that individual private interests not benefit unduly from public investment, these offerings provide support for the NPO based on the value it is providing to users. The operations that support government grant issuance and monitoring are typically funded with government appropriations, but the NPO will have a variety of sources of funds for projects. A more sophisticated, user-centric model provides for more precision in the value/pricing exchange. The model includes:

- **Success Fees:** Success fees are charged for the completion of an agreement. The transaction could be a successful match between funding sources and projects for both grant and private funding arrangements. This would include both research and education related projects. Projects entering the NPO as fully funded, whether by grants or private sources, would not be charged transaction fees. Parties to this type of transaction indicated that they spend a lot of time in this process currently, and not always successfully; so the value of this arrangement to the parties is in the efficiency created by the marketplace mechanism.

- **Special Royalties:** The NPO can charge a nominal special royalty to applicable proprietary projects. Concerns were raised about the use of ISS and government supported transportation for "profit making" activities. Yet, especially in the nascent stages of ISS use, charging the full cost to users may create a price point that is too high for the risk involved. A mechanism for resolving this is with a royalty paid in connection with the sale of resultant products or services. In this way, users only pay if they have benefitted. This arrangement is in keeping with the principles used in other national laboratory proprietary and non-proprietary research models (further described in the full report).

- **Member Fees:** To support the diverse interest in services from the NPO, it can formulate a tiered membership structure. Fees should be customary and reasonable for services such as the support of the marketplace activities, professional development, programming, research materials, events and forums, etc. This model is customary in a variety of analogs and supports the sense that this organization is designed to benefit and support the users.

- **Fundraising:** There are a myriad of individuals and foundations who wish to contribute funds to support research topics, causes or missions. These are not fees imposed, but voluntary donations.

The goal of a self-supporting organization is in keeping with the value maximizing objective of the model. By charging fees for value delivered, not only does the organization reduce the burden of costs to the American people, it actually regulates the use of the NPO by establishing a fair market price for services. Underpriced services tend to be overused, while overpriced ones tend to be underused. The NPO has the incentive to create value for users or face the inability to raise funds. It is true that the government can and may need to support new market categories (such as those developed in low Earth orbit) until the value potential is recognized. Indeed, without that support, the market may never materialize due to the risk and cost. However, the value of the services of the NPO is easier to recognize and fees should be in keeping with like services in the market and the value being created.

The NPO Structure and Governance

BOARD STRUCTURE– the Board of Directors (BOD) is one of the key success factors for the NPO. Unlike a government agency that reports to the Executive Branch for oversight, an enterprise such as this needs to be carefully constructed to ensure both effectiveness and accountability.

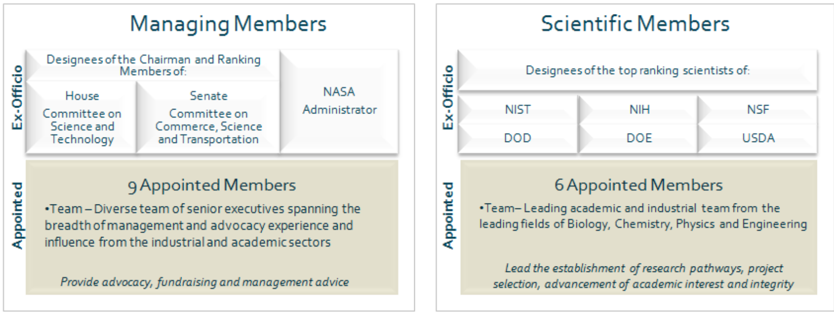


Figure 8

BOARD MEMBER REQUIREMENTS: National stature and world-class caliber talent spanning the breadth of capability to "cover" the areas identified (Figure 8). The members will all have working roles and must be able to effectively perform these roles, or the NPO's capabilities could be significantly impaired.

- **Appointed Members** – 15 Members appointed for the initial BOD with the flexibility for additional members later if needed. The board would be selected from the private and academic sector and would subsequently maintain its membership through a self-perpetuating process.

- **Ex-Officio Members** – There are two groups of *ex-officio* members whose role is to select the initial BOD and provide ongoing advice and counsel.

  (A) The "Managing" *ex-officio* members are representatives of the government constituencies, Congress and the Administration. Suggested members are:
  - (i) The Chairman and ranking member of the Committee on Science and Technology or their designees;
  - (ii) the Chairman and ranking minority member of the Committee on Commerce, Science and Transportation or their designees; and
  - (iii) the NASA Administrator;

  (B) the "Scientific" *ex-officio* members are the designees of the top ranking scientific leaders of the agencies most likely to use the ISS. Suggested members are:
  - (i) The National Institutes of Health;
  - (ii) The National Institute of Standards and Technology;
  - (iii) The National Science Foundation;
  - (iv) The Department of Defense;
  - (v) The Department of Energy; and
  - (vi) The Department of Agriculture.

- **Appointed Members (Initial Selection)** – The appointed BOD will be selected using a fact-based, impartial process to ensure that a balanced and appropriately skilled team is assembled.
  - A list will be formed of qualified candidates meeting all of the technical requirements by any credible source whose sole purpose is to ensure that the BOD has the highest caliber talent with the appropriate mix of skills. Given the Congressional representation on the *ex officio* BOD, The NASA Administrator in consultation with the Office of Science and Technology Policy could formulate this list to provide more balanced participation in the process from the Executive branch.
  - Managing ex-officio members will select from the list of qualified candidates who are able to provide advocacy, fundraising and management advice across the spectrum of areas identified.
  - Scientific ex-officio members will select from qualified candidates who are able to establish research pathways, participate in project selection and to advance the academic interest and integrity of the NPO. The individuals should span a range of scientific topics including biology, chemistry, physics, and engineering from both academia and the industrial R&D sector.

- **Board Operating Requirements**
  - **Voting**: The appointed members are the voting members of the BOD. Ex-officio members are not voting members but are invited to participate in board activities such as meetings and working groups to provide advice and counsel.
  - **Terms:** An initial 1 year term which serves as a "trial period" for both the BOD member and NPO, and subsequent 2 year terms with a maximum duration of 7 years.
  - **Compensation:** The BOD members may receive compensation for service that includes reimbursement for travel or modest stipends.

SCIENCE SUBCOMMITTEE AND COLLEGIUM: The scientific members of the BOD form a Science Subcommittee designed to lead a network of science and technology professionals who are independent from the BOD (Figure 9). The collegium would be mentored by and collaborate with scientific BOD members to support research pathway development and the prioritization of research selected for the NPO. The collegium adds to the breadth of expertise, builds the knowledge base of the NPO, and provides a broader base of talent for project prioritization to avoid conflicts of interest.

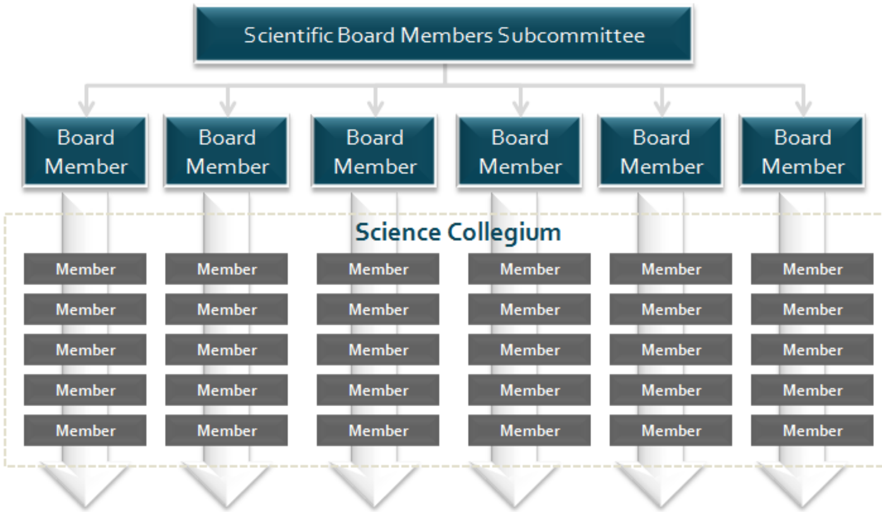


Figure 9

- **Standard Peer Review:** The use of the science collegium for project prioritization is like a peer review process, but enhanced with a value-based frame and a multi-disciplinary approach.

The NPO Organization Structure

Organization in the ProOrbis® Method is a function of analysis. Organizational structuring for many enterprises is driven by elements such as the power positions of managers, constraints of existing management talent, or the preferences of the chief executive. In this model, the organization design creates value by "managing" the capabilities of the enterprise to ensure the delivery of the positioning.

In addition, culture and leadership play a critical role in organizational performance. The imperatives of the culture are the belief patterns that are absolutely required to execute the positioning and capabilities ("cultural imperatives"). A start-up organization offers an opportunity to create the culture that best fits, reinforces and enables the successful execution of the enterprise. Leaders are the stewards of culture and the imperatives are a critical screening factor for selection.

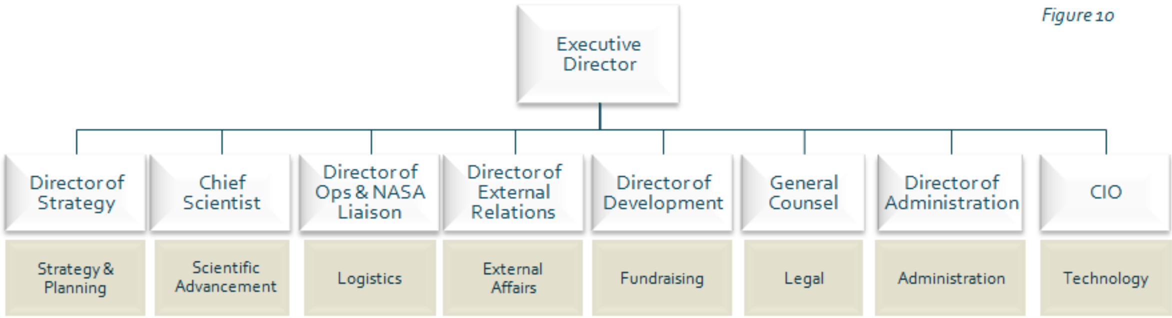
We have identified two fundamental belief patterns that would be required for the execution of the NPO model:

1) The organization can create value and become self sustaining. The understanding that private sector sources of funds should be matched to projects and that it is inappropriate and unnecessary for the government to fund all things – a profound paradigm shift for some sectors.
2) The entire continuum of science is valued. The historical "struggle" between basic (pure science/research) and the practical application of research (applied research) needs to be put aside in favor of a more comprehensive approach to research pathways – an inter-disciplinary approach.

The NPO has been modeled as a *de novo* organization. To add or attempt to embed the critical NPO capabilities into an existing organization could greatly increase the likelihood of added overhead, creation of complicated organizational "work arounds" to accommodate the existing structures, and conflicts of interest from competing missions.

Furthermore, the probability that an existing team would exhibit the cultural imperatives needed for a successful execution is a significant risk consideration.

Figure 10



Each leadership role is designed to provide the expertise to the management team and has direct accountabilities for their assigned capabilities. The team is designed to collaborate in the execution of certain cross-organizational capabilities, but there is always clear accountability for performance. Each organization is designed with technical expertise as follows:

- Strategy & Planning: economics, finance and science management
- Scientific Advancement: broad science stewardship of content and education
- Logistics: operations, logistics, engineering and relationship management
- External Affairs: marketing, event planning, and communication
- Fundraising: fundraising and grant management
- Legal: contract compliance and general legal
- Administration: HR, accounting, facilities management
- Technology: information technology and technology infrastructure management

One of the needs for a de novo organization is the ability to obtain a Board of Directors with the right level national stature, skill mix, and accountability and an organization with the exact right mix of assets The BOD is critical to success, especially to a start-up. The model has taken great care in articulating the selection process for the initial BOD to ensure that it will attract the best talent. The design of the organization is very lean and specifically purposed which is reflected in the budget for operations. Requirements for technology assets and physical facilities are included in the full report. Again, specially purposed organizations can be designed to execute sets of capabilities very efficiently. Repurposing an existing organization introduces risks of non-value added overhead cost, conflicted interests, mismatched assets (human, technology or physical capital) and ingrained problematic cultural patterns which may seriously impair performance.

Creating accountability for performance requires a combination of a clearly articulated objective and purpose, the capabilities to execute and measures to demonstrate progress.

Dashboard of Performance Measures

The measures required to manage the performance of the NPO must be comprehensive and value-oriented. The following table provides a conceptual description of some of the key types of measures needed to demonstrate the performance of the NPO's outcomes as well as its performance in managing the operations.

Type	Measures Requirement	Calculation Samples
Overall Value– Intangible (U.S. Economic Interest, Education , Security, Life on Earth or Space , Leadership in Space)	Dimensionalize the net value of research or educations created as a result of ISS-NL projects	• Value to American people generated from the unique activities of the NPO minus amortized investment of the ISS-NL stakeholders (Net Value) • Net Value of contribution ISS technology makes to products and services revenue and related tax revenue from the profits • Net Value of the improvement to human capital stocks
Positioning	Performance against the functioning objectives of the enterprise	• Performance against the NPO BOD, congressional mandates and NASA requirements (such as the Ratio of Utilization % of the ISS-NL allocation to NPO investment) • Tangible Value to Investment Ratio • Net Value • Growth rate in net Value
Strategic Objectives	Indicators of progress toward key strategic goals	• Ratio of appropriated to NPO-generated funding • Ratio of NASA to NPO Educational Funds • Projected Value of Research Pathways in Development
Portfolio Objectives	The value created by the investment in NPO resources. Operational Efficiency	• Ratio of total ISS-NL research funding to NPO Investment • Ratio of total ISS-NL research value created to NPO Investment • Ratio of education programs funded to NPO investment

Budget

We have assumed that the NPO would begin operations in fiscal year 2011 for at least 8 months of on-going operations. Fiscal years 2011 and 2012 break out the start-up and capital expenditures. It is contemplated that the NPO would receive governmental appropriations in the formative years of operations. The NPO generated funds have been estimated using the pricing of offerings (products and services) provided to NPO members and expense increases are scaled to the offerings provided. Proceeds from NPO operations are used to fund additional research and educational activities.

*in 1000s	2011*		2012		2013	2014	2015	2016	2017	2018	2019	2020
Estimated Sources of Funds*												
U.S. Government Appropriations		$15,000		$15,000	$15,000	$15,000	$15,000	$0	$0	$0	$0	$0
NPO Generated Funds		$0		$2,892	$5,860	$11,180	$15,451	$20,217	$24,991	$29,085	$32,540	$37,321
Subtotal		$15,000		$17,892	$20,860	$26,180	$30,451	$20,217	$24,991	$29,085	$32,540	$37,321
Total Cost of Operations*	**Cap-Ex**	**Op Expense**	**Cap-Ex**	**Op Expense**	**Ongoing Operating Expenses**							
	$5,814	$5,663	$2,190	$9,054	$9,890	$10,199	$10,687	$11,247	$11,906	$12,537	$13,092	$13,803

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Funding for ISS-NL Research Projects	$3,000	$15,226	$27,679	$52,023	$72,820	$90,831	$100,088	$108,797	$116,252	$124,757

Conclusion

The model for this enterprise is both effective as an operation and has the ability to be self-sustaining with a relatively modest cost profile (less than fourteen million dollars per year).

Once up and running it can attract total funding for research and education projects of well over one-hundred million dollars per year (cost of research). Not all of these research funds would flow through the NPO, but it is a good indication of the volume of activity the NPO can manage.

The value of the research managed is a result of the nature of the projects and how they add value to the American people. These numbers could and should easily be in the billions of dollars (value of research). Estimating this value through the valuation frames and monitoring results through a comprehensive dashboard will create accountability and provide vital information for designing better, more valuable projects over time.

Message from the Authors

The International Space Station is a remarkable human endeavor. There are those who argue that it has already returned substantial value to the American people based on its triumph as one of the world's great engineering feats and as a symbol of international peaceful cooperation. It is arguably one of the county's most valuable assets for sparking the imagination and interest in science, technology, math and engineering. Perhaps that is enough; but it was not the objective of this study.

Our goal was to maximize the value of the investments in ISS using the ProOrbis® Method. In for-profit firms this approach benefits the shareholders. In this model, the results are designed to benefit the American people. They are the shareholders of ISS.

Maximizing value for them was not a matter of ease or expediency. Indeed, if this were easy, it would have already been done. In fact, this is a challenging management undertaking and more sophisticated approaches were needed to solve for all of the variables and to develop a practical model. The result is a very carefully architected, lean, fully integrated enterprise. Seemingly small changes could dramatically affect the efficacy of the model and balloon the cost profile.

This is not to say that there are not similar challenges throughout government and that some of these approaches would not be useful for solving a host of intractable issues. Just remember, that every organization presents a unique assemblage of assets and opportunities. Therefore a solution that works well for one circumstance may not work in another.

This is the strength of the ProOrbis® Method. Comprehensive frames and microeconomics allow us to apply our approach to the specific conditions of an organization and come up with a remarkable result for that particular organization for a particular time in its history. This is the optimal model we could formulate with the information we have. Could this have been done years ago? We do not know, but we do know that it can be done now.

ISS is an asset with a useful life. Every month that goes by that it is not being fully utilized with value-creating projects, the American people lose value. There is no doubt that delay is destroying value. We hope this model will help to accelerate the implementation of a new management organization to seize the opportunities to create the next frontier of science that will deliver results for the American people.

It has been a genuine honor and privilege to be a part of this project.

Appendix A - The ProOrbis® Framework and Credentials

The ProOrbis® Framework is a strategic paradigm that defines the value-oriented architecture for an enterprise including business strategy (positioning), operations design (capabilities), asset portfolios (including tangible and intangible assets) and asset management. The Framework classifies and connects all the activities of the enterprise into a fully integrated, interoperable system that links value to the investment the enterprise makes in its **own** capabilities. This evolution of the concept of productivity can dramatically improve performance for publicly traded, private, non-profit, and governmental enterprises.

ProOrbis® Enterprise Applications are the tools and techniques configured to real business situations and designed for a particular client need. These Applications transform segments of businesses, individual businesses, portfolios of businesses, and extended enterprises by taking a systematic and comprehensive approach that links to value. Using the best of what a client currently has, strategies are created that leverage the strengths and identify gaps for a fast, high ROI transformation. Projects are architected from strategy through execution — designed to build the client's capability throughout their transformation to sustain improvements.

ProOrbis® Informatics Applications are deployed in a wide variety of tools designed to support more intelligent decision-making. ProFrameware™ is the newest application for on-going decision support that leverages the client's existing data and information technology into a new capability that fully integrates their spatial, process flow, and/or data array modeling using the ProOrbis® Framework. Our comparative tools put an organization's performance into a context — over time, against industry peers, or against a supply chain. Fully narrating the analysis for both traditional and ProOrbis® Signature Measures provides managers with insights to effectively use comparative data.

ProOrbis® Licensed Application Development is an innovative way to engage ProOrbis management scientists to develop a unique Application for a company's ongoing use. Whether to build new internal capabilities (such as strategy and planning) or for new commercial services to offer to the market, ProOrbis has a variety of opportunities for collaboration that can improve performance. This is especially useful for complex extended enterprise networks that need interoperable and highly integrated operations.

ProOrbis collaborates with universities, trade groups, publishers, think tanks and government institutions to advance the recognition, accounting, valuation, and management of the world's tangible and intangible assets. The mission is to help design companies and economies that create a more productive, sustainable world.

ProOrbis® Method: Defined

The **ProOrbis® Method** is comprised of the comprehensive Framework and real-world Applications.

- **The ProOrbis® Framework** is a combination of strategic and analytic concepts with a project approach that offers a comprehensive, integrated, and value-oriented paradigm for managing the ROI of the tangible and intangible assets of an enterprise.
- **ProOrbis® Applications** are tools and techniques configured to real business situations that are designed for particular client needs. These Applications produce strategies, plans, and change facilitation designed to execute - resulting in dramatic improvement. The ProOrbis® Framework is applied to each enterprise through a licensed Application which is customized for each client. Highly skilled ProOrbis certified staff design projects to create a high return on the client's investment in the Application project. This can range from designing projects that clients can execute on their own, to facilitated projects in which ProOrbis develops tools for the client to use, to heavily resourced projects for our clients who do not have project resources available. All ProOrbis projects are a world-class development experience for the internal staff involved which creates significantly enhanced capability within the company. Advanced Optimization Applications are available for clients who have completed an Application and have the requisite capabilities to use more advanced ProOrbis® Methods.

Project Approach ProOrbis® Applications are fully integrated and linked to value and therefore they create systemic improvements. As ProOrbis and clients work through any challenge, the project approach employed begins with high level architectures in all areas of the model and then drills down to more detailed designs. Change management is not a "separate event", but is built into the process. This integrated approach ensures that decisions are made in the right order, the links to value are always present, and that remarkable shifts occur with speed and discipline — creating excitement, momentum for change, and real-world results.

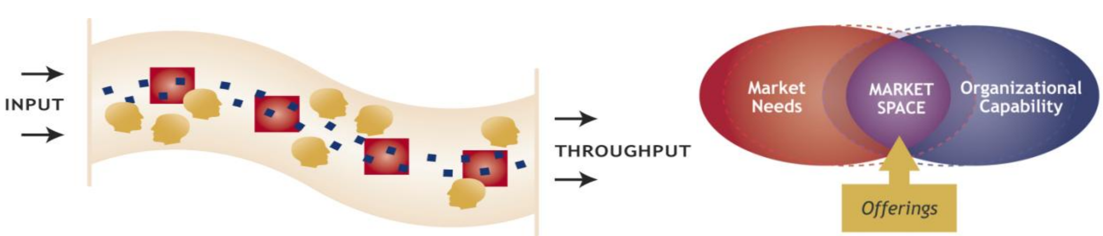
Client Profile ProOrbis clients are generally leaders in their categories, often with a long track record of success. They range in size and nature, but are often complex, global businesses with a wealth of expertise. ProOrbis brings a new perspective to help them meet the next challenge – dramatic growth, productivity improvement, or migration to a new market by uncovering opportunities and a path to seize them. A ProOrbis project is ideal for senior executives who are new to their positions and need a fresh, comprehensive perspective as well as established executives who are staging for a major shift in the organization's growth or profitability.

ProOrbis® Framework

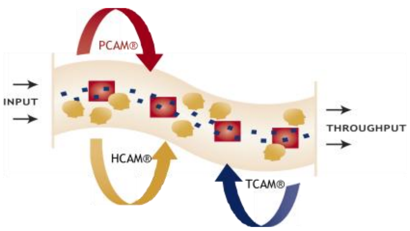
Market Positioning Market Positioning is essential to the understanding of how and where a business creates value. By discovering the areas where an organization's market opportunities intersect the organization's capabilities, clients are able to better identify the market space into which offerings (products and services) are best positioned. The future positioning is determined by trending the market and establishing the requirements for the organizational capability shift. This provides a transformation trajectory for the organization's offerings and capabilities — a clear, actionable business strategy.

Organizational Capability Organizational capability is everything the organization *can* do; on it's own or through its extended enterprise such as shared services, suppliers, alliances, partnerships, etc. The organization's capability is comprised of three core assets – physical capital (PC), including all tangible assets; technology capital (TC), including product technology, R&D, information technology and process technology; and human capital (HC), including employees and contract staff. An asset, tangible or intangible, is any productive means the organization materially controls that can be used to create value. These three core assets are combined (by process technology) into production functions that are designed to take *Inputs* and produce valuable output – *Throughput* – which are the offerings designed to execute the positioning. Since the assets *in combination* create the organization's capability, then return on the asset investments of the enterprise (R) can be calculated:

$$\frac{\text{Throughput - Input = Value of the Assets}}{\text{Investment in Human, Physical, and Technology Capital}} = R$$



Asset Management



An Asset Portfolio is a collection of assets. Asset Management is the organizational capability that manages the lifecycle of the portfolio including: strategy, planning, organizing, acquiring, maintaining, upgrading, and divesting. There are three principal asset management capabilities: **Human Capital Asset Management (HCAM®), Technology Capital Asset Management (TCAM™), and Physical Capital Asset Management (PCAM™).**

All assets in the enterprise are either in the business of creating Throughput or creating Assets. Therefore, there is no "overhead." Assets derive their value from the organizational capability for which they were acquired. Therefore, the investment in assets has a value — and therefore a ROI.

Although this approach addresses the performance of all tangible and intangible organizational assets, human capital is the most misunderstood and "under-worked" asset ; creating significant opportunities for productivity improvement in most organizations, industries, and countries.

Human Capital Asset Management (HCAM®) HCAM® is the management system that produces the right human capital to do the work required to execute the capability. This is a fully integrated approach to the performance management, rewards, culture, and leadership designed to optimize the ROI in human capital. This paradigm clarifies *how* to make investments in human capital that generates value in business terms.

Dashboards One of the hallmarks of the ProOrbis approach is world-class analytics, particularly in the measurement of tangible and intangible assets and value. Dashboards are fully integrated with analytics designed to describe, explain and predict performance to inform decisions and track results. The dashboard cascades from equity market performance, to the return on both tangible and intangible assets, to the performance of plans and programs that manage assets. Dashboards are used for highest organizational view to the individual level.

ProOrbis History

ProOrbis is a small business founded in 1998. They have been a member of WBENC (Woman Business Enterprise National Certification) since 2006 and have had a GSA Schedule 874 MOBIS (Mission Oriented Business Integrated Services) contract since 2003 to deliver services to Federal Government clients.

All ProOrbis products and services are built on ProOrbis' proprietary methodologies that were developed by the Principal, Jeanne DiFrancesco. ProOrbis has developed an entire suite of unique and trademarked applications of these methodologies. ProOrbis consultants apply these methodologies to a wide range of real world issues (see ProOrbis Business Description). These methodologies may only be employed by ProOrbis and licensed clients, partners, or vendors.

ProOrbis' clients are licensed and trained to use the application developed specifically for them, which often leads to performance improvements even while a project is underway. This is different from many consulting organizations that do not transfer capabilities to the client. Also, unlike other consulting organizations that focus on cost reductions, ProOrbis methods provide tools for value creation and return on investment.

Credentials

Ms. Jeanne DiFrancesco is the Principal of ProOrbis, LLC. She holds an MBA from University of Pennsylvania: Wharton School of Business and an interdisciplinary undergraduate degree from the College of William and Mary. She is the author of the ProOrbis® Framework, the breakthrough strategic paradigm and economic techniques for managing the investments in and value of both tangible and intangible assets to make investments that achieve dramatically improved returns. She has over 25 years of executive and strategic level experience with leading companies in health sciences, electronic materials, investment banking, insurance, financial operations, power generation, logistics, the U.S. Federal Government, and the Department of Defense.

Ms. DiFrancesco authored a course for the Institute of Management Accounting (IMA) on "Valuation and Accounting for Intangible Assets", and has participated in Financial Accounting Standards Board activities to set standards for U.S. and international accounting.

Ms. DiFrancesco speaks frequently at conferences and is an expert advisor for various groups. She has worked with: The Human Capital Institute (HCI), The American Nuclear Society (ANS), The Conference Board, Institute of Human Resource Information Management (IHRIM), the Brookings Institution, Drexel University, The Harvard Club, and continues as a long-time guest lecturer at the Wharton School.

ProOrbis Publications

- "The Power of Prediction: Improving the Odds of a Nuclear Renaissance". Montgomery Research, The Utilities Project Volume 8. May 2008.
- "The Liability of Cost Cutting: A CEO's New Challenge". Montgomery Research, The Utilities Project Volume 7. May 2007.
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REFERENCE MODEL

FOR THE

INTERNATIONAL SPACE STATION

U.S. NATIONAL LABORATORY

REPORT

September 20, 2010

Prepared By: ProOrbis, LLC

Commissioned By: NASA

ISS U.S. National Laboratory

Table of Contents

Study Background and Approach

Note from the Authors

NASA requested an independent study to formulate a reference model for an enterprise to manage the uses of the U.S. share of the International Space Station (ISS) by organizations other than NASA. NASA's objective for this project was to obtain a model organization designed to maximize the value of the national investments in ISS. ProOrbis has proprietary methodologies that are uniquely suited to building such a model and was tasked by NASA to conduct the study using the ProOrbis® Method with an objective, independent perspective.

This report reflects the results of a 90 day study in which ProOrbis used its methods combined with independent research, NASA working sessions and, over 200 interviews with current and previous managers and users of ISS including: academic, industrial and government scientists, payload developers and integrators, research organizations, astronauts, NASA personnel, education experts and potential funding sources (both private and philanthropic). Participants were provided confidentiality for their input to this report to facilitate an open dialog.

The ProOrbis® Method is advanced management science that includes a comprehensive strategic framework and economic techniques for maximizing the tangible and intangible value of investments (Appendix A – The ProOrbis® Framework and Credentials). All points in the model have been tested for practicality using proprietary ProOrbis® Applications*. We introduce ***method terms*** throughout the document, noted in bold, green italics.

Maximizing value is a common objective for profit-making firms. Governmental organizations generally have the task of accomplishing a specific mission within a budget constraint. The value of the mission, if articulated, is rarely calculated and is not usually the functioning objective to which the organization is held accountable.

This is an original model built specifically for the intended purpose of maximizing the value of the investments in ISS; making this, from the outset, an unusual assignment. ISS is a unique physical asset operating in an environment with which most R&D organizations have little or no experience. Given the unique nature of the asset and the unusual nature of the assignment, it may not be surprising that the result of this study is an innovative design. As with all innovations, a certain amount of resistance and skepticism is to be expected. However, because something has not been done before, does not mean that it cannot be done. Leaders recognize the challenges of innovation. Our intent with this report is to enable leadership by describing both the vision and the practical design of a new enterprise for a new frontier of science.

Innovation is as important in management as it is in science or technology. The objective of this study is to maximize the value (both tangible and intangible) to the American people of the investment in ISS. We have identified a myriad of complex management challenges which have been solved in this project using advanced management science. The result is an original, specially purposed enterprise designed to be implemented practically and with the highest return for the public investment required to support the initial years of operation.

**This study was commissioned and prepared for broad publication and does not include proprietary or confidential material.*

Background of ISS and the ISS National Laboratory (ISS-NL)

The International Space Station (ISS) is the largest inhabited space station ever to be constructed. It is an international research laboratory located in low Earth orbit (LEO), which hosts unique scientific and technological facilities that support fundamental and applied research across the range of physics, chemistry and biology as well as opportunities for aerospace technological development and Science, Technology, Education, and Math (STEM) education.

In 2008 at a Heads of Agency meeting, the leaders of the ISS partner space agencies expressed their mutual interest in continuing ISS operations after 2015[2]. In 2009, the presidentially mandated committee, the Review of U.S. Human Spaceflight Plans Committee (also known as the "Augustine Committee"), and later the Government Accountability Office (GAO)[3] recommended the extension of ISS through 2020. In February 2010 the President's FY 2011 budget to Congress proposed extension of ISS to 2020 or beyond.

The U.S. research capacity aboard the ISS has not been fully utilized by NASA[4]. This is attributed to the focus to complete the space station and to uphold the Vision for Space Exploration, which was a policy that emphasized activities and research that focused on space exploration rather than on a broader research program as historically planned.[5]

> *Though there has been historical international competition in the "space-race", the ISS is a symbol of peaceful international cooperation and a triumph of human engineering.*

THE GENESIS OF THE NATIONAL LABORATORY CONCEPT. The NASA Authorization Act of 2005 designated the U.S. segment of the ISS as a national laboratory to be made available for use by U.S. public and private entities. According to the law:

> "The Administrator shall seek to increase the utilization of the ISS by other Federal entities and the private sector through partnerships, cost-sharing agreements, and other arrangements."

Subsequently, the 2008 NASA Authorization Act elaborated on the requirement of a management plan:

> "As part of the plan required in paragraph (1), the Administrator shall develop a Research Management Plan for the International Space Station. Such Plan shall include a process for selecting and prioritizing research activities (including fundamental, applied, commercial, and other research) for flight on the International Space Station. Such Plan shall be used to prioritize resources such as crew time, racks and equipment, and United States access to international research facilities and equipment. Such Plan shall also identify the organization to be responsible for managing United States research on the International Space Station, including a description of the relationship of the management institution with NASA (e.g., internal NASA office, contract, cooperative agreement, or grant), the estimated length of time for the arrangement, and the budget required to support the management institution. Such Plan shall be developed in consultation with other Federal agencies, academia, industry, and other relevant stakeholders. The Administrator may request the support of the National Academy of Sciences or other appropriate independent entity, including an external consultant, in developing the Plan.[6]

The designation of ISS recognizes two distinct uses for the U.S. portion of the ISS: (1) achievement of NASA mission objectives and; (2) meeting the national needs of other governmental agencies, non-profit institutions and private firms (non-NASA use). This national laboratory approach introduces the need to prioritize projects with a wide breadth of mission purposes.

The objectives set forth by Congress over the coming decade require the selection and prioritization of projects with a wide breadth of mission interests, value propositions and funding sources which represents a significant, if not extraordinary, management challenge.

ISS Capabilities and R&D Opportunities

THE ADVANTAGES OF THE ISS ENVIRONMENT. The findings from the research completed on the ISS provide opportunities for ISS-derived knowledge to be applied to science and innovative technologies. Conducting science in space affords various types of value to scientists. Several promising markets for science in space have been identified leveraging the unique features of ISS including microgravity, extreme conditions and its location in low Earth orbit. The following is a distillation of the ISS research advantages, which can be found in NASA and industry reports such as the National Research Council reports.

The microgravity environment in space offers a unique platform for discovery not found on Earth. Microgravity, or more precisely weightlessness, is a naturally occurring phenomenon that results from the combined forces of angular acceleration and Earth's gravity. Microgravity is a very unique condition in that it cannot be produced on Earth for a sustained period of time. The loss of the 1G gravitational force, which is omnipresent on Earth, affords an opportunity to create a variable from what was always a constant, thereby opening the possibility to learn new things about processes in physics, chemistry, and biology. Advances made from studies in microgravity teach us about the effects of long-term spaceflight on humans as well as provides ISS-developed technologies to be applied to new fields.[7]

The extreme conditions in low Earth orbit include exposure to extreme heat and cold cycling, ultravacuum, atomic oxygen, and high energy radiation. Testing and qualification of materials exposed to these extreme conditions simultaneously has provided data to enable the manufacturing of long-life, reliable spacecraft and satellite components.

ISS has a unique vantage point due to its 350 km altitude in low Earth orbit and orbital path over 90% of the Earth's population. This can provide improved spatial resolution, but also variable lighting conditions compared to the sun-synchronous orbits of typical Earth remote sensing satellites.

Unlike any other research laboratory in existence, ISS has certain unique features that cannot be replicated on Earth. Early indications are that the ISS environment has the potential to offer revolutionary advances in our understanding of basic physics, chemistry and biology in microgravity. However, what has been accomplished to date is not necessarily reflective of what is possible, but rather what has been done with the conditions and constraints of the ISS assembly environment and management of the program to date.

Previous Experience and Interests of Potential Users

Our interviews with previous, current and potential users has revealed varying opinions and diverse experiences with the practicalities of using the ISS facility in addition to the issues they anticipate with the migration to a new era of ISS utilization . It is important to note that our analysis was not designed to evaluate the decisions of the past. This feedback data is designed to be used for the *pro forma* analysis. The experience of users creates a “market perception”, which we encountered repeatedly in the course of the interview process – regardless of the veracity of the facts. The experience of users and perceptions of potential users will enhance or hinder efforts to build interest in the use of ISS in the future, thereby affecting the value that could be realized.

AWARENESS. Our interviews revealed a lack of understanding of the advantages of conducting research and development in low Earth orbit and on the ISS. Most previous users with this ISS knowledge regaled their experience, but it was sometimes colored by issues of the past (some of which have since been corrected), while others did not realize the government was interested in anything other than use to support NASA’s mission. The science community questioned the expense of ISS and believes that the annual budget could be more effectively spent in ground based labs. Government officials also questioned the expense and lack of tangible results to date. The most often asked question asked by all parties was, “Why can’t this science be done on earth?” The answer is simply that microgravity and extreme conditions cannot be replicated on Earth. The earth-based alternatives do not provide results that are closely comparable to results shown in low Earth orbit.

BASIC AND APPLIED SCIENCE CONNECTION. Interview findings from highly informed constituencies of ISS showed a philosophical rift between those who thought ISS should be used only for basic research (primarily government funded) and those that felt that R&D applications from translational research was the only work that would create value. In extreme opinions, basic researchers felt that the only value that is important is the degree to which the findings advance science in the form of published research, citations, academic awards and education of the researchers involved in projects. Industrial R&D interests indicated less interest in “why” something was happening; only “that” it was happening. The reality is that translational research and product development have theoretical and basic science underpinnings. This work is on a continuous pathway, although it is rarely understood and even more rarely articulated. Diverse interests that are in fact reinforcing the need for ISS research appear to be competing.

FUNDED RESEARCH PROJECTS. Historically, it did not appear that there was a shortage of potential projects for use of ISS. All indications suggested that when government funding was readily and reliably available, project proposals were abundant. Although NASA’s funding for research remains significant, there is also a significant amount of funding that has been provided and retracted over time as a result of changes in Presidential priorities and appropriations by Congress. “Scientists must have a reasonable level of confidence in the sustainability of research funding if they are to be expected to focus their laboratories, staff, and students” according to The Life and Physical Sciences Research for a New Era of Space Exploration: An Interim Report[8].

Our research also revealed an interest in the part of new potential private investors and foundations in the types of research developments identified thus far on ISS after the potential valuable uses and value propositions of ISS were articulated to them in a way that was accessible to their way of receiving information.

Funded STEM Education Projects. Space related assets (such as Hubble, Shuttle, etc) and ISS in particular are thought to be some of the nation's most valuable assets for inspiring interest in science, technology, engineering and mathematics. Educators are very excited by the possibilities of using ISS, but are very frustrated by the diverse, uncoordinated program initiatives and the unreliable funding to sustain any particular program. According to the Committee for the Review and Evaluation of NASA's Precollege Education Program, "NASA's education portfolio has experienced rapidly shifting priorities, fluctuations in budget, and changes in management structure that have undermined the stability of programs".[9] There is an abundance of good ideas for using ISS for STEM education, however funds available for STEM education as provided for through a myriad of vehicles are not well coordinated or used.

Priority. Current protocols and rationale for prioritizing the national laboratory usage of the ISS appear unclear to current users. The National Research Council emphasized in their Decadal Survey Report "Life and Physical Sciences Research for a New Era of Space Exploration" need for an increased transparency of NASA's prioritization process for both agency-sponsored and non-agency sponsored research[10]. Interview feedback suggest that the past perceptions and experience of non-NASA users has been one of being lowest priority and receiving the remaining capacity after NASA has taken what it needs. Potential users have expressed concern that that they could significantly invest in developing a project only to have it "left on the tarmac" and university researchers are concerned that they could risk the time and funding of their labs on projects that may "never fly". Some current users feel more assured that their projects are a priority due to their agreements with NASA and the personal commitment of individual NASA staff.

Time Horizon. The International Space Station is a physical asset with a finite asset life. The opportunities exist for doing research on ISS, but would require potential users to undertake significant changes to their current research approach and protocols. Even with a possible ten year life span, potential users have expressed concern about the relatively short life span in the context of the development cycles for research-intensive industries and the availability of this type of facility in low Earth orbit.

Ease of Use. Potential principal investigators are very concerned about the complexity of using ISS. The NASA legal and tactical operations process is intimidating and seemingly mired in "red tape". Experienced users are less intimidated and have expressed that they have adjusted to the pace and paperwork. However, previous, current and potential new users have uniformly expressed great interest and need for a support system for the entire process from contracting through to implementation and post-flight support. They have lamented on the difficulty in finding information and not having a resource that could answer all questions (whether they could answer the questions or find the answers), but rather having to make 3 or 4 inquiries to find the information they were seeking. They have also expressed frustration in not knowing the full capabilities of ISS, transportation, and available support resources for ground support.

Space Research Expertise. Due to shifts in policy and funding support for NASA mission-oriented research, the project pipeline for grant-funded research from 2002-2008 decreased substantially as the Agency's focus changed. The portfolio of NASA projects peaked in 2002 with 966 academic research investigations, with 127 of those aboard the ISS. In 2008, that number dropped dramatically to 285 total projects whose focus was exploration rather than research. Eighty four of those projects made it to low Earth orbit.[11] The result was a reduced academic community actively pursuing space-based research. Due to those historical uncertainties for funding there is now hesitancy on the part of government-funded academic researchers to re-commission those resources even if governmental funds were recommitted.[12] Interview feedback has suggested the development of space research as a distinct scientific area has been limited and scattered a research community that was once more focused.[13]

*NASA has worked to improve the experience of non-NASA users as the program has progressed, so some issues have been corrected in fact over time. Articulating these issues is important to understanding the interests and perceptions of users. These are the foundation of **market needs** as identified in the ProOrbis® Method and are important factors in designing an enterprise that both meets user requirements and addresses the issues that potential ISS users anticipate.*

The Current ISS Supply Chain Capabilities

To maximize the value of an investment in an asset requires an articulation of the assets and capabilities that enable it to be "productive". Value is derived from the use of an asset (see Appendix A). The use of ISS is the result of a vast network of organizations working together to conduct R&D projects aboard ISS, which we refer to as the ISS supply chain. This supply chain was analyzed for both its capability to enable valuable utilization of ISS and constraints that could limit utilization. Not all capabilities in a supply chain are required for every use of ISS. The current network of providers required to utilize ISS is robust and experienced with the notable exception of transportation. A high level, simplified view of the current network is depicted in Figure 1.

Figure 1

- Research laboratories that perform research and formulate project ideas for use of ISS
- Existing funding sources such as governmental grants and private funding
- Payload developers that develop new equipment necessary to support research experiments or to adjust existing equipment to work for a particular research project (implementation partners)[1]
- Labs for testing experiments designed to work in the microgravity environment
- Payload integrators and NASA who work together to integrate all payloads and support crew training, safety and real-time operations support (implementation partners)
- Transportation provided by NASA, international partners and future commercial services (upmass and downmass)

[1] Payload Developers and Integrators have recently been termed "implementation partners". Companies that are termed implementation partners perform one or both of these services.

- ISS which is the research facility that supports the research projects
- Processing laboratories that enable researchers to analyze the results if samples are returned
- Throughput includes completed projects that are applied to create value.

Post-completion, the ISS presents different potential for use than what was available during the construction phase. Utilization of these capacities requires an elaborate supply chain of labs, payload developers, payload integration and transportation. Our analysis of the supply chain revealed two key elements to the formulas to determine the maximum theoretical utilization of the ISS, 1) the facilities and supporting resources on ISS and 2) the availability of transportation, both up and down.

ISS Capabilities. The capabilities of the ISS research facilities are well-documented by NASA and reports such as the 2009 Augustine Committee and GAO report. The ISS facilities have the ability to support a broad base of research disciplines.

Capacity Considerations. The full capacity available for ISS research is not quantifiable by total number of research projects. The design and full utilization of ISS is a complex process that requires the integration of projects that require varying types and amounts of resources.

On-orbit Crew. Crew time is a limiting resource for use of ISS; however, the automation of equipment can eliminate some of this constraint. To optimally schedule the on-orbit crew, it is necessary to balance the needs of ISS maintenance with the needs of research.

Transportation. Transportation, to and from the ISS, is a limiting resource variable for full utilization of ISS. Until now, the Space Shuttle has been the main source of transportation to and from the ISS. However, the Space Shuttle is scheduled to retire in early 2011.

The National Aeronautics and Space Administration Authorization Act of 2008, Section 602 provides that the Administrator shall:

> "Establish a process by which to support the ISS National Laboratory users in identifying their requirements for transportation of research supplies to and from the international Space Station, and for communicating those requirements to NASA and International Space Station transportation service providers and develop an estimate of the transportation requirements needed to support users of the international Space Station National Laboratory and develop a plan for satisfying those requirements by dedicating a portion of volume on NASA supply missions to the ISS." [14]

The Federal Aviation Agency signed agreements with Commercial Orbital Transportation Services program (COTS) and the Cargo Resupply Services program (CRS) which authorize the service organizations to use the NASA launch sites for Space launches. NASA has made significant investments in each of these programs to support the goal of providing a new commercial service to replace the space shuttle after its retirement. Although NASA has signed agreements with both Space Exploration Technologies, Inc. ("SpaceX") and Orbital Sciences Corporation, Inc. (OSC), these U.S. commercial transportation and service providers may not be immediately available after shuttle retirement. Therefore, NASA has planned to use the Russian Progress vehicle, European ATV and Japanese HTV until such time as the domestic commercial services are available [15].

The transportation capabilities available in the post-shuttle era are summarized in Appendix B - Post-Shuttle Transportation Capabilities. The down-mass capabilities and the capability for late-load and early delivery of sensitive biological samples will be reduced with the retiring of shuttle. Late loading allows for biological research to be loaded onto the launch vehicle close to scheduled launch time preferably 12-48 hours prior to launch due to the sensitivity of the samples and their required temperature control.

The future transportation options to ISS involve continuing cooperation with our international partners and the promise of U.S. commercial transportation providers. Reliable transportation is essential to a successful ISS-National Laboratory program and for current and future flight operations. Depending on the capabilities of the transportation vehicles, there is more or less possibility for what research can be accomplished.

The ISS is a physical asset that offers a unique environment for conducting science and technology research. The network of providers required to utilize ISS is experienced and robust with the notable exception of transportation. The capabilities of the current ISS supply chain provide the foundation of understanding of what missing capabilities are needed to maximize value.

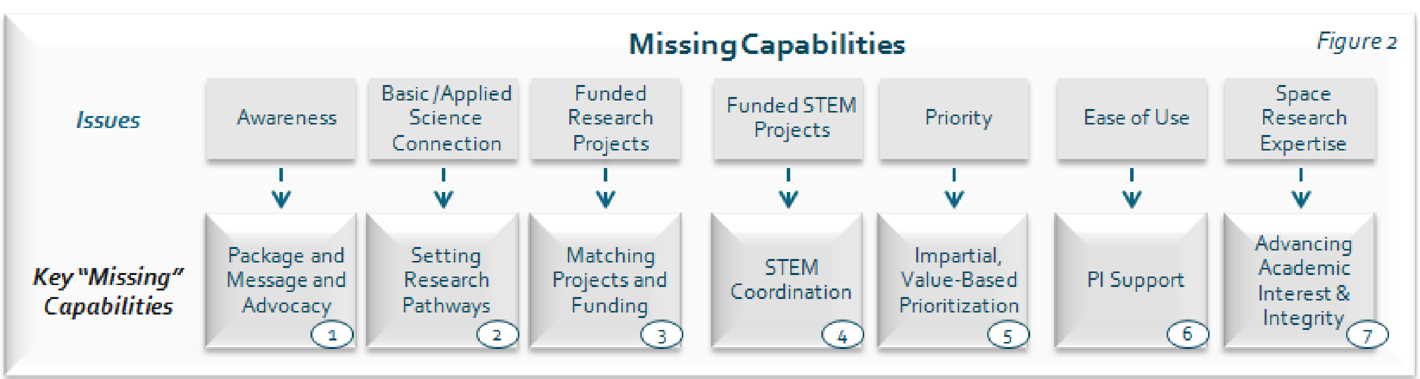
For the purposes of the analysis, the ISS facility was modeled as a constant (although new on-board equipment is an open option) and transportation was modeled as a constraint.

Key Missing Capabilities

The findings from extensive interviews illuminated key issues to be addressed and the result of our analysis is the articulation of the capabilities required to fill in the supply chain. We used the following principles in establishing and designing these missing capabilities:

1. Not to replicate well functioning, existing capabilities in the supply chain (reference Figure 1);
2. Anticipate issues of users and other constituents with the start-up of the enterprise in the current political and economic climate (reference Previous Experience and Interests of Users) and;
3. Ensure that the missing capabilities in fact can be delivered given the constrains of legislation, regulation and difficulty of the design requirements

The introduction of key capabilities into the supply chain form the foundation of the requirements for an organization that meet the needs identified (Figure 2). Delivering these "missing capabilities" opens up the value potential of the current capabilities in the supply chain.



Package and Message and Advocacy
1

Package, Message and Advocacy. Addresses the issue of broad lack of awareness amongst the potential ISS constituency groups of the advantages of performing science in space by communicating this information in formats and forums that meet the unique needs of each audience. In addition, identifies advocates from the private and public sectors and formulates comprehensive strategies to access those advocates. This requires deep insight into the interest of a broad constituency and expertise in external relations, outreach and program development.

Setting Research Pathways
2

Setting Research Pathways. Addresses the issue of diverse and sometimes competing, scientific interests in utilizing the ISS by bridging basic science with industrial R&D applications through the development of research pathways. These pathways would connect basic and applied research along a continuum rather than treat them as independent activities. This requires a multidisciplinary environment that allows fundamental and applied scientists to collaborate and extend beyond their current disciplinary areas without requiring either group to abandon their principle mission.

Matching Projects and Funding
3

Matching Projects and Funding. Addresses the issue of an unreliable funding channel; which has contributed to a diminished project pipeline; by creating a mechanism to match potential projects with interested investors. This requires an understanding of the unique needs for each of these groups as well as the applicable rules and regulations governing the potential arrangements between parties (such as intellectual property, federal funding, established agreements, etc).

STEM Coordination
4

STEM Education Coordination. Addresses the abundance of interest in Science, Technology, Engineering, and Mathematics (STEM) project opportunities for ISS and lack of consistent funding by creating a mechanism for matching projects with interested funding sources. Projects could include education programs, education distribution channels, curriculum opportunities, and related ground-based projects. The matching capability described in #3 would serve a similar function for ISS education projects. This would require the ability to coordinate amongst the existing STEM project opportunities available from a wide variety of sources in order to maximize the existing project pipeline and not proliferate or create confusion for education consumers.

Impartial, Value-Based Prioritization
5

Value-Based Prioritization. Addresses the concern that non-NASA users are treated fairly by providing a reliable, impartial, transparent prioritization process that balances a diverse portfolio of research disciplines and stages of research. This requires a process that can consider a wide variety of tangible and intangible value and can account for the magnitude of the value impact on the U.S. In addition, users need feedback to understand why a project was not selected so that they could choose to improve the design to create more value. This requires in-depth scientific and economic multi-disciplinary knowledge that can capture the values of the diverse research potentials for ISS utilization.

PI Support
6

Principal Investigator Support. Addresses the concerns of previous, current and potential new users who are intimidated by or apprehensive about the process for getting research to ISS by providing a mechanism for a seamless support system for the entire process. This requires facilitating users throughout the process from contract negotiation through payload development and implementation and post-flight support by leveraging experience and close working relationships with extended enterprise partnerships (such as implementation partners) and NASA to assist investigators, which can improve both their experience and project efficiency. This activity is more direct and hands-on in the beginning, especially for those completely new to the process, and becomes more of a support resource for the principal investigator in later stages where NASA or implementation partners are generally more involved.

Advancing Academic Interest & Integrity. Re-build the cadre of scientists with expertise in the low Earth orbit environment by developing the skills and sparking interest in the next generation of leaders in STEM disciplines, which is essential to improving the management of the knowledge base for conducting science in space. A myriad of mechanisms will be required such as scientific forums, formulation of academic curricula, and dissemination of findings through published results. From the highest levels of scientific discovery to the introduction of topics to young children, the translation of findings and promise of the low Earth orbit environment will need to be made available in a way that is accessible and inspiring.

The "missing capabilities" are the foundation for the activities to be designed into this enterprise. Completing the supply chain leverages the existing infrastructure by enabling the entire system to produce more ***Throughput*** *(output that has value), which improves the value of the entire network. In this way, relatively small investments in precisely the right capabilities can leverage cumulative investments of the network, thereby creating significantly improved returns.*

Recommendation for a Separate Organization

Several previous studies have established the need for a separate organization other than NASA to manage the national laboratory uses of ISS. According to the 2009 Augustine report:

> "The committee believes that an organization is needed to mediate between NASA operations managers and the broad stakeholder community". This could facilitate access to ISS assets by a disparate user community (with widely varying levels of sophistication about spaceflight activities), and could help organize the multiple demands of the users into more unified requirements. Without a mediated dialogue between [NASA] operations managers and users, it will be difficult to realize operational efficiencies."[16]

Figure 3

This study concurs with these findings and has not identified an existing entity that is designed to execute these missing capabilities. Therefore, this model is has been built as a new (*de novo*) organizational entity that is specially purposed to deliver the missing capabilities of the ISS supply chain (Figure 3). The rationale for each of the design features unfolds in this report as each aspect of the analysis is addressed along with some of the implications of "retro-fitting" an existing organization.

This separate entity is referred to hereinafter as the Non-profit Organization ("NPO").

An enterprise that can deliver the missing capabilities would need to be designed precisely to do what is required (no more, no less) to avoid both redundancy and ineffectiveness.

Establishing a New Entity

The previous sections outline the capability requirements for this reference model; however, the NPO has several overarching objectives that are needed to fulfill the guiding principle of value maximization.

THE NPO OBJECTIVE. Most organizations have a singular "objective level" goal. Publicly held firms typically operate with the objective of shareholder value. Value in these terms is a long-term concept that includes value from current earnings and the sustainable value-added that can be created by the assembled assets of the enterprise. In the simplest terms this is like the value of a company.

The operating objective of the NPO is to maximize the value to the United States of investments made in the International Space Station.

The equivalent of value-added for this enterprise would be the combined long-term value that could be created by advances using ISS to the U.S. citizenry minus the investment it would take to create this value. The concept is simple; the execution is more complex, but understanding this conceptual frame is essential to the analytical rationale. The microeconomics used in the ProOrbis® Method is further described in our prior work as referenced in Appendix A.

LONGER TERM-FOCUS: ADVANCING SCIENCE IN SPACE
WORLD-CLASS, ESTABLISHED, RESPONSIVE, ACCESSIBLE, INNOVATIVE
IMPARTIAL, UNCONFLICTED
CREATING A COMMUNITY OF INTEREST

THE NPO PURPOSE AND FEATURES. There are certain key strategies the NPO would need to employ to deliver the missing capabilities. These are the attributes of the ***Positioning***:

- *Long-term Focus*. To provide confidence and stability to investors and researchers to make the investments necessary to move to this new research platform, we recommend the adoption of a longer-term focus for the NPO, which is to advance research and development in space. This concept is referred to as "advancing science in space". By creating an enterprise that builds a community of interest in this type of research, ISS could become a stepping stone to future space-based assets which bridges a major concern about the life span of ISS. This longer-term focus would enable the community of users to pool their resources and influence to promote a longer-term presence in low Earth orbit if it proved valuable and worthwhile.
- *Caliber and Accessibility*. The NPO needs to be both a world-class enterprise and a national establishment. By carrying the respect and prestige required to accomplish its objective while operating as a responsive, flexible

and sufficiently sophisticated and innovative enterprise, the NPO will be able to attract a wide array of participants from venture financiers and major companies to leading universities, foundations and school children. To support these interests, we believe the NPO should be an organization that can be "joined", supporting the membership model and creating an atmosphere of inclusiveness, accessibility and collaboration. This collegial concept is well established in a host of analogs from industry consortiums, academic societies to national science museums. Although not a concept used in the management of other national laboratories, the breadth of mission interests of the users and their active participation in the use of the lab are well-suited to a membership model.

To demonstrate "establishment support" and provide time for the building of awareness and space research capabilities, some government appropriations will be required. The NPO can raise funds for projects and charge fees for value-added services (discussed further in the Sources of Funds section), but a community of interest and demonstration of value will take time to develop. Given the projections in the financial analysis (outlined in the Budget section), the NPO could reasonably be expected to be self-supporting in about 5 years.

To accomplish the NPO's objective, it will be necessary to employ a world-class and effective management structure with as little constraints as possible. Federal government regulations, especially for contracting and employment, are designed for a different type of entity (one with a mission and a budget) with no expectation of self-sustainment. Managing this as a government entity would significantly increase unnecessary cost, adding to the budget requirements and potentially impairing the organization's performance.

- *Impartial and Unconflicted*. It is essential that this organization have a singular and un-conflicted goal. Both the fact and appearance of impartiality is an absolute requirement to give users confidence in the reliability of the organization's decisions. Conflicted interests are also the concern of the Administration staff and Congress. The use of ISS for profit-making ventures without due consideration, using the power to prioritize projects to penalize competitors, or advancing one agenda over another have all been expressed as critical flaws to be avoided.

ENTITY TYPE. Given the nature of this activity and requirements of operation, the analysis of organizational forms identified a 501(c)(3) public charity as the best fit instrument. Key factors included the ability to: 1) be designed to support a special and uniquely purposed enterprise, 2) raise and receive funds from public and private entities and use proceeds for education and research, 3) support membership models, 4) accommodate a vast array of interests (mission oriented and private), 5) be set-up in a timely fashion, 6) be relatively flexible to change to a different legal entity if needed in the future, and 7) be managed by appropriate rules for a mission-oriented organization. The tight fit of this form enables management and control for the least amount of additional cost.

The management of an enterprise requires investment, and like all investment can be designed to maximize return (ROI). However, this requires the design to be more of a technical matter than an exercise in power or control. It is important that the purpose of the NPO be set forth clearly and that its duties are to create value for the American people through its users. An unsuitable instrument or organizational form, even if permissible, could have a significant deleterious impact on the results and create a non-mission focused administrative burden for NASA.

Conflict of interest is one of the major concerns in use of a non-governmental entity and therefore the establishment of a de novo enterprise is recommended to ensure a specially purposed organization that has a singular objective, effective governance structure and efficient resourcing.

Sources of Funds

The following valuable services, ***Offerings***, have been identified that could be sources of funds to create a self-sustaining NPO. In keeping with the concerns of policy-makers that individual private interests not benefit unduly from public investment, these offerings provide support for the NPO based on the value it is providing to users. The operations that support for government grant issuance and monitoring are typically funded with government appropriations, but the NPO will have a variety of sources of funds for projects. A more sophisticated, user-centric model provides for more precision in the value/pricing exchange. The model includes:

- Success Fees: Success fees are charged for the completion of an agreement. The transaction could be a successful match between funding sources and projects for both grant and private funding arrangements. This would include both research and education related projects. Projects entering the NPO as fully funded, whether by grants or private sources, would not be charged transaction fees. Parties to this type of transaction indicated that they spend a lot of time in this process currently, and not always successfully; so the value of this arrangement to the parties is in the efficiency created by the marketplace mechanism.
- Special Royalties: The NPO can charge a nominal special royalty to applicable proprietary projects. Concerns were raised about the use of ISS and government supported transportation for "profit making" activities. Yet, especially in the nascent stages of ISS use, charging the full cost to users may create a price point that is too high for the risk involved. A mechanism for resolving this is with a royalty paid in connection with the sale of resultant products or services. In this way, users only pay if they have benefitted. This arrangement is in keeping with the principles used in other national laboratory proprietary and non-proprietary research models (further described in the Intellectual Property Section).
- Member Fees: To support the diverse interest in services from the NPO, it can formulate a tiered membership structure. Fees should be customary and reasonable for services such as the support of the marketplace activities, professional development, programming, research materials, events and forums, etc. This model is customary in a variety of analogs and supports the sense that this organization is designed to benefit and support the users.
- Fundraising: There are a myriad of individuals and foundations who wish to contribute funds to support research topics, causes or missions. These are not fees imposed, but voluntary donations.

The goal of a self-supporting organization is in keeping with the value maximizing objective of the model. By charging fees for value delivered, not only does the organization reduce the burden of costs to the American people, it actually regulates the use of the NPO by establishing a fair market price for services. Underpriced services tend to be overused, while overpriced ones tend to be underused. The NPO has the incentive to create value for users or face the inability to raise funds. It is true that the government can and may need to support new market categories (such as those developed in low Earth orbit) until the value potential is recognized. Indeed, without that support, the market may never materialize due to the risk and cost. However, the value of the services of the NPO is easier to recognize and fees should be in keeping with like services in the market and the value being created.

NPO Operations – Functional Description

A ***Capabilities Architecture*** is the highest level of design for the operating model for the enterprise. The design of the capabilities set forth the requirements for the design of the organization as well as the resources required to deliver those capabilities (human capital, physical capital and technology capital assets). Figure 4 depicts the capabilities architecture to deliver the "missing capabilities" to complete the ISS supply chain

The following functional description is designed to describe the way the model is designed to operate. Because of the design innovation in this model, certain capabilities were selected to be developed in more detail to ensure both operability and to identify the nuances of execution (see Detailed Capability Descriptions).

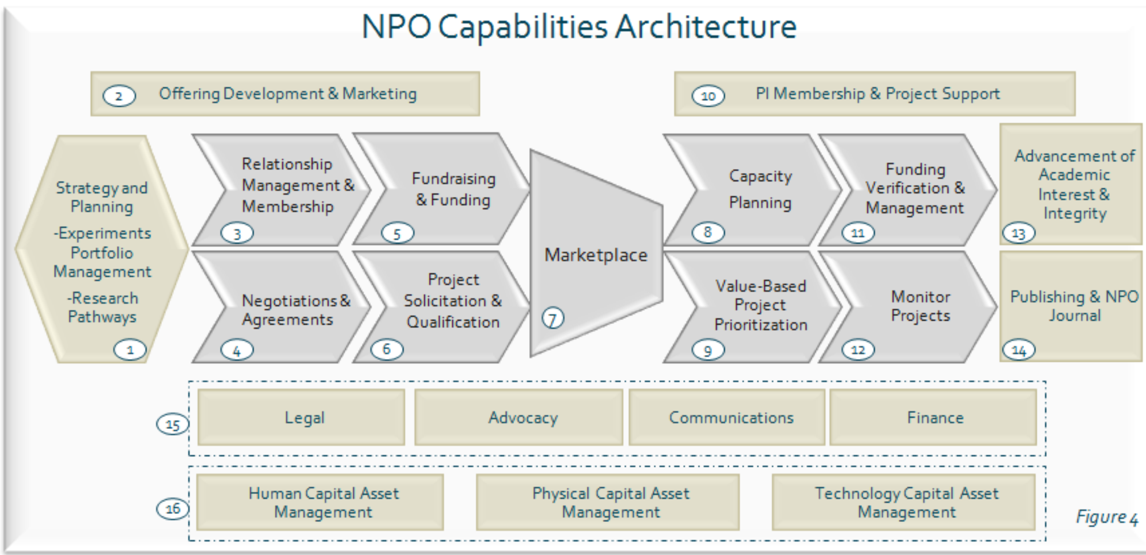


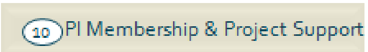
Figure 4

An enterprise creates value through its ***Offerings***, the products and services offered to its customers (in this case the "users"). Offerings are designed to meet the objectives of the enterprise by providing value to users, which is usually in exchange for funds (most easily thought of as revenue). The offerings portfolio is comprised of a mix of products and services with the breadth required to meet the needs of a broad array of constituencies at price points that enable a valuable exchange. In mission-oriented enterprises such as this, the design of offerings is a more complex, but conceptually it is the same as in a profit making enterprise.

To address the need for advocacy and outreach, the marketing capability is designed to develop and manage brand strategies, creative designs, website and communications materials that support broadening the user-base of ISS-NL and expanding sources to fund those uses.

The NPO has been designed as a joinable enterprise to a vast array of constituencies and as such would need to build interest and awareness for membership and use of the ISS-NL as well as to solicit and manage members and users for the NPO. Due to the nature of activities and offerings contemplated, members could range from individual school children to universities and governmental agencies. Members are also managed in portfolios based on their needs and interests.

Members agree to the procedures and protocols for use of the NPO, especially those involved with projects using ISS. The establishment of standard frames and rules facilitates a more orderly and efficient process and creates a more professional experience. The Relationship Management capabilities gather data about the users and their interests while the Negotiations and Agreement capability ensures that the NPO has sufficient agreements between the parties in place to deliver the offerings. Details of these agreements are addressed further in the section on Master Agreements.

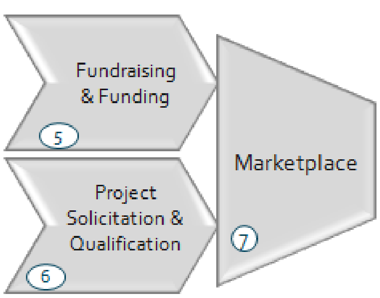


To facilitate ease of use, principal investigators and funders are provided with a relationship manager to give them varying degrees of assistance throughout the project development and execution process depending on their degree of involvement with projects. Many members may only be involved as observers in order to stay abreast of developments whereas others may have active projects. Support needs will vary by member and may change over time. The support infrastructure of both the NPO and NASA is significant and complex. Relationship managers help users understand how best to use the resources to meet their needs.

The Strategy and Planning capability is the "brains" of the enterprise and is designed to manage the overall objectives of the NPO, select an approach to achieve those objectives (strategy) and determine the resources it will take to execute (planning) and monitor the results.

The research pathways set the strategic scientific agenda for the NPO. Scientific opportunities are identified and placed on a continuum frame from fundamental to applied research and analyzed for value. Findings from ISS-NL research and related ground based advances are incorporated into pathways and value models, which results in continuous and active management of the science agenda. This capability requires a multidisciplinary approach that includes not only academic and industrial science but also economics, finance and strategy. This capability provides the strategic frame that links research to value, which allows the users of ISS to stay focused on their own missions. This approach creates a solution to the issue of diverse and sometimes competing nature of research today. The research pathway concept is further described in the Research Pathways Section.

The experiments portfolio is a collection of information on all of the past and current projects conducted in the low Earth orbit environment. Each project profile would include the data needed at various stages in a projects lifecycle to ensure fair and accurate project selection, track progress towards meeting objectives and effectively manage and calculate the value-based outcomes.



To create a stable marketplace to match projects with interested investors requires the capabilities to develop and manage a sustainable pipeline of funding and project sources.

The fundraising capability ensures that worthy projects for science in space gain access to funding through a wide variety of mission-oriented funding sources including direct government appropriations, other federal agencies (e.g. NIH, NSF), charitable foundations, private firms and individuals as well as groups. The requirements for this capability include the development of a comprehensive fundraising pipeline that meets the breadth of research and education projects being solicited.

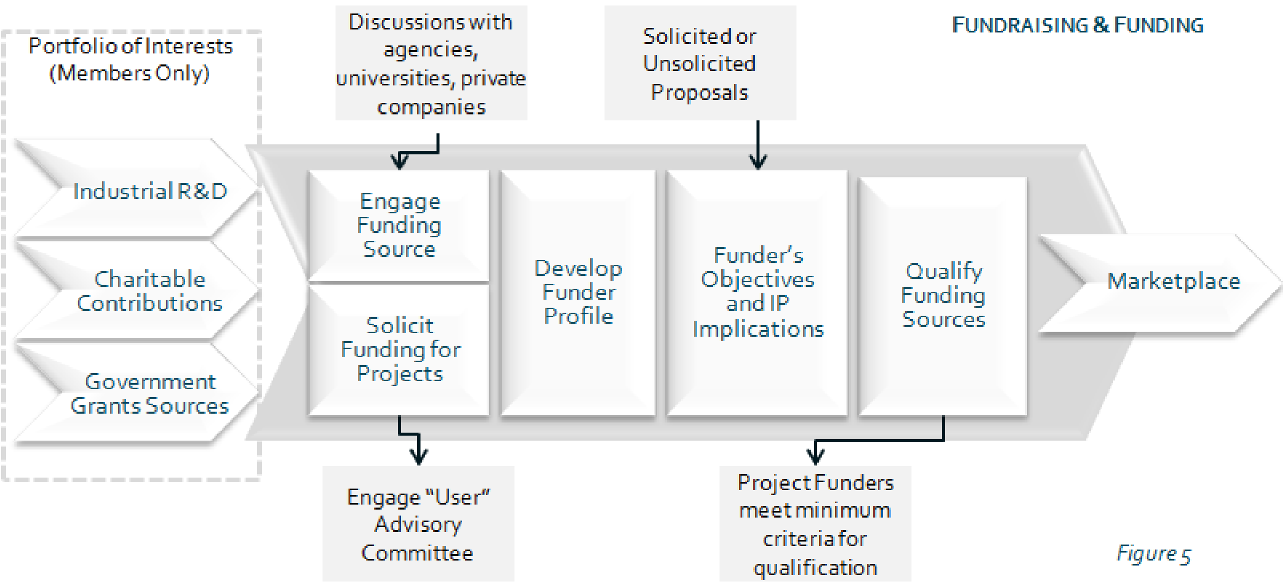


Figure 5

This capability identifies and develops a portfolio of interested funding sources meeting the types of funding needed (level and interest) to support the goals of the NPO (Figure 5). Projects are solicited either directly, through public announcements, or by utilizing a User Advisory Committee (the committee is further described in the Membership and Advocacy Committee section). Funder profiles are then developed to identify the amount of funding available followed by the funder's objectives for participation and intellectual property preferences (e.g. some funders may only fund projects whose results would be published). The final step in the process is to qualify the funding source as a credible source, meeting the minimum criteria for qualification.

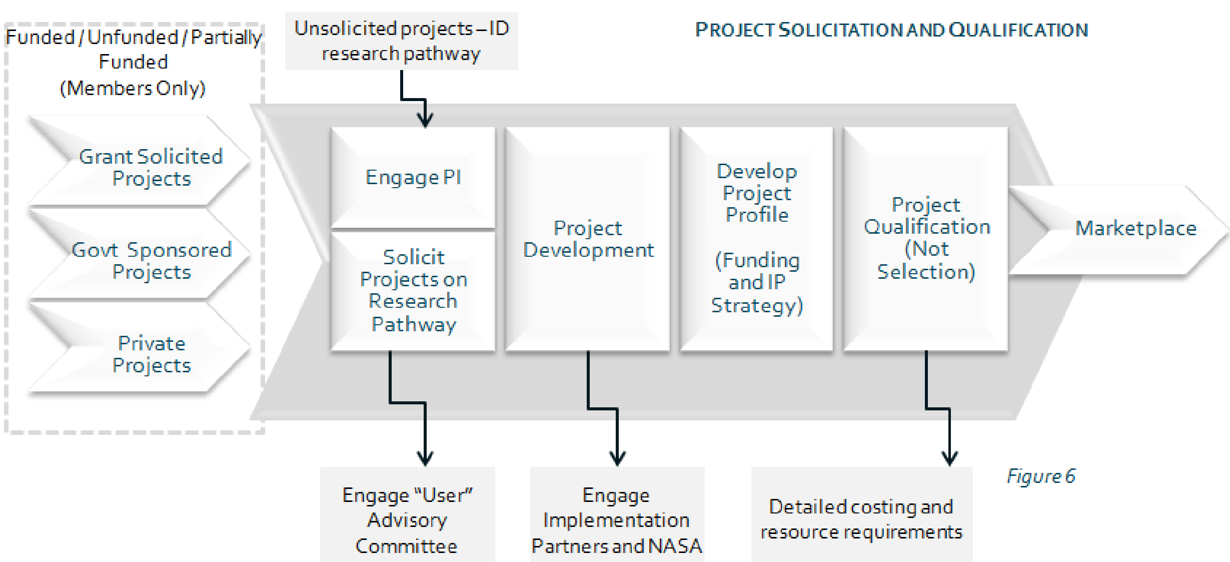
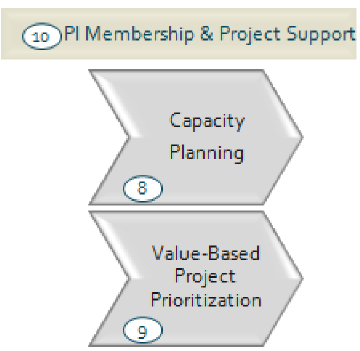


Figure 6

The NPO can accept funded, unfunded, or partially funded projects for grant solicited projects, government sponsored projects, or private projects (Figure 6). For unsolicited projects, the NPO identifies whether the project is on an existing NPO research pathway and if it is not determine whether a new pathway should be developed. The NPO staff works with the researchers to develop projects by articulating their value propositions prior to entering the marketplace and working with NASA and implementation partners to ensure that the design of the project adheres to what is possible and practical. Project profiles are then developed that describe the project and includes the principal investigator's preferences for funding. The project development and profile step is critical for projects entering the marketplace because this exercise articulates the details of a project tailored for communication to the desired investors (e.g. private investors and potential grant sources of funding request information in different ways). Finally, projects are qualified, which is the "sign-off" step prior to entering the marketplace.

MARKETPLACE. The purpose of the marketplace is to provide a user-friendly connection between various types of funding sources with available projects. This requires a forum staffed with marketplace experts trained across all experiment portfolios of the various project categories. The marketplace capability provides for a broad range of potential scenarios. Projects enter the marketplace as partially or completely un-funded. There could be a multitude of match scenarios that vary depending on the intellectual property considerations, previous revenue commitments (e.g. royalty interests) assigned to projects, number of parties needed for a match, and preferences of each party for making a match. These considerations are discussed in further detail in Marketplace Protocols section.



To support both the value-based selection of projects and transparency of the process, it will be necessary to prioritize projects efficiently and offer project management support to principal investigators.

There are limited resources for use of ISS so therefore it would be necessary for the NPO to perform capacity planning for ISS increments, which are the 6-month cycles that match the crew rotations. Capacity planning enables the NPO to be aware of the capacity constraints for each increment to the extent that they impact the process. This information forms a baseline parameter for the prioritization process for a particular increment and more further described in the NPO and NASA Interface Section. Subsequently, projects are prioritized by determining the potential value of each project considered for a given increment by using defined value criteria. The prioritization process is discussed in further detail in Valuation and Project Prioritization Section.

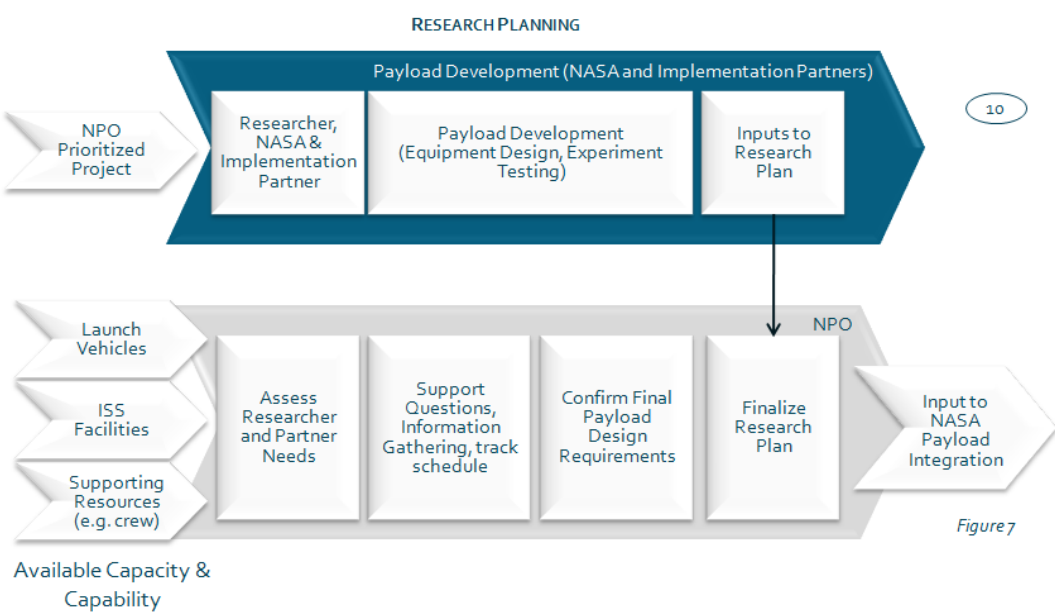
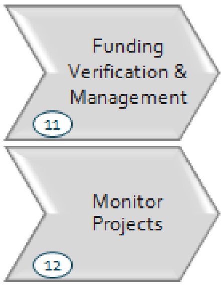


Figure 7

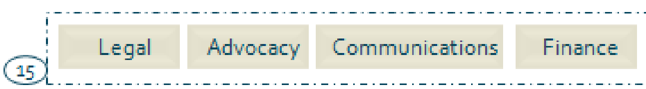
Projects that are selected for a particular increment on ISS design and develop experiments that are suitable to the ISS environment. The NPO Project Support capability is designed to help identify implementation partners to provide payload development and integration services should they not have in-house capability for payload development. The final payload designs and requirements are then incorporated into the NPO's research plan provided to NASA. Following research planning, the NPO provides seamless relationship support to ensure that all parties have the information and resources required to meet the needs of the project.



After projects are selected for flight, the NPO would provide verification of funding and operational monitoring of milestone payments for matched projects as well as management of NPO funded projects until the project is successfully completed.

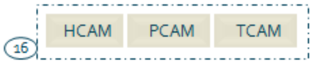
Once the project is complete, relationship management activities include follow-up with principal investigators to gather updates and progress of research findings. This serves to track market performance/results for input to the evaluation of value frames and NPO measures. NASA also maintains information on ISS research results for its purposes and can leverage NPO information if needed.

The business processes, up to this point, are about creating new knowledge. Advancing academic interest and publishing are about making information available and accessible to build the next generation of space-based researchers and encourage STEM education. Education oriented projects that utilize ISS capacity are managed like research projects. These education-oriented capabilities are focused on understanding the needs and interests of those who would use the insights and discoverings from ISS to further advance learning. This includes everything from on-line materials for teachers, interactive resources for K-12 students to publications of scientific findings. As with other capabilities, the NPO has been designed to leverage, not duplicate, well-functioning education programs or processes.



To enable the NPO operations, there are several support capabilities required including:

- **LEGAL** - provide the standard legal support necessary to support an enterprise, such as reviewing standard legal contracts and handling legal issues.
- **ADVOCACY** - serve as the process that manages the external relations with NPO constituencies. This includes management of speaking engagements, interaction with the media, and the strategies related to any other external communications that support the NPO's operations. This capability also manages the interface with the NPO's boards and committees.
- **COMMUNICATIONS** - execute communication strategies that have been developed.
- **FINANCE AND AUDIT** - manage all standard finance and audit functions such as developing and managing the budget, maintaining compliance, managing the NPO's investment portfolio and performing internal audits as necessary.



To ensure the model can obtain the needed assets to run the operations, several ***Asset Management*** capabilities have been designed including: human capital asset management (HCAM®), technology capital asset management (TCAM®) and physical capital asset management (PCAM®). The management of assets in this model deploys a lifecycle approach and links asset investments to value as well.

> *This is not a model that is designed to emulate something that exists – rather it is specifically designed to deliver the missing capabilities. This does not mean that nothing like this exists, however, it may exist in bits and pieces in many different places, but not all in one place configured specifically as designed here.*

Governance

One of the more significant challenges in the formulation of a new entity is the structure for governance. Unlike a government agency that reports to the Executive Branch for oversight, an enterprise such as this needs to be carefully constructed to ensure both effectiveness and accountability. In addition to the management challenges ahead, the ISS-NL constituencies and potential users of ISS-NL would seek immediate and strong leadership, making the initial selection of board members an imperative for setting the right tone to the public for what type of management and leadership the NPO would employ.

DESIGN OF A BOARD. The selection, design and structure of the board of directors (BOD) are leading success factors for the NPO. A board of directors that is of national stature is of top priority. The board is responsible for providing management advice, support for the fundraising needs as well as advocacy for the NPO. The board would be staffed with leading multi-disciplinary professionals to provide the coverage for a wide array of constituencies and scientific interests who could advocate and represent the interests of the NPO. The leadership of the board of directors would have an immediate and strong impact to the perception of the NPO by the many constituencies vying for the success of the ISS-NL.

There are many implications and methods for designing a board and governance structure for an enterprise. The method employed in this study was to analyze the leadership and governance requirements recommended to successfully achieve the objectives of the NPO and to interview and consider the advice of individuals who would be qualified to serve on a national stature board. We studied other nonprofit and for-profit boards to understand the strengths and weaknesses of those boards. The following are the areas studied for the NPO: board membership, board size, term limits, and committees, roles of the boards and committees and governance rules for the organization as a whole.

BOARD COMPOSITION. The NPO board of directors is comprised of members who could provide the management advice to the organization as well as scientific leaders who would support the scientific agenda of the ISS-NL. We describe the two groups of the boards as the managing members and scientific members of the board (Figure 8).

Figure 8

These two groups collectively decide on matters before the board. However, the members selected in these two groups are chosen for distinct purposes. The primary role of the managing members is to provide advocacy, fundraising and management advice. The scientific members lead the establishment of research pathways, guide the project selection and advance the academic interest and integrity of the NPO.

In order to support the wide array of constituencies and "coverage areas" needed for research and outreach, the managing and scientific board members would be comprised of scientific members from the industrial, government and academic sectors (Figure 9).

EX-OFFICIO MEMBERS. The government sector is represented by an ex officio group of members that provides management and scientific support. There are two groups of ex-officio members whose role is to select the initial board of directors and provide ongoing advice and counsel. The "Managing" ex-officio members are representatives of the government constituencies, Congress and the Administration. The suggested members are:

- The Chairman and ranking member of the Committee on Science and Technology or their designees;
- the Chairman and ranking minority member of the Committee on Commerce, Science and Transportation or their designees; and
- the NASA Administrator;

The scientific ex-officio members are the designees of the top ranking scientists from agencies most likely to use the ISS National Laboratory. Suggested members are: NIH, NIST, NSF, DOD, DOE and USDA. Refer to Appendix O - Ex-Officio Regulations.

- The National Institutes of Health (NIH);
- The National Institute of Standards and Technology (NIST);
- The National Science Foundation (NSF);
- The Department of Defense (DOD);
- The Department of Energy (DOE); and
- The Department of Agriculture (USDA).

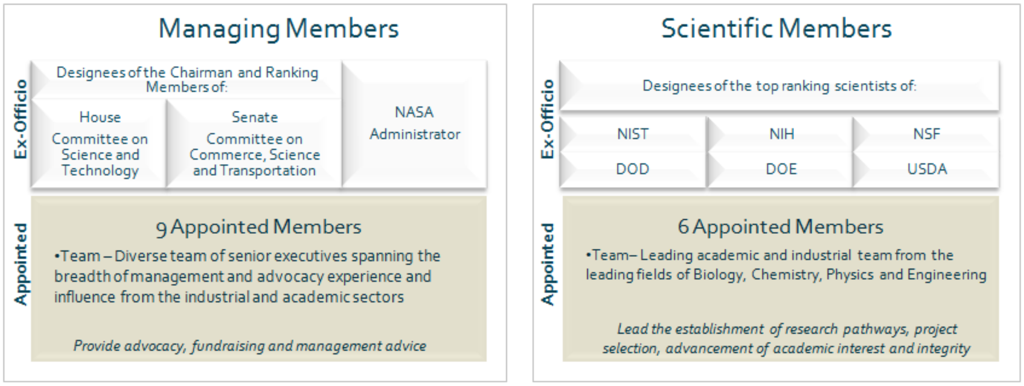


Figure 9

APPOINTED MEMBERS. The industrial and academic sectors are represented by an appointed group of members selected to provide coverage for the wide variety of constituencies and skills required to manage the board from a business and scientific management perspective.

The scientific members are comprised of members that span a range of scientific topics including:

- 2 from the field of biology with at least 1 from academe and 1 from commercial science development
- 1 from the field of engineering
- 1 from the field of general chemistry; and
- 2 from the field of physics with 1 from academe and 1 from commercial science development

COLLEGIUM. In order to manage the breadth of scientific support needed by the NPO, the scientific members form a committee to solicit and manage a network of science and technology professionals who are independent from the board. We have named this group the Science Collegium (see Figure 10). The collegium would be mentored by and collaborate with scientific BOD members to support research pathway development and the prioritization of research selected for the NPO. The collegium adds to the breadth of expertise, builds the knowledge base of the NPO, and provides a broader base of talent for project prioritization to avoid conflicts of interest.

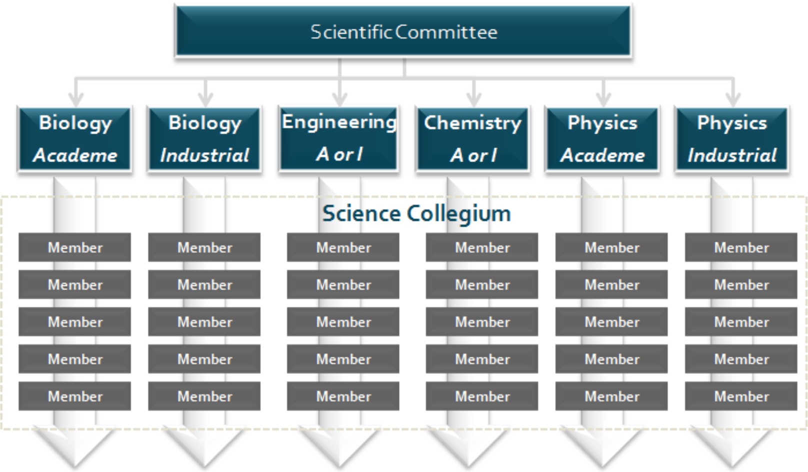


Figure 10

BOARD SIZE. The size of the board is a careful balance between the need for breadth of skill and manageability. We studied companies and other non-profits of varying size and configurations. After careful consideration of both the technical requirements and practical experience needed, the analysis resulted in a 15 member voting board, 6 of which comprise the Science Subcommittee.

INITIAL MEMBER SELECTION. Interviews with industry leaders and potential board candidates of national stature indicated that potential board member candidates prefer an official appointment for an assignment such as this. Other institutions whose board and governance structures were researched included the Smithsonian Board of Regents, the Foundation for the National Institutes of Health and the American Red Cross.

Since the ex-officio members of the board would be selected based on their governmental position, the selection of the initial appointed board members can be made by this group from a list of qualified candidates (Figure 11). A list must be carefully constructed with candidates that meet all of the technical requirements as a group (note: the right mix of skills is critically important when limiting the number of members). The list could be formulated by any credible source whose sole purpose is to ensure that the board has the highest caliber talent with the appropriate mix of skills. Given the Congressional representation on the ex officio board, the NASA Administrator in consultation with the Office of Science and Technology Policy could formulate this list to provide balanced participation in the process that includes the Executive branch.

Figure 11

BOARD MEMBER REQUIREMENTS. The appointed Managing and Scientific members will require traits such as high-performance, national stature, the ability to work in a team environment, professional maturity, and most importantly possessing passion for the purpose and focus of the NPO and the willingness to be actively engaged. Board members have a real role and will not be able to serve simply as figure heads.

- *Managing Members*. The appointed managing members include a diverse membership of senior executives that have the ability to provide management advice as well as advocacy amongst the wide range of NPO constituencies. Managing members, as a team, should have the ability to assist with fundraising for projects across all potential scientific disciplines and from various funding sources such as corporations, charities, venture capital and public sources of funding. The optimal mix of managing members will also possess the breadth of skills including experience such as: chief executive, space flight or aerospace, industrial R&D, university administration, non-profit management, financing or fundraising, and media/public relations.
- *Scientific Members*. The appointed scientific members should include leading scientists and experts selected to span the range of scientific disciplines of biology, chemistry, physics, and engineering with vision and breadth to lead the development of research pathways and identify and mentor the Collegium. Members should have the credentials and insight to advance the academic interest and integrity in space-based science as well as provide advocacy for the NPO among the federal agencies, industrial organizations, universities, and other academic organizations.

BOARD MEETINGS. Two to four BOD meetings are anticipated per year with an expectation for mandatory attendance. It has been suggested that the meetings should be centrally located for ease of travel.

TERMS AND LIMITS. Determining the appropriate number of years for a term limit is a function of the need to sustain the institutional knowledge of a board, maintain fresh perspectives, and to keep an engaged composition of board members. To accomplish this, the design includes a first term as is an initial period of twelve months. The initial term has a shorter time period which serves as a "trial period" for both new board members and the NPO. Then members would be eligible for 2 three-year renewable terms for a maximum term of 7 years. Should there could be circumstances where a losing a particular board member could be detrimental to the board, the bylaws may provide for an exception whereby the Chairperson could request that board member continue to serve on the board subject to approval through a unanimous vote from the board. In addition, the board will require a mechanism to remove ineffective members before term end. The term limits for the Ex Officio members are in accordance with the terms of their public role.

ON-GOING SELF-PERPETUATION. Following the initial selection, the appointed board members will subsequently renew membership through a self-perpetuating process and have the option to add or subtract membership as they deem necessary.

VOTING. The appointed members are the voting members of the BOD. Ex-officio members are not voting members but are invited to participate in board activities such as meetings and working groups to provide advice and counsel.

CONFLICTS OF INTEREST. A conflict of interest policy is incorporated in the governance plan. The NPO organization as designed required top professionals in fields closely related to the interests of the NPO and the ISS and therefore conflicts of interests could arise. A conflict of interest may exist when the interests or concerns of a board member are seen as competing with the interests or concerns of the organization in which they serve Appendix P - Conflict of Interest Policy.

BOARD COMPENSATION. The board members may receive compensation for service that includes reimbursement for travel or modest stipends. These compensation mechanisms would be offered, but not mandated. Many board members eligible to serve on the NPO board would have the means and passion to serve without the need or desire for compensation. Government agencies typically handle the costs of travel expenses for their employees who serve as ex-officio members.

BOARD FIDUCIARY RESPONSIBILITIES. The appointed members of the board have a fiduciary duty to the board. In general, the board members of the NPO are subject to common law fiduciary duties and whatever standards are federally mandated. Once the NPO is state chartered, the board members likely would be subject to the same general standards, with greater certainty to the extent provided by the corporate law of the state under whose corporate law the NPO would be incorporated. The fiduciary duties of a board are further described in Appendix N- Board Fiduciary Duties.

BYLAWS. The bylaws are designed to regulate the BOD operations and include rules for elections, organization finances, board incentives, duties, financial investments and responsibilities, meeting procedures and bylaw modification. The board would establish procedures for the receipt, retention and treatment of complaints that may be received by the organization regarding accounting, internal accounting controls or auditing matters. The bylaws, most importantly, provide the framework for a flexible governance structure.

SUBCOMMITTEES. There are several committees of the board, which provide an opportunity for board members to be engaged in their areas of interest where they are typically most effective, while providing a smaller forum of decision makers to execute focused topics. We described the scientific committee activities above (Science Collegium). Board members may serve on the committees per the bylaws and per their interests. The board could add or subtract committees as they are needed. For example, an education committee may be needed in the future to manage the education activities of the board. In addition to the Scientific Committee, the model includes four standard subcommittees.

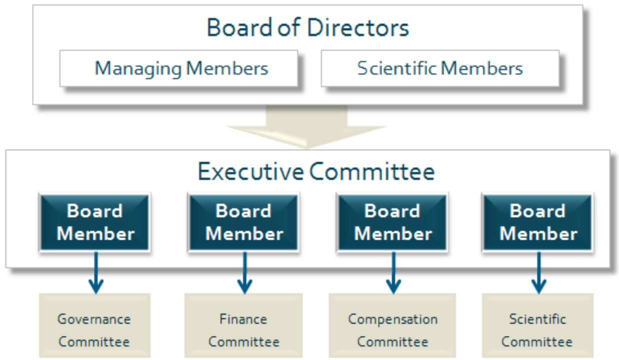


Figure 12

- *Executive Committee*. The chair of the board has the flexibility to select up to 4 board members to be part of an executive committee. The board members are the leads of the various committees (see Figure 12), which ensures that the activities of the subcommittees are coordinated and meet the goals, strategies and activities of the NPO.
- *Governance Committee*. A governance committee is a mechanism for the board to ensure that it is working within the best structure to be effective. The governance committee is "responsible for assessing the board's current composition and identifying needs, developing board member and officer job descriptions, creating a recruitment plan and timeline, identifying and cultivating prospective members",[17], while ensuring the governance structure of the board is effective towards meeting the NPO board's requirements.
- *Finance Committee*. The Finance committee ensures that the organization is operating in accordance with the law or applicable standards, but especially if the NPO hires an independent auditor to review its financial statements. Refer to Appendix R to review a more detailed description for audit committees.
- *Compensation Committee*. The compensation committee is formed to set the compensation standards for the board. The compensation committee ensures that the board members are compensated fairly and justly in accordance with IRS regulations, which require rates that are consistent with those of similar non-profit boards.

GOVERNANCE TRANSITION. The 2008 Authorization Act established a committee for the national laboratory uses of ISS (referred to as the ISS National Laboratory Committee - INLAC) as outlined below:

> According to the Authorization Act of 2008 "The Committee shall monitor, assess, and make recommendations regarding effective utilization of the ISS as a national laboratory and platform for research. The Committee shall submit to the Administrator, on an annual basis or more frequently as considered necessary by a majority of the members of the Committee, a report containing the assessments and recommendations".[18]

This committee would become part of the governance structure of the NPO as part of the natural transition of national laboratory activities to the NPO. NASA has recruited members for this group and formally approved the charter for the committee. The recruited members have not yet been formally invited to participate due to the undetermined future for ISS-NL management. Presently, the members of the committee are composed of organizations that have formal agreements with NASA to utilize the ISS per the 2008 legislation.

One of the needs for a de novo organization is the ability to obtain a Board of Directors with the right level national stature, skill mix, and accountability and an organization with the exact right mix of assets The BOD is critical to success, especially to a start-up. The model has taken great care in articulating the selection process for the initial BOD to ensure that it will attract the best talent.

Cultural Imperatives

In the ProOrbis® Method, culture and leadership play a critical role in organizational performance. ***Cultural Imperatives*** are the belief patterns that are absolutely required to execute the positioning and capabilities. A start-up organization offers an opportunity to create the culture that best fits the needs of the enterprise. There is a strong culture surrounding the current scientific industry and research communities, which calls for special attention to the selection of human capital and extended enterprise resources.

The analysis has identified two fundamental belief patterns that are required for the successful execution of the model:

1) the organization can create value and become self sustaining. The understanding that private sector sources of funds should be matched to projects and that it is inappropriate and unnecessary for the government to fund all things – a profound paradigm shift for some sectors.
2) the entire continuum of science is valued. The historical "struggle" between fundamental (pure science/basic research) and the practical application of research (applied/translational research) needs to be put aside in favor of a more comprehensive approach to research pathways – an inter-disciplinary approach.

Leaders are the stewards of culture and the imperatives are a critical screening factor for selection.

Organization Design

Organization in the ProOrbis® Method is a function of analysis and is designed to manage the work, resources and communications of the enterprise. Organizational structuring for many enterprises is driven by elements such as the power positions of managers, constraints of existing management talent, and the preferences of the chief executive. To support an organization design, just the internal maintenance, such as attending staff meetings, writing reports and making decisions, consumes vital human capital capacity. The design of an enterprise that yields high return on investment requires "tight fit" with the requirements of the capabilities including integration with the nature of the work and alignment with the cultural imperatives and rewards strategy.

The NPO has been modeled as a *de novo* organization. To add or attempt to embed the critical NPO capabilities into an existing organization could greatly increase the likelihood of added overhead, creation of complicated organizational "work arounds" to accommodate the existing structures, and conflicts of interest from competing missions. Furthermore, the probability that an existing team would exhibit the cultural imperatives needed for a successful execution is a significant risk consideration. In ProOrbis' experience with transforming organizations, there is a general tendency for established enterprises to add new work but reluctance to eliminate existing work. Changing culture is one of the most challenging activities of a transformation which could actually make setting up the special purpose NPO take less time and be more effective than attempting to modify an existing organization.

SCALING THE ORGANIZATION. The roles required to execute the NPO operations have been created to meet the best configuration of human capital needed to execute the capabilities and to keep staffing capacities at the optimal level. If there is a good fit between the role requirements and the skills and abilities of the staff the model should function as predicted.

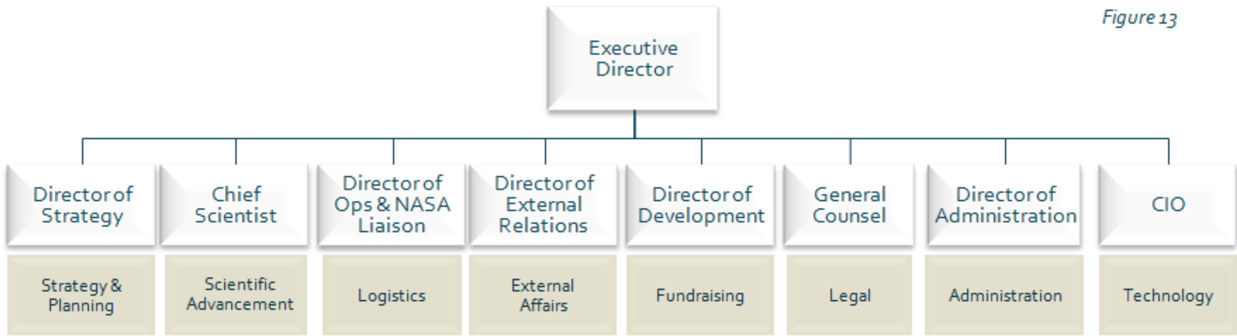
The organization size has been modeled to deliver to the demand anticipated for NPO activities from 2011-2020 assuming increases in staffing or budget that follow changes in user demand, ISS-NL capacity availability and external funding for NPO activities. The size and composition of the NPO organization are not understated as doing so would create a distortion of the investment with respect to the value created.

OUTSOURCING. Core and strategic activities are typically owned by the enterprise. Variable, non-core and/or complementary capabilities are more of a make/buy decision. Outsourced activities that reside in the extended enterprise are required to meet the performance criteria and be managed by internal staff. The time needed for management of outsourced services is included in the capacities in order to execute the model. There is further discussion on internal versus external resource needs in the Resourcing and Extended Enterprise Section.

ORGANIZATIONAL GROUPS. Groups within the organization manage the capabilities with clear and measurable accountabilities, which are assigned to group and individual roles in order to ensure the execution of the process and outcomes. The groups include a diverse set of skills and a breadth of disciplines (Figure 13) as follows:

- Strategy & Planning: economics, finance and science management
- Scientific Advancement: broad science stewardship of content and education
- Logistics: operations, logistics, engineering and relationship management
- External Affairs: marketing, event planning, and communication
- Fundraising: fundraising and grant management
- Legal: contract compliance and general legal
- Administration: HR, accounting, facilities management
- Technology: information technology and technology infrastructure management

Figure 13



LEADERSHIP ROLES. Each leadership role has direct accountabilities for their designated capabilities, to participate in other cross-organizational capabilities, and to collaborate within the organization. The following is a brief description of the role requirements for the senior positions:

- Executive Director: Professional with experience engaging with executive constituencies at the highest levels including branches of government with a technical or scientific background. This role is the primary interface with the board and NASA headquarters and manages the operations of the NPO. This is a high-profile role requiring executive presence and leadership.
- Chief Scientist: Senior and well respected scientist well versed in the scientific protocols of the space environment with the ability to formulate research pathways (science on a continuum) and enable multidisciplinary teams. This role manages the interface with the collegium, NASA ISS Program Scientist and manages the science agenda.
- Director of Strategy: Senior strategist with a business or commercial background, ideally in a product development organization of a large R&D company or other commercial organization. This role requires the ability to understand the continuum for scientific discoveries and what research pathways best create value.
- Director of Operations: An engineer with management experience in space operations or logistics. This role is the critical interface with the NASA ISS program office.
- Director of External Affairs: Knowledgeable and well respected externally facing executive with an insight into the constituencies and issues facing the NPO with a command of media and other aspects of communications. This is the prime advocacy and outreach role and would interface with communications and other third parties.
- The Director of Development: Well seasoned, development executive with a proven fundraising track-record and established contacts in the industry to solicit sources of funding.
- General Counsel: Credentialed attorney with ability to conduct legal strategies and manage external counsel on key matters of IP; conduct negotiation and manage agreements.
- Director of Administration: Broad and comprehensive experience managing a small to medium size organization's assets including finance.
- Chief Information Officer: Skilled and experienced information technology professional with the ability to manage the diverse technology needs of the NPO.

Roles include the cultural and critical skills requirements. Culture and enabling competencies are frequently the reason for poor fit and poor performance of an individual, as much as an absence of a job skill.

ENABLING SKILLS. The human capital required to execute the NPO's roles must possess *enabling* skills in addition to the core skills identified above as well as the appropriate cultural fit and leadership skills. There is an interdependency of the roles designed to execute the mission and therefore success is only assured through proper mix of skills and collaboration. Enabling competencies support the breadth of disciplines working together to a common purpose and include:

- Vision: The ability to "see" the future of the NPO in the broader context of creating a long-lived investment for the advancement of science in space and the ability to turn that vision into actionable strategies.
- Disciplined Execution: The ability to execute to value with rigor, speed and precision.
- Innovation: The ability to turn ideas into actionable outcomes.
- Mission Accountability: The ability to apply the individual disciplinary skill to the mission outcomes.
- Collaboration: The ability to execute one's role and to work with others to achieve a mutual goal.
- Driving Change: The ability to see change as less risky of an alternative to the status quo and to drive action to make change.
- Value Orientation: The ability to make decisions in the value context defined in this report.

COMMUNICATIONS. This design leverages existing assets from other organizations to avoid duplication of those assets. Due to the interdependency of the roles and leverage of the extended enterprise, the NPO will require robust communication protocols to enable a seamless operation.

Membership and Advocacy Committees

In order to manage the diverse memberships and constituencies effectively, they have been organized and assigned to the leadership team as follows (see Figure 14):

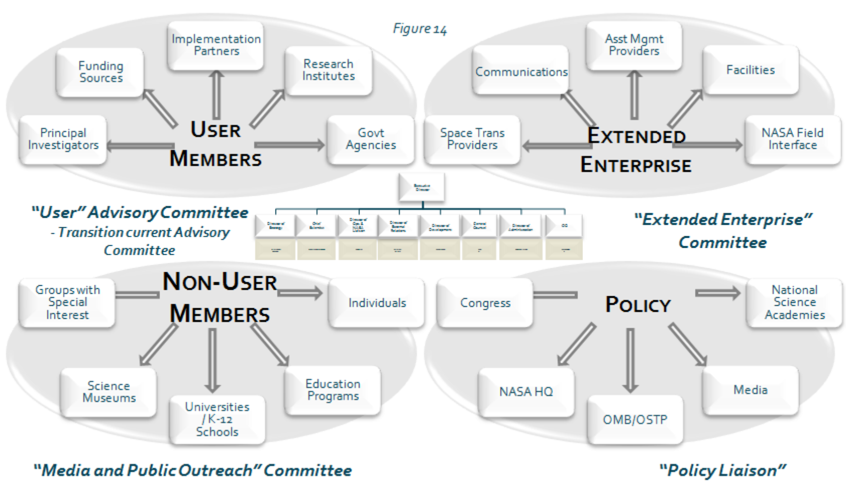


Figure 14

- "User" Advisory Committee: Group of individuals who are members of the NPO for the purposes of sending research or education projects to ISS. This group would take on the role of the legislated INLAC committee, described in the Governance Section, as this group would be comprised of organizations that utilize the ISS. This committee is managed by the Director of Strategy.

- Media and Outreach Committee: Group of individuals who are members of the NPO other than for direct use of ISS-NL such as groups with special interest, science museums, universities, K-12 schools, and education programs. This group is managed by the Director of External Affairs.
- Extended Enterprise Group: Group of individuals who participate with the NPO as a partner that provides products or services such as: communications, technology providers, facilities management, the NASA field interface, and relationships with space transportation providers. This group is managed by the Director of Operations.
- Policy Liaison: Group of external constituencies that have an interest in the ISS, NPO activities and science in space. These groups include: Congress, NASA headquarters, OMB/OSTP, Media and the National Science Academies. This group is managed by the Executive Director.

The design of the organization is very lean and specifically purposed which is reflected in the budget for operations. Specially purposed organizations can be designed to execute sets of capabilities very efficiently. Repurposing an existing organization introduces risks of non-value added overhead cost, conflicted interests, mismatched assets (human, technology or physical capital) and ingrained problematic cultural patterns which may seriously impair performance.

Detailed Capabilities Descriptions

Because of the design innovation in this model, certain capabilities were selected to be developed in more detail to ensure both operability and to identify the nuances of execution. The following sections describe these capabilities: Research Pathways, Valuation and Project Prioritization, Marketplace Protocols, Intellectual Property Protocols and Master Agreements, and the NPO and NASA Interface.

Research Pathways

Specific Value Propositions

Using the scientific advantages, we examined some of the specific potential uses of ISS and the ways in which they create value:

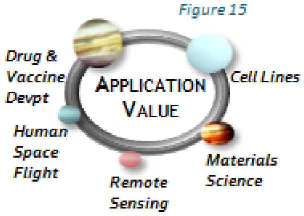
- The ISS is a unique research environment that offers microgravity, a spectrum of extreme conditions and a vantage in low Earth orbit. It enables advances in our understanding of basic physics, chemistry and biology in microgravity.
- The ISS could accelerate R&D cycle time through new insights that are not achievable on Earth.
- The ISS could enhance the stock of human capital (e.g. collective knowledge and skills) in the U.S. by creating opportunities to lead in new advances in science and to inspire the next generation of scientists and engineers.

The research that could be conducted on the ISS-NL also supports the scientific research priorities set by the President's national space policy issued on June 28, 2010 and further supported by the memorandum issued by the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP) issued on July 21, 2010. The memorandum lists a number of research challenges that could be addressed by the ISS-NL supported research including:

- "Support research to establish the foundations for a 21st century "bio-economy." Advances in biotechnology and improvements in our ability to design biological systems have the potential to address critical national needs in agriculture, energy, health, and the environment.
- Prioritize research investments in technologies that have the potential to accelerate the pace of discovery in the life sciences, especially imaging, bioinformatics, and high-throughput biology.
- Prioritize investments to reduce the time needed to develop vaccines for future pandemics, consistent with the President's Council of Advisors on Science and Technology's recommendations on Influenza Vaccinology.
- Prioritize investments in the research and development of clean energy technologies, especially solar energy, next-generation biofuels, and sustainable green buildings and building retrofit technologies.
- Support investments in chemical and biological agent defenses with an interagency effort to improve the Nation's ability to defend against the use of high-threat agents as weapons." [19]

The following is a summary of the opportunities for the applications identified (Figure 15) based on the implications of findings to date and possibilities for significant outcomes, which demonstrates that objective, fact-based value propositions for research can also support national policy.

Figure 15



VACCINE DEVELOPMENT. As discussed before, space provides a new platform for discovery in vaccine research. The microgravity environment facilitates an array of alterations in microbial gene expression which have been linked to pathogenicity of some bacteria. By examining the differences in gene expression of microbes grown in microgravity relative to the 1g environment of Earth, it is possible to identify the genes important for infection of the host. This platform for discovery can uncover and accelerate new targets in organisms which can lead to the successful development of new vaccines or therapeutics based on novel information on pathways for a microbe to interact and infect its host. The research happening in this area is both basic research to understand the fundamental mechanisms at work and it is translational research aimed at creating new vaccines.

DRUG DESIGN. Space may provide a new platform for discovery in drug design research. The microgravity environment facilitates better macromolecular crystal growth than is achievable on Earth with optimized conditions; the crystals have been grown larger and with higher quality. These higher quality crystals enable diffraction analysis or neutron analysis with greater resolution so that the structure of the protein or virus can be understood. A better, new, three-dimensional structure can lead to understanding of these structures could lead to an enhanced ability to target drugs very specifically which can minimize off-target side effects. Research possibilities include the development of accelerated vaccines or therapeutic development protocols which could be used to address issues such as pandemic illness.

CELL LINES. Microgravity simulations in bioreactors have shown that some types of cells will replicate rather than differentiate. This discovery opens up compelling possibilities in the area of stem cell production. For example, in plants, the replication of undifferentiated plant parenchyma on orbit could result in the ability to manufacture large numbers of cells (one cell = one plant) of endangered species, specimen plants and the replication of new varieties produced on orbit. Earth based bioreactors provide some aspects of weightlessness but cannot duplicate all components of weightlessness. If primordial (undifferentiated parenchyma) can replicate en masse much like single celled bacteria, this can provide an unlimited supply of single cells that can become plants. It has also been shown that cells exhibit large changes in gene expression as many genes are observed to be up or down regulated in their expression. This altered gene expression may allow for the development of customized plants to suit environments considered hostile and to increase production and quality of product. This could be achieved by exposing the cells with altered gene expression to stressing factors, which could encourage the change in characteristics desired. The acceleration of changes in plants could provide valuable survival tools for the future.

Gene expression of the stem cells in space compared to cultures in bioreactors and traditional culture can be influenced by exposure to stressing factors such as cold, heat, humidity, salinity, acidity and other factors to better understand mechanisms of differentiation. Insights into stem cells for space could be relevant to the whole range of potential applications from genetic engineering to treatment of disease. Research possibilities include the formulation of accelerated cultivar development protocols for plants that can be adapted to various environmental conditions.

MATERIALS SCIENCE. ISS provides a platform to expose materials to the extreme conditions of space in order to develop new materials for use in satellites and other spacecraft. This platform allows for the testing of combined environments at one time. The testing conditions include exposure to extreme heat and cold cycling, ultra-vacuum, atomic oxygen, and exposure to various sources of high energy radiation. It enables the testing of out-gassing of a material which can occur in vacuum environments and can be harmful to optics and other sensors on space assets. It also allows for exposure to ultraviolet light and atomic oxygen which is very corrosive and limits the lifespan of space assets. This testing should be completed on a platform like ISS because these materials need to be studied in detail. Testing and qualification of materials exposed to these extreme conditions has provided data to enable the manufacturing of long-lived, reliable spacecraft and satellite components.

The ISS also provides a platform for the study of materials which lead to innovative applications of materials for use on Earth. The lack of gravity leads to an absence of thermal convection, sedimentation, buoyancy, hydrostatic pressure and the gradients inherent in these one-G phenomena. It also reveals other mechanisms which would not be apparent under one-G conditions, such as Marangoni and capillary forces. Finally, it allows the measurement of critical thermo-physical properties that cannot be measured under one-G conditions. ISS allows experiments with control over a parameter of gravity which could never be previously controlled. The growth of benchmark materials and the testing of thermo physical properties occur as a result. This research has lead to improved alloys of high-strength glassy metal materials which are now being used in consumer electronics applications. Research possibilities include thermo-physical properties measurement that could be used to address issues in metals, ceramics, electronic and electro-optic materials, such as optimizing alloy properties to produce superior characteristics.

REMOTE SENSING. Orbiting platforms provide an excellent vantage point for many types of study of the Earth such as meteorological, geological and oceanographic. The ISS position in low Earth orbit provides improved spatial resolution, but also variable lighting conditions compared to sun-synchronous orbits of typical Earth remote sensing satellites. The ISS can be a valuable platform to test advanced sensor technologies due to its vantage point and resource support as a crewed station. Research possibilities include the development of a hyper-spectral sensor suite that could enable advances in environmental monitoring, geologic exploration and mining, urban and regional planning, or oceanographic measurements.

HUMAN SPACE FLIGHT – NON NASA. Exposure of humans to the reduced gravity environment of space accelerates some changes in the body, including bone loss, muscle wasting and balance disorders. This provides the unique opportunity to take advantage of microgravity conditions as a screening test for therapeutics with applications in both space and on Earth. This was part of the strategy used by Amgen to test its anti-bone wasting drug Prolia™ (denosumab), which was approved by the FDA in June 2010 to treat patients at risk for osteoporosis. The NPO would not have a biomedical research pathway for human performance in space, but the value of this NASA research could be maximized by coordination of research synergies for other applications.

There is clearly interest and support amongst potential users including major firms, principal investigators, academic institutions, and government agencies for exploring research and development opportunities in space. However, because of the nature of the findings to date, scientists involved in the study have had a wide range of perspectives on both the findings and their implications. The general consensus is that ISS offers unique opportunities to explore a new frontier of science and significant value can be gained, but that certain missing capabilities are needed to take advantage of these opportunities.

Research Pathways

Basic scientific research is often thought of as being separate and distinct from applied or industrial research. However, basic research can be considered more like an early step in a continuum which leads to value in the form of a new product or service application. Our studies have illustrated the rift that sometimes exists between more fundamental scientists who view commercial activity as a bit "unseemly and ignoble" and industrial researchers who feel that basic research activity is more like a "hobby" and disconnected from the "real world". Although it is always dangerous to over generalize, in the extreme, the applied researcher only cares *that* something happens, not necessarily *why*. The basic scientist is interested in *why* something happens, but less in *what* it would be useful for when applied.

In *Life and Physical Sciences Research for a New Era of Space Exploration: An Interim Report* written by the Committee for the Decadal Survey on Biological and Physical Sciences in Space, they discuss the circular link between basic research and translational and applied research. In this model, the relationship of the research stages from theory to the development of applications that create value is termed a *research pathway*.

MAXIMIZING ISS UTILIZATION. A "pathway view" of research is critical to the effective use of the ISS because it's a relatively expensive laboratory environment with a limited lifetime, resources and accessibility. Because of these limits it is imperative to focus on research that can maximize value in the most efficient way possible. Value maximization can be done by identifying the pathways to potential value for the various areas of research for which the ISS is well suited. By identifying the value and the components of value on each pathway it is possible to select the research with the greatest potential value for using these limited resources.

CONCEPTUAL MODEL. Figure 16 depicts the high-level conceptual relationships of research steps on a pathway which include:

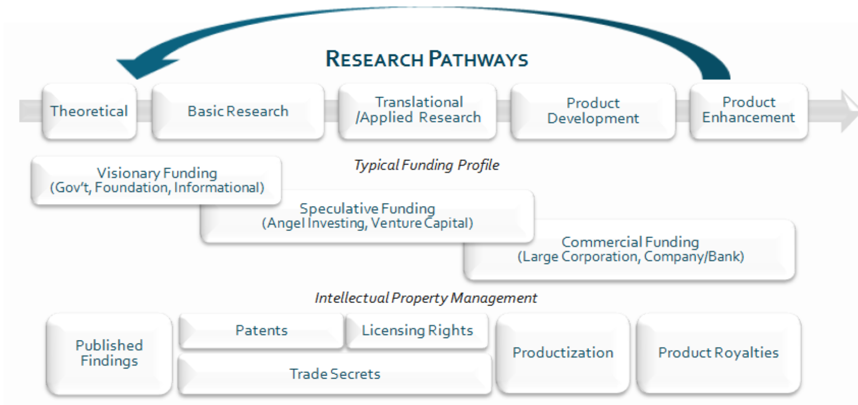


Figure 16

1. Theoretical: A theory is developed with which to develop a hypothesis and design an experiment
2. Basic Research: Ground based and space based research is conducted to verify the hypothesis.
3. Translational/Applied Research: Further research is conducted to apply these findings to a valuable use on Earth or in space.
4. Product Development: A new product is developed using the applied research
5. Product Enhancement: The product is refined through further testing and improvements

*Late stage enhancements can generate discoveries that may indicate the need for more basic research.

Each stage is associated with a typical funding profile and an intellectual property strategy which are essential to understanding how projects are funded throughout the pathway. Although not all pathways will be complete or developed by starting at the beginning, the following is a characterization of a very simple, new pathway.

THEORETICAL AND BASIC RESEARCH. The pathway starts with a new theory (such as a hypothesis on the behavior of cells or molecules). Basic ground-based research can help to better understanding the theory and the substances to be tested on orbit. Ground based research includes analyses of the equipment needed to successfully execute the experiment on orbit. This could involve the development of new equipment or the study of how the substances behave in existing (flight certified) equipment in order to minimize the risk of issues arising on ISS. The next stage is space-based basic research which in many cases may take several rounds of experiments to establish the proof on concept and to refine the theory.

TRANSLATIONAL / APPLIED RESEARCH. The pathway then moves into the applied or translational stages of research that may also consist of ground-based and space-based research. These stages of research aim to prove a concept concerning the use of on-orbit facilities to enable discovery or production of valuable knowledge or materials that can then be translated into valuable products or services.

PRODUCT DEVELOPMENT AND ENHANCEMENT. If the applied or translational research is successful, the pathway moves into the product development stage that could be ground-based, space-based or both. This stage could also take place on private space platforms in the future if they become available as some entrepreneurs suggest. This is where the value is realized as new products or services. Once products are launched, ISS can be used as a testing platform to enhance product performance.

There have been projects conducted in low Earth orbit in every stage of a research pathway, but not all of the steps of each project's pathway have been completed. There are a myriad of findings in which we know that things happen but not why. A key capability of this new entity is to manage the research pathways for a broad range of science conducted in low Earth orbit by leveraging the portfolio of completed research, formulating pathway options, and leading the coordination of the science community in the design and consideration of projects for the future.

Figure 17 graphically depicts a more likely scenario whereby basic research understandings open up several opportunities for market applications. Projects can enter the process in any phase of a pathway. Later stage projects may produce findings that lack theoretical underpinnings, which may lead to only one application. By going back and conducting more basic and theoretical research, additional opportunities for market applications may be opened.

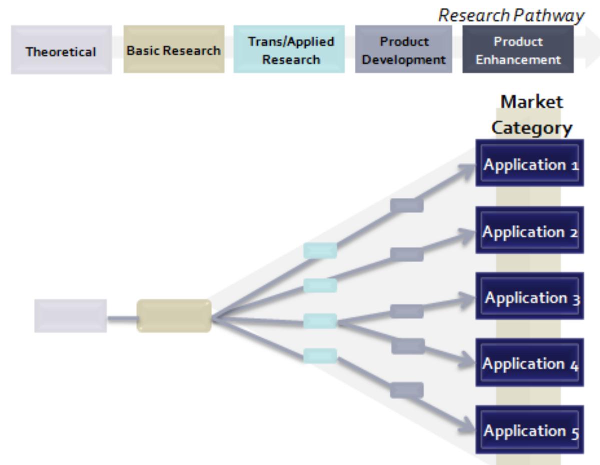


Figure 17

Because proposed projects could be at any point in the research pathway, the process is designed to determine where a project is and to build out the pathways around it to determine its value potential.

As discussed in the NPO Operations – Functional Description Section, projects can also be solicited by the NPO to "fill in" research pathways, especially in the theoretical and basic research categories. In this way, grant funding that is made available through the NPO "opens up" research pathways, which creates more targeted government investments in basic science that is designed to bridge a pathway to later stages that are more suitable for private funding.

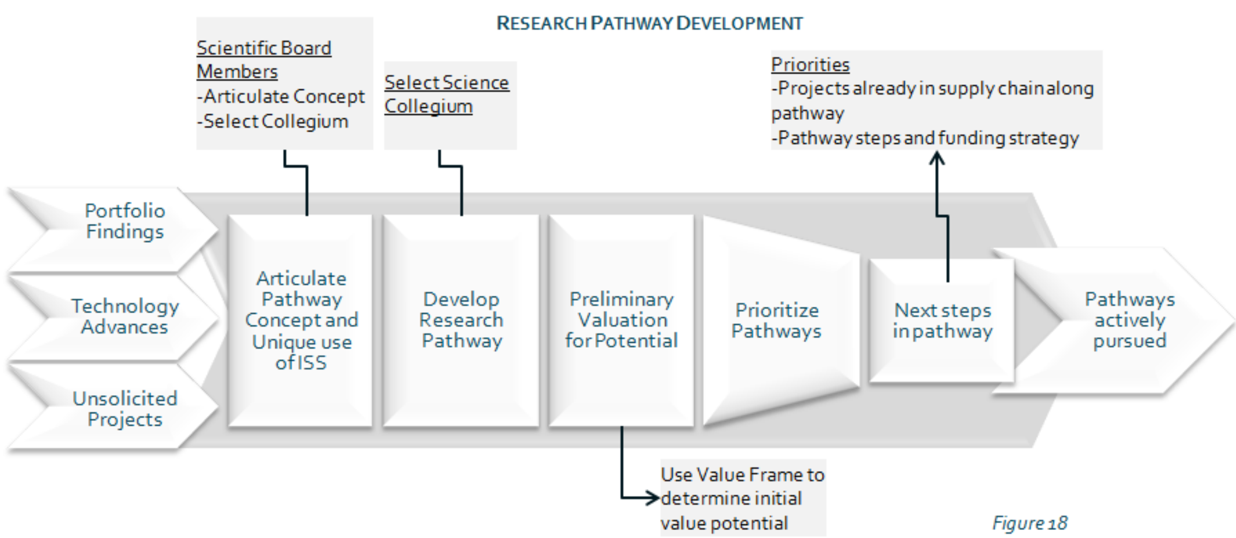


Figure 18

Research Pathway Development. Figure 18 above shows the steps by which pathways are created and used. The steps are:

1. Initiation from a new finding, new idea, or new project proposal.
2. Scientific board members perform an initial articulation of a possible pathway and determine the expertise needed from the group of scientific experts ("science collegium", further described in Governance) to create the details of the pathway.
3. The science collegium members develop the steps and details for the pathway including options, risks, uncertainties and timing.
4. A preliminary valuation of the pathway is developed by NPO staff to determine its value potential and general resource requirements.
5. The new pathway is prioritized against other pathways with consideration of a host of factors including the timing of resource use and value realization.
6. Strategies for completing a pathway are identified and plans are developed for pursuing projects along the pathway.

Research pathways are the key to valuing fundamental science. They put R&D projects in their "value context" and help to establish what we know, what we don't know and what it might be worth to know it. In this way, they provide the strategic frame for both building a more robust underpinning for applied research and the relevancy for basic research. Articulating what value could be derived from a discovery and formulating a pathway to that value creates the opportunity for more targeted investment that shortening the cycle time between discovery and practical application. Improving national returns on R&D investments and articulating the value created could lead to dramatic increases in funding for basic research and more efficient use of funds available.

Valuation and Project Prioritization

Value Dimensions

Grasping the full breadth of the value of research and development using the ISS requires the identification of a constituency for whom the value is being created. Shareholders are typically the beneficiaries of value creation in public, for-profit companies. In this analysis, we considered the value that could be realized by the American citizenry as a result of these activities and they serve as the shareholders in our analytical frame. Although the value achieved could benefit the world at large, we considered the value propositions from the perspective of global impact to U.S. interests. This model employs a sophisticated, comprehensive, fact-based valuation frame.

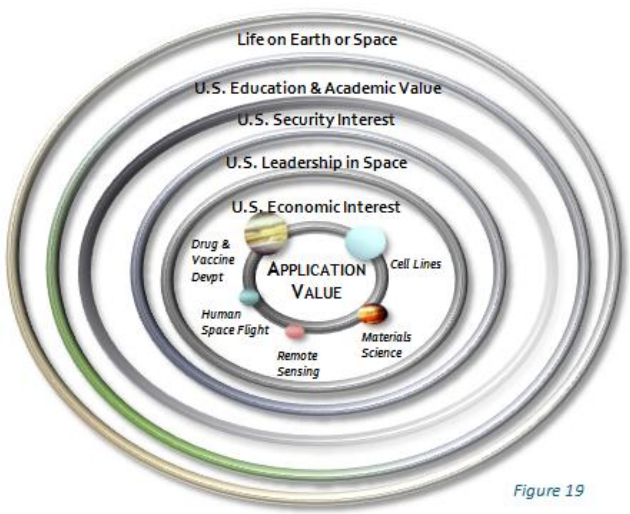


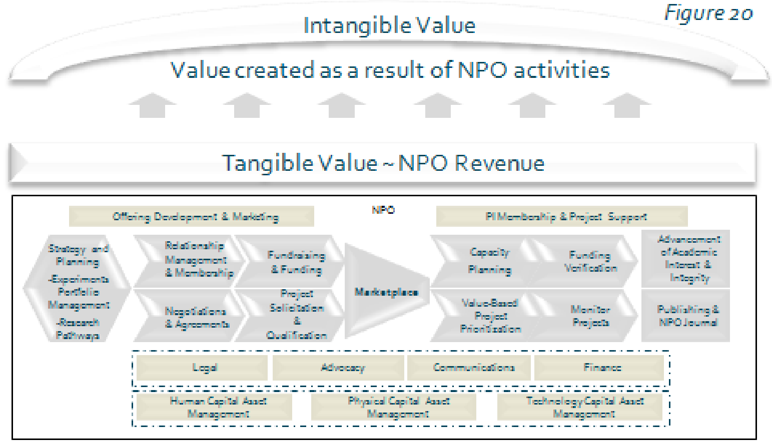
Figure 19

Tangible & Intangible Value. For the purpose of this analysis, we will use the terms tangible and intangible value. In the ProOrbis ® Method, tangible value generally refers to the direct value created by the enterprise. A simple and direct way to measure this is in the form of revenue. In general, the term "intangible value" refers to value created by the entity that does not flow "through" the entity – in other words value that is not received directly by an entity.

Intangible value is the additional or collateral value the activities of the enterprise creates such has improving human life or health, creating interesting and meaningful work for employees, or helping to improve the environment. Note that intangible value is not incalculable or "feel good" value. Intangible value (in general) builds on practical applications, expanding the value equations (see Figure 19), and considers factors well beyond just commercial value. The value is the throughput of the supply chain.

Whether benefit is tangible or intangible is *not* a function of the ability to measure it, but rather is a matter of what is considered value created "inside" and "outside" of the organization (Figure 20). Intangible benefits are not incalculable; they are just not always realized directly as value by the organization that created them (especially in standard accounting statements).

Figure 20



The broad consensus is that the ISS creates significant intangible value, but the definition of this value varies widely. Generally the intangible value of ISS is thought of in terms of international cooperative achievement, the engineering feat of its construction or its use for STEM education. In this analysis, dimensionalizing how utilization of ISS can create value is the first step to understanding how to maximize that value. Value considerations include:

Life on Earth or Space. Advances in science and technology are ultimately about changing the experience of life. Innovations can impact humans, animals, plants, climate, and resources now or in the future (the value of sustainability). Value estimates can include factors such as fewer deaths, fewer sicknesses, healthier livestock, a more abundant food supply, the protection of endangered plant or animal species, reduction in pollution, etc. The question of value can become more esoteric or aesthetic (what is it worth to live a healthier life?) but to a sovereign nation, this usually is more readily and reliably measured in economic terms.

U.S. Education and Economic Advancement. Undeniably, one of the most valuable assets of a nation is its human capital. Although natural resources, infrastructure, industrial base, etc are all important to a nation's wealth, one of the leading indicators of the standard of living in a country is the productivity of its people. In the ProOrbis® Method, human capital, as an asset, is not people. People are the owners of their human capital and invest it themselves – in work, raising families, volunteering for charities – all productive activities for a nation. Investments in education are like any other investment. They are designed to generate return and this is measured in a concept known as human capital stock. The stock of human capital for a company is the sum total of the investment people make in their work. For a country, the stock of human capital is the sum total of the productive capability of its people.

Education is an important factor in building human capital stocks. Over the past several decades, there has been a growing concern about the performance of Americans in science, technology, engineering and math (STEM). This has been reflected in the Administration's most recent "Educate to Innovate" initiative in which the President set forth a most ambitious objective of moving from a national ranking of number 21 in the world to number 1 in STEM education.

Space assets (and ISS in particular) are valuable assets in the inspiration of future generations of Americans to study core science, technology, engineering and mathematics (STEM) subjects and to become global leaders and innovators. Intangible value is created by projects when the interest of students in studying STEM subjects is increased or when the projects enhance a student's understanding of a technical subject.

Advances in science can improve university level science curriculums which would prepare the U.S. workforce to lead in space-based science and space exploration. As the ISS research capacity is increased and space-based commerce increases, it will be vital for the United States to have a workforce that allows the nation to capitalize on these new opportunities.

A quality education in STEM can help satisfy future science and technology needs by creating a larger pool of a diverse scientific talent. Research projects develop scientists (the ultimate "on the job" training) for both industrial and university roles. Publishing scientific advances enables for more rapid developments in science by allowing researchers to build on each other's work and provides content for educational curricula.

U.S. Economic Interests. The national interest in innovation is rooted in the advances that can be made in products and services. New medicines, vaccines, materials, information, and services benefit both the companies that offer them and the consumers that purchase them. These improvements are measured in terms of GDP, additional jobs, productivity and thereby in the increased tax revenue generated from those activities. Improvements can also decrease government spending (i.e. better vaccines can lead to lower healthcare costs). A healthy economy and population are key objectives for government.

U.S. Security Interests. Low Earth orbit is an important strategic frontier. The U.S. presence on ISS provides the opportunity to understand the conditions of this environment and to ensure we remain competitive with other nations including considerations of the defensive implications of the capability to operate in low Earth orbit and the impact of ISS R&D advances on the nation's ability to avoid or mitigate aggression or destruction. This requires a host of value parameters including clear articulation of the desired result, the comparative cost of ground-based alternatives (if any), and the impact of the result on the mission interests.

U.S. Leadership in Space. U.S. leadership in space has been a consistent objective for the U.S. government however the value of this objective has not been consistently articulated. If space exploration activities result in advances in materials, technology, human health, etc. then the impact would be noted as U.S. economic interests. To the extent that the U.S is falling behind other countries such that a national security interest is compromised, or we are avoiding a natural disaster (such as an asteroid strike), the investment and value would considered in the national security frame.

Exploration of space is a different matter. To the extent that there is a national interest in pursuing other planets for humans to inhabit, tapping resources, or other expansions of our world, then knowledge that will enhance space exploration such as: 1) improvements to the design of spacecraft, 2) mitigation of the effects of microgravity or radiation on humans, and 3) advancements in the understanding required to develop replenishable food sources in space would have mission-oriented value.

ESOTERIC VALUE. The values described support the fact-based frame used in this model. However, the discussion of value would not be complete without addressing value in a normative context. The *application* of science begs the questions:

- Does basic knowledge of science enhance the human experience, even if it never changes anything?
- Is science valuable if never applied?
- If you never do anything with it, does just knowing it have value?

This would be more akin to the aesthetic style of argument with which this section began. There is a value to an individual of being healthy – regardless of the value of their improved productivity. Science could be valued like art, music or literature. Beautiful and worthy just as a thought; something that feeds the human soul in some way. This too could be valued. The implications are more complex, but not inestimable. This model does not include this dimension in order to avoid the need for opinions or judgments of value, which would require a more normative frame.

Dimensionalizing value helps to establish the fact-based frame of reference for defining, delimiting and ultimately quantifying value. Intangible value is not "indescribable or unquantifiable", rather it is value that is not realized directly by the entity that created it. Nor is it subjective value, which is an individual assessment of a project against criteria. Intangible value may require an estimate, but that is not the same as a subjective assessment. We have also not included a normative value frame for esoteric value as it requires the establishment of "good" science, regardless of its practical uses, which is not an objective contained in any of the policy guidance we referenced.

Building fact-based frames for considering intangible value is one of the most challenging and important technical capabilities of the NPO required for both achieving transparent prioritization and measurable ROI.

Project Prioritization

Prioritization in this model relies on sophisticated measures of intangible value. Projects are evaluated and articulated within the same valuation frame, whether they are on an established research pathway or unsolicited, thereby creating a mechanism for evaluating a diverse portfolio of projects.

ASSIGNING INTANGIBLE VALUES AND AVOIDING CONFLICTS OF INTEREST. Project valuations take into account the five identified intangible value categories. However, because projects could have different value propositions they may not all have value, nor need to have value, in each of the categories. NPO staff will perform analyses for each project to determine the total value which is a quantitative sum; generally a dollar value. Value ranges are determined using data and statistics from credible sources, estimates from experts and are adjusted for factors such as risk and timing. Because this frame is fact-based, rather than normative, it is more difficult for subjective biases to contaminate the analysis. Further, the scientific board members, scientific collegium, and NPO staff form a unique team for each group of projects to be prioritized, further diminishing the tendency toward bias that could be present with a single, standing prioritization team.

ALLOCATION METHOD. This model does not require an allocation method that would assign percentages of resources to certain disciplines or research stages (e.g. 20% for basic science). Allocations based on science discipline, research stage or research institution restricts the maximization of value because value is limited to each allocation category rather than allowing for the highest value projects to be selected overall. In the absence of a value frame, a more normative frame which would include policy-based priorities, special allocations for more favored research, or any other special interests would be needed. This study finds that agencies that fund ISS research understand their mission interests very well and there is no reason to believe these projects would not compete favorably in a value-based frame. However, it has been suggested that the principal investigators be engaged in the beginning of any solicitation, from the NPO or any other government agency, to ensure they recognize the importance of the full value frame within which their project will be evaluated so that they design their projects to generate the highest value.

SCORING SYSTEMS. This model does not employ a more traditional scoring system such as the five or ten point scale to select projects because that limits the ability to make distinctions between projects with very large differences in potential value. The NPO's valuation process serves as a "scoring system".

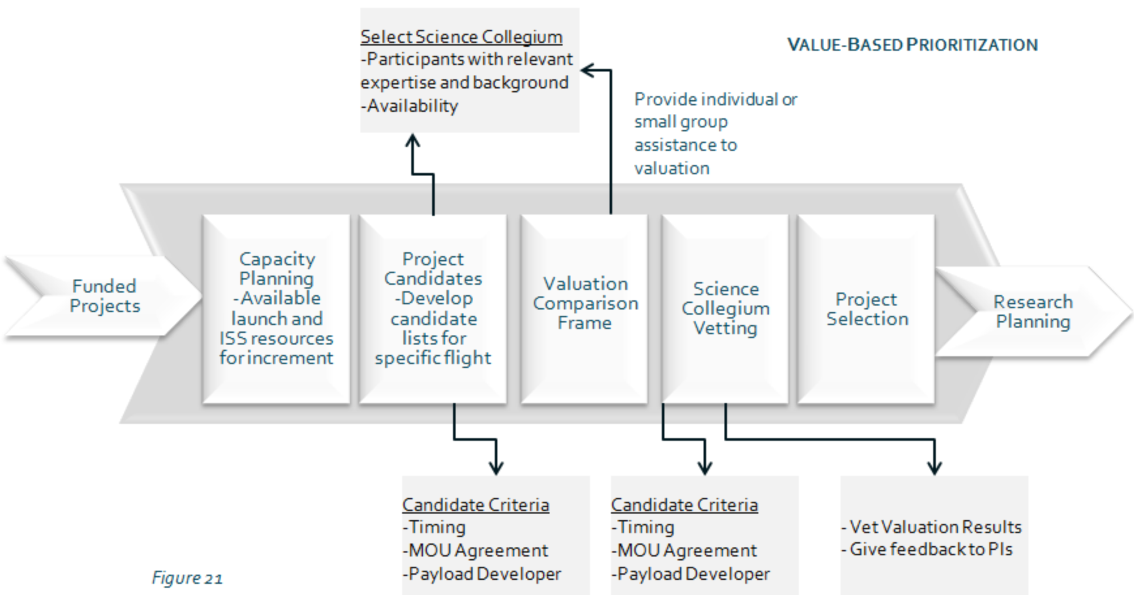


Figure 21

PROJECT PRIORITIZATION PROCESS. Figure 21 depicts the process designed for the NPO prioritization and selection of payloads. Projects with committed funds are eligible for prioritization. Based on capacity availability, a group of projects that meets certain criteria (such as project readiness for the given time increment) are grouped for prioritization. The participants from the Science Collegium and Board of Directors are selected based on the expertise needed to value and prioritize the given list of projects. The initial articulation of value is performed when projects initially enter the NPO (Project Solicitation and Qualification capability). Once projects enter the prioritization process, the valuations are upgraded and revised by the science collegium and NPO staff as necessary to ensure all applicable information is considered. Following the technical valuation, the portfolio of candidate projects is analyzed to determine a final list of project payloads for the increment. There may be certain criteria that are not valued using an economic calculation, but can be considered using other analytic techniques (such as value of human life).

The science collegium concept is, in effect, a peer review process; however it differs from a standard scientific and technical peer review process, which is typically required for the receipt of federal grant funding. The early stages of the NPO contemplate government funding, however, there are no apparent federal or NASA regulations that require standard peer-review for research in receipt of sub-grants.

Once decisions are made regarding prioritization and projects are selected for flight the researchers are then notified of the decision. The review team provides feedback to the researchers regarding how the priorities are determined and advises them on steps that could be taken to improve the value for projects, which could improve the probability of future selection. This feedback also enables the NPO to ensure that its process remains transparent.

PRIORITIZATION APPROACH. This model utilizes a tailored approach for soliciting, prioritizing and selecting projects. This process is based upon the selection of research that maximizes shareholder (American citizenry) value. In order to understand best practices in the selection of scientific projects to be funded, ProOrbis studied the processes of a number of major grant-funding institutions (see Appendix U). A key difference is that government organizations have research agendas set by agencies that determine national priorities for research and reflect the most urgent needs as perceived by policy-makers. The prioritization process modeled for the NPO identifies the highest value research pathways that can be pursued in the low Earth orbit environment. Specific government grant funding for projects can be tied to a particular objective and national research agendas may inform the value implications of topics, but no additional agenda should be required.

MODELING CONSIDERATIONS. The proprietary models built for establishing this valuation frame use established mathematical techniques of economics, operations research, and principles of finance (such as periodicity match, reliability or relevance) and are designed carefully to inform comparisons, which are the core of a prioritization decision. Building models that attempt to "boil the ocean" will usually result in an overload of information that impairs decision-making rather than informing it.

Value frames are not the same as numerical compilations of individual assessments, which are inherently subjective. Valuation may involve estimates (i.e. how much of a particular crop gets a particular disease and what are the chances a discovery will mitigate the disease), but that is different than a numerical rating of a subjective assessment (i.e. the intellectual merit of a proposal on a scale of 1-10). Subjective assessments rely on the opinion of experts to judge against criteria whereas fact-based frames require the articulation and dimensionalization of the value criteria and the components of investment. Fact-based frames are more often used when the organization is accountable for return on investment (ROI) and transparency. With proper structuring and feedback, these frames can be improved over time with experience and can be used to create higher value projects.

A broad value frame enables a more fact-based and transparent discussion of prioritization. This eliminates the need for a research agenda to be established based on anything other than value to the American citizenry. Fact-based frames both inform the structure of the research (since research projects can be designed to create more or less value) and the level of investment required to create that value. As the ISS is a relatively expensive asset to utilize, dimensionalizing value is critical to managing its use for ROI.

Marketplace Protocols

To create a pipeline of funded projects for prioritization, the model employs a marketplace capability. The purpose of the marketplace is to match R&D and STEM education projects with funding, creating a market mechanism to improve both efficiency and the success rate of funders and principal investigators. This capability enables the NPO to address the missing capability to fill and maintain a stable pipeline of projects for use of ISS-NL. We chose the name "marketplace" to signify a place (database) and opportunity (a market, by definition, is where parties may exchange) to create the best match between researchers' and funding sources' interests.

MEMBERSHIP. This capability requires standard frames and rules for marketplace participants to facilitate a more orderly and efficient process and create a more professional experience. To establish these guidelines, up front, the model has employed the concept of membership. Members of the marketplace would agree to the rules and only members could participate. Members would have a profile (both for projects and funding interests) and the marketplace would match their interests through management of data and creation of forums for interaction. The intellectual property considerations are complex and addressed in the Intellectual Property Protocols Section below.

Members are provided access to the details and interests of projects and funding sources. To the extent that there is confidential information that is beyond the scope required for matching potential parties, members would have the option to elect to keep certain information outside of the marketplace. The breadth and range of projects possible requires an equally wide range of potential funding sources that includes sponsors from the public and private sectors.

- Public sources include the federal government, state governments, public universities, and quasi-governmental organizations.
- Private sources include private foundations, private universities, venture funding, corporations and high net worth individuals/angel investors.

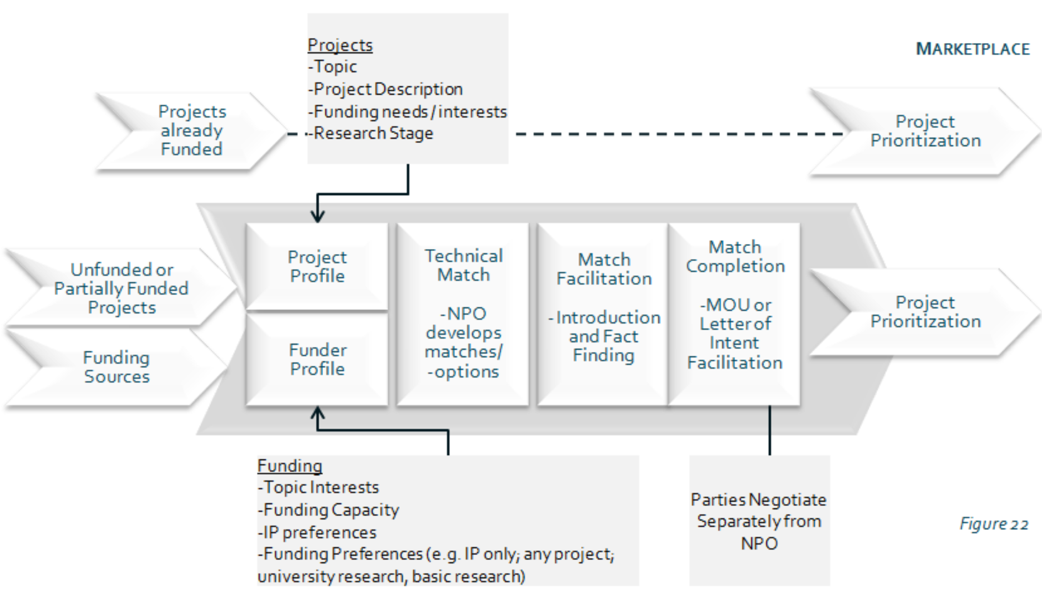


Figure 22

MARKETPLACE PROCESS. Both R&D and STEM education projects would enter the marketplace as unfunded and partially funded projects along with various funding sources (Figure 22). Projects that require funding are put into context of a research pathway to determine the nature of the appropriate funding (project profile). Technical matches are made upon review of the project profiles and funder profiles (e.g. funding source preferences, preferences for types of projects to fund). Parties are notified of the potential matches and meetings are facilitated by the NPO staff to. Parties wishing to pursue a partnership are required to formulate an MOU or letter of intent. This agreement indicates the parties' intent to meet the agreement obligations should the project be selected. Funded projects are placed on research pathways for the purpose of valuation and proceed directly to prioritization.

UNDERSTANDING FUNDING SOURCES AND PROJECTS TO FACILITATE MATCH. The baseline for understanding the potential match between a funding source and project is to understand the relationship between a research pathway and the typical funding sources. As discussed previously, research pathways typically consist of the following stages (described in time sequence): basic/theoretical research, proof of concept, translational research, product development and then product enhancement. A general rule to consider is that the earlier the research stage of the project, the higher the perceived risk by the funding source which in turn could result in a lower upfront monetary investment by the funding source (i.e., much of the perceived value may lead to larger back ended payments). Similarly, the later the research stage of the project, the lower the perceived risk to the funding source, thus a higher amount of initial investment could be expected.

Another way the research pathway stage comes into play is with regard to the type of funding sources that are potentially interested in funding the project. Generally, venture funds are more attracted to investing in projects that are further down the research pathway. For example, venture funds like to see that the research in a project has sufficiently developed so that a product or "lead compound" for the selected treatment regimen has been identified. Whereas the earlier stage research projects are generally funded by federal, state or private grants or private foundation monies for which the researcher likely applied.

INTELLECTUAL PROPERTY AND ROYALTY RATES. Another aspect of a match is the intellectual property expectations of a funding source or intellectual property attachments to a project imposed by previous funding sources. Intellectual property is further described in the Intellectual Property Protocols section below. Most funding sources expect a future return for their investment, such as a royalty fee, which is a charge that denotes payments in connection with the sale of products or services covered by an intellectual property agreement.

The royalty rates for an early stage project tend to be lower than the royalty rates for a later stage research project. Similarly, it is generally considered that a non-profit organization, such as a research institute or university, tends to receive a lower royalty rate than that received by a company, small or mid-sized. This trend likely tracks with the stage of the research pathway because universities and research institutes generally have projects in the earlier stages of research which equates to a higher risk profile, a longer time for a product to reach the market and larger capital requirements than if the product was further down the pathway to market.

Although surveys show royalty rates that are on average 5.66%, in practice royalty rates can be lowered to 2 - 4 % by the requirement for some limited clinical development prior to product development whereas the royalty rates can be lowered even further to 1 – 3% when full scale clinical development must be performed for proof of safety and effectiveness prior to marketing. These lower royalty rates can be expected even when most or all of the basic research and proof-of-concept work has been done by the licensor.

Non-profit organizations tend to secure royalty rates that are generally lower than for the industry as a whole. This may be reflective of the fact that non-profit organizations generally have earlier stage technology which also means a longer time to market with the need for higher amounts of funds to develop industrial R&D applications.

Further, the agreement between parties is a document in flux in which each agreed upon term affects other terms. For example, the royalty rate can be reduced below the normal rate if there have been additional payments made by the funding source during the licensing agreement, such as upfront fees, reimbursement for patent prosecution costs, milestone payments when specific events occur during the development of the product and possibly licensing fees. Thus, as some of these amounts increase, others decrease.

MATCHING. The NPO has an active role in the matching of parties and would facilitate the potential matches between owners of the projects and funding sources, but the parties negotiate the terms amongst themselves. Parties to an agreement typically have their own legal staff and processes for handling negotiations. For researchers who do not have access to legal support, the NPO could provide referrals to experienced external firms. If the NPO staff negotiated agreements for the parties, this would add a significant amount of additional staff and budget required to support this capability. Once a preliminary match is made, the parties then agree to a Memorandum of Understanding or Letter of Intent as a minimum threshold for a match in order to move to the prioritization process. The memorandum sets forth the goals of each of the parties in their negotiation. The parties would be encouraged to negotiate and establish an agreement in a timely manner in order to ensure their selected projects are prepared for the ground based-work research planning process, which has a long lead time prior to launch.

Projects may enter the marketplace as unfunded or partially funded. Fully-funded projects are simply profiled and move directly to prioritization. In all scenarios, the potential transactions between funding sources and researchers could be limited by prior intellectual property or economic attachments. Preliminary intellectual property information is gathered from the researchers as a baseline for matching. Fully funded projects do not need to be matched with a funding source and could be immediately eligible for the NPO's prioritization process if it meets the selection criteria for prioritization, such as the ability to meet the timeline to be ready for a scheduled increment. Partially funded and unfunded projects could be matched with one or multiple funding sources. Further, the matching potential between researchers and funding sponsors may be limited by the specific interests of funding sources such as whether a project is within a specific science discipline, has educational components, or supports a particular research interest.

AGREEMENTS. Parties enter into their own agreements for projects. The NPO is only a party to NPO grant funded projects and master agreements with members. There are several types of relevant transaction vehicles for negotiation. To some extent the research stage of the project and the type of funding source determines which type of agreement should be selected to set forth the rights and responsibilities of the parties and how the intellectual property is or should be owned, utilized and valued.

The following provides some initial information on the characteristics of the most commonly used transaction vehicles to protect the intellectual property of a project and the rights of the parties (e.g., inventors/owners and the funding sources). Protection of the intellectual property is the most important aspect in these business transactions because this protection provides an asset by which the parties can value the results of the project. The following provides examples of likely agreements that could be used to set forth the rights and responsibilities of the parties (owners of the projects and the funding sources). Single types of agreements, multiple types of agreements, and/or combinations of agreements could be used to reach a satisfactory goal for the parties.

- Confidentiality Agreement (CDA) – a legal agreement between the parties setting forth the scope of each parties' confidential information, and how this information is to be handled including non-disclosure.
- Material Transfer Agreement (MTA) – a legal agreement entered into by the parties when one party delivers materials and information related to those materials to another party, which could use or study the materials for the purposes set forth in the agreement.
- Research Collaboration Agreement – a legal agreement that is used early in the research stage of a project that sets forth the scope and purpose of the research collaboration between the two parties and how the intellectual property that results from any inventions by the individual parties and from the collaborative research effort should be handled during the course of the collaboration.
- A "Joint Research Agreement" (JRA) permits collaborating inventors with differing affiliations to patent improvements that would otherwise be rejected because they would be "obvious."
- Product Development Agreement – a legal agreement that is used later in the research stage of the project when the research has identified a product for development to set forth the rights between the two parties. These rights may identify the product or product family, the "field" of the product development and commercialization, the geographic/territorial bounds of the agreement, the relevant intellectual property, and payments and other relevant issues.
- License Agreement – a legal agreement between the parties that is used to transfer the technology from the owner of project to the funding source where the rights and responsibilities of the parties and compensation to the licensor are set forth.
- Cooperative Research and Development Agreement (CRADA) – a legal agreement between a federal laboratory and a non-federal party to conduct specified research and/or development that are consistent with the missions of the federal laboratory.

The CRADA is a possible model agreement to use between the parties but we do not believe that a CRADA per se could be used as the technology transfer vehicle because the legal agreement must be between the national laboratory and a non-federal party that carries out the research in the national laboratory. The NPO is a management entity that manages the uses of the national laboratory, but the ISS national laboratory is representative of a portion of the U.S. allocation of ISS and is not a stand-alone facility such as the traditional national laboratories. However, it is possible that a modified CRADA could be used.

Standard Master Agreements

The NPO is the primary contracting party for users unless there is a unique payload that requires special attention from NASA. This is more fully described in the NPO and NASA Interface Section.

MEMBERSHIP AGREEMENTS. The following are key provisions of the NPO membership agreements:

- At least a nominal membership fee to discourage participants with no realistic interest or potential for developing worthy projects;

- Agreement by the member to abide by the procedures used by the NPO in selecting and prioritizing projects;
- Agreement by the member to waive any claims against the NPO for its actions in selecting and prioritizing projects.
- Membership procedure for a disappointed user to appeal an unfavorable decision as to selection or prioritization of a project.
- IGA Cross-Waivers of Liability, more further described in the NPO and NASA Interface Section

Grant Agreements. The NPO will disseminate some of its funds in the form of grants. In each such case, the NPO could enter into a Grant Agreement with the user. The NPO is anticipated to receive funds from NASA in its formative years (2011-2015) and as such the NPO would "flow down" certain provisions to each grant recipient as relevant.

Payload Integration Agreements. A Payload Integration Agreement (PIA) is executed by NASA and the individual Payload Developer (i.e., user) for each payload. While the NPO could provide a concurring signature, the technical nature of the agreement suggests that it would best be developed as an agreement between the technically relevant parties – the implementation partner and NASA.

Implementation Partners. The NPO provides the opportunity to "match" users with appropriate implementation partners. The NPO could also create standard model agreements to be used by users and implementation partners. Users could then enter into appropriate agreements with the implementation partners. These agreements would include the minimum characteristics of clear articulation of obligations of user and implementation partner and IGA cross-waivers of liability.

> *A marketplace mechanism would enable a more efficient and user-friendly process for the users seeking to utilize the ISS and low Earth orbit. Otherwise, the market creates work arounds that are inefficient such as leaders of research laboratories that spend a significant portion of their time seeking funding rather than productively managing and performing research for which they were trained. The NPO marketplace restores this balance to the supply chain.*

Intellectual Property Protocols

In order to create a viable marketplace that attracts interested investors and protects the interest of the researchers, the NPO would have a thorough understanding of, and protocols for, handling the intellectual property considerations for each project. Since ISS became available to non-NASA users in 2005, there has consistently been the option to protect intellectual property and this should continue to be offered. Almost all potential funding sources have an interest or concern regarding the intellectual property of projects. When private investors assess the potential and viability of an investment, they aim to create certainty around as many variables as possible. Understanding the intellectual property of a project is one of the areas that could offer a sense of certainty to an investment. Public funding sources also have interests in intellectual property, as evidenced by rules such as those in the Bayh-Dole Act (Appendix C - Bayh-Dole Requirements) or university practices surrounding technology transfer (Appendix D - University Technology Transfer).

Information about IP of Projects. The integrity of the intellectual property of projects could have an impact on the perceived value to funding sources. Information regarding the intellectual property of the project is collected (preliminary due diligence), but the NPO would not perform a full due diligence effort to investigate the intellectual property. Due diligence efforts vary based on the deal and preferences of the investigating party, which makes it a business decision. In addition, there is a business risk associated with performing more or less of a due diligence effort and as such should be left to the parties upon negotiation, which is a standard practice. However, the membership agreement between the researcher and the NPO requires that the principal investigator represent and warrant that the intellectual property information is true and complete to the extent of their knowledge. This offers a baseline for review from the interested funding sources as well as minimizes the expenses associated with supporting this effort.

Intellectual Property for Project Portfolio. The intellectual property information collected in the project portfolio includes the information below. There is a full analysis and further expansion of the list in Appendix E - Intellectual Property Considerations

- Inventorship & Ownership of the Project
- Information Regarding an Invention Disclosure Statement
- Determine Claim Scope to Cover Product/Method of Project
- Patent Filing Status and Information
- Information Regarding Publication of the Project or Similar Technology
- Information and Whether Invention Could Result from ISS-NL Utilization
- Information regarding Compensation of the Inventors by the Owner
- Information Regarding Proprietary Biological Material
- Source of Project
- Information Regarding any Agreements Between the Researcher and Third Parties
- Rights of Prior Funding Source
- Prior Source of Funding for the Project

All research conducted on U.S. or U.S.-negotiated space is considered to be done in the U.S. in accordance with the Intergovernmental Agreement (IGA) (Appendix F – Inventions in Outer Space on the ISS-NL).

Standard National laboratory IP Practices. A standard practice for national laboratories is to offer the opportunity to conduct non-proprietary or proprietary research using the laboratory's facilities and resources.

- Non-proprietary research is research performed where users do not need to fully fund their projects and may only be charged for ancillary resources which must be intended for publishing.
- Proprietary research is research performed at a laboratory that is fully-funded by the user and provides the opportunity for the user to maintain their intellectual property.

These concepts of proprietary and non-proprietary research meet the requirements for a fair economic exchange, which is the exchange of goods or services for a comparative value (either monetary or other compensation) in a way that advances the economic interests of both parties. For non-proprietary research, the exchange involves the provision of services at minimal cost provided by the national laboratory for the publication of the research results by the researcher. For proprietary research, the exchange is receipt of funding for use of the facilities by the national laboratory for the protection of intellectual property received by the researcher.

NPO IP PRACTICES. The current plans of NASA and Congress include continued financial support for transportation, use of ISS facilities and requisite resources such as crew time. This level of resource support inherently meets the requirements for the non-proprietary research model used by other national laboratories[20]. This model provides for the same two options to its users, but with modifications due to its unique circumstances.

In the case of the ISS, requiring that users pay for the full use of the ISS facilities could create a price point that is too high for the risk involved. NASA does not plan to charge its users and NASA is not required to charge users of ISS for use of its facilities or resources (Appendix H - User Fees for Use of NASA and ISS Resources) nor would either of these options encourage utilization by the private sector.

In order to provide a proprietary research option and still meet the requirements of a fair economic exchange, the NPO retains a nominal interest in the intellectual property for proprietary research projects. This interest is realized as a special royalty that the NPO would receive for future revenue streams generated by market applications. This special royalty serves as the return on investment to the American people for their investments in the operations of ISS-NL and would be used to support future grants for research and education related projects.

Building the pipeline of the investors from government to private industry requires the consideration of their interests, such as intellectual property protection, within the rules of microeconomic theory to manage the use the ISS.

NPO and NASA Interface

The NPO is a *de novo* entity that is uniquely purposed to accomplish the objectives set forth. NASA provides the program management of ISS operations and manages the relationships with partner countries. In order to leverage the existing capabilities the NPO has robust interface protocols to take advantage of NASA's capabilities and facilitate the use of the ISS-NL. We have designed the preliminary protocols for a relationship between the NPO and NASA, however, this interface needs to adapt and adjust over time as the relationship and procedures matures.

NASA Commitment

One of the most challenging areas of the model is the commitment and allocation of resources for ISS accommodations and transportation. There is capacity available for research that falls into three categories 1) NASA sponsored research to support its mission interests, 2) International partner accommodations and 3) national laboratory projects sponsored by organizations other than NASA.

A firm commitment of ISS accommodations (physical payload sites) and resources (up-mass/down-mass, crew time, power/thermal, data transmission, etc.) is essential to the success of the NPO and, more importantly, to achieving objective value-based productivity of the national asset. Ideally, this would be directly and clearly addressed with a directive such as guidance from the NASA Administrator in consultation with the White House, and subject to applicable Congressional statutes. Such clearly documented executive guidance would add to the establishment credibility and would allay broad concerns over prioritization. The NPO could be accommodated like the international partners (who receive an up-mass, down-mass, and crew time allocation). In all cases the safety of the crew and the maintenance of the ISS are the top priorities and it appears that NASA has workable procedures for equitably allocating resources should there be maintenance interruptions.

Commitment of resources for non-NASA users is a cornerstone for ISS utilization. Significant U.S. investors in ISS-based research could perceive being treated any less favorably than the international partners as very problematic, which would be a risk variable that could have a seriously deleterious impact on utilization.

NASA Interface Protocols – Working Relationship

ISS HEADQUARTERS INTERFACE. The establishment of the NPO to stimulate, develop and manage uses of the ISS by organizations other than NASA has been designated as a high priority performance goal by the Executive Offices of the President of the U.S. This level of visibility on the national agenda requires that NASA Headquarters maintain close coordination and insight into NPO operations. All aspects of NPO policies, procedures and protocols are closely coordinated between the NPO Executive Director and a NASA Liaison in order to fully achieve the objectives of an agreement between the parties. NASA's strategic interfaces with the White House, Congress, NASA Advisory Council, National Research Council, international partners, academia, industry and the press should reflect accurate and timely information on progress at, as well as constraints on, the NPO. Since the NPO supports a Federal policy initiative, adjustments and clarifications to national policy can be anticipated over the next decade as the enterprise matures and begins to yield benefits.

ISS RESEARCH PROCESS. The ISS "research process" is the full supply chain process of bringing a research project from inception to design to operations on ISS and then post-flight analysis. We have worked in close coordination with the NASA ISS Payload's Office to identify the needed interfaces, and we have received feedback from interviews on both historic and recent experiences that have informed our recommendations.

RESEARCH SYNERGIES. The ISS is a unique research facility; however, it has limited capacity. Therefore, the capability to work with other research sponsors to identify potential synergies and collaboration opportunities that best enables the maximum utilization of the ISS is paramount to maximizing the value of research done on ISS. This model employs the capability to interact with other ISS research sponsors including NASA communities and the international partners through the NASA ISS Program Office, which hosts an ISS Program Science Forum that provides such a brokering function for research collaborations across the participating agencies. The NPO could make or receive proposals through this established forum.

ISS STAKEHOLDERS. During the integration process as it is carried out today, NASA receives its requirements based on the research plans from all of the various stakeholders including the international partners, NASA and ISS national laboratory "pathfinder" projects. The NPO is an additional stakeholder in the ISS. There is an understanding amongst all stakeholders that regardless of the specific resource allocations planned, the integration process may necessitate adjustments to accommodate fully optimized operations integration.

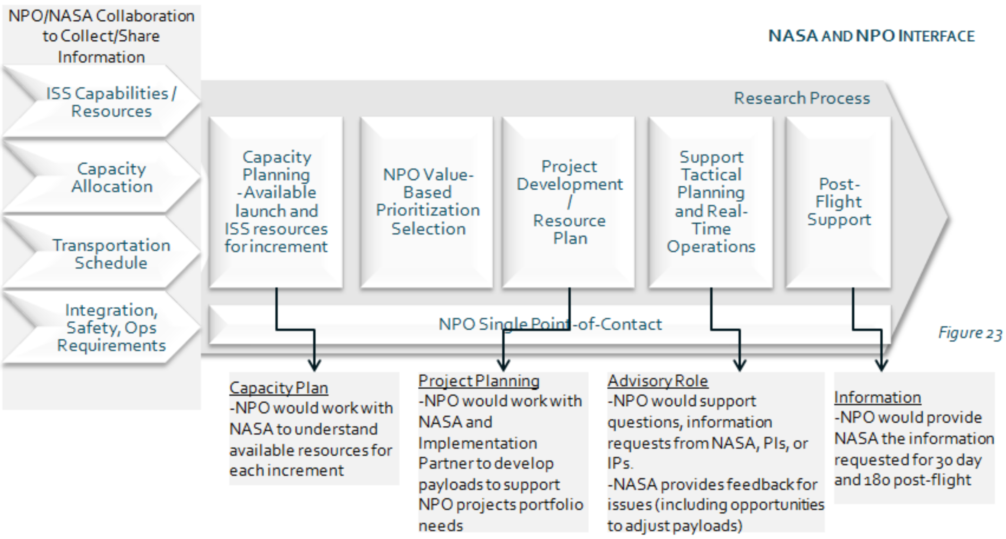


Figure 23

Research and Operations Process. As Figure 23 shows, the NPO research process begins with the knowledge of available ISS capabilities, allocations, transportation schedules and high level understanding of the operations and safety requirements for use of ISS and capacity availability for future increments. This information is the basis for the NPO's capacity planning capability. Prior to the prioritization and selection of projects (candidate payloads), knowledge of the high level availability of resources is used to determine how many projects were possible for a given increment. Following capacity planning, the NPO prioritizes a candidate group of payloads based on the capacity availability. For example, if there was a smaller allocation available for a given increment due to planned maintenance of ISS then the NPO would not spend the time to value and prioritize the typical full list of candidate payloads. However, the NPO could also respond to unplanned opportunities for use of ISS by staying coordinated with NASA. After selecting payloads for an increment, NASA, implementation partners and the NPO work together to develop further design details for a project. This includes developing and signing Payload Integration Agreements, which include allocations for resources and accommodations. Since these agreements are typically formed early in the process, clear allocations are usually not made because the needs are unknown. This agreement could become a living document so that when more specific information is known that it is added to the agreement. Closer to the tactical phase, the NPO works with NASA to determine the more specific assignments and capacity availability for a given increment. During Tactical Planning, the NPO provides support in an advisory role (e.g. act as an Ombudsman to the process) to both the user and NASA. Post-flight, the NPO tracks the results of payloads and provide the results at 30 days and 180 days post-flight as requested by NASA.

Below is a more detailed description on NASA's processes and the role that the NPO would serve in this context.

NASA's Research Planning Process. NASA maintains a strategic manifest with a 5 year horizon which is updated once a year. This serves as an internal working document that projects future utilization so that the ISS Program Office can plan for potential demand and needed resources. The NPO would participate in this process and provide projections for its future utilization. NASA's tactical research integration process begins 18 months prior to flight with a NASA kickoff meeting. The group gives research sponsors, such as the proposed NPO, indications of available crew time, up mass, cold storage and other types of available resources for an increment. One month later, 17 months prior to launch, the research sponsors turn in a candidate list of prioritized research projects as input to NASA's internal tactical scheduling process for payloads. Based on these candidate lists, NASA develops a baseline plan for payload transportation, accommodations and operations. In practice, there could be changes from the baseline plan to the "as flown" plan as optimization proceeds. Any changes to payload requirements or additional payload requests during this period go through a formal change request process. The overall plan that is turned over from the research sponsor to NASA is called a research plan, which includes all of the requested resources for payloads.

TACTICAL PLANNING PROCESS. Once the NPO turns over the research plan to the ISS Payloads Office for integration and implementation, the NPO decreases its direct involvement while increasing its status monitoring role on behalf of the principal investigators. At this stage, the NPO continues to act as an ombudsman, while the NASA Payloads Office personnel implement the research plan in coordination with the user and the performing organizations responsible for day-to-day ISS systems operation. The end-user then maintains contact with their respective NASA Payload Integration Manager (PIM) who is the NASA contact during the execution phase, as well as having been a signatory to the Payload Integration Agreement executed between the user and NASA. In the event of unresolved issues between the user and the PIM, the user could review the issue with the NPO in its continuing role as ombudsman. In such cases, the NPO could seek consultation with the NASA National Laboratory Manager to resolve such issues where feasible. In addition, the NASA National Laboratory Manager could seek to resolve issues with the NPO should NASA have issues with NPO users, such as not receiving information needed to execute the process in a timely way.

IMPLEMENTATION PARTNERS. In this design, implementation partners continue to support the payload development process by identifying the equipment requirements and options for the national laboratory users' research experiments. Implementation partners continue to work with NASA on the principal investigator's behalf during the payload development and integration process to understand the integration requirements for various ISS facilities and resources. Following the development of the research plan, implementation partners stay involved in the tactical operations planning with NASA to do payload integration, crew training, operation support, and post operation support.

INTEGRATION. Once the NPO's research plan is submitted to NASA for tactical operations, NASA integrates NPO payloads with its own research plan as well as that of the international partners. The NPO needs to be prepared to deal with adjustments necessary to its payload plans within a reasonable degree of change due to the inherent nature of ISS system operations. NASA provides feedback in regards to necessary changes for payloads, so that the NPO could reprioritize and/or adjust experiment protocols as necessary to best meet the original plan. The fully integrated plan is finalized at the Payload Control Board (PCB) meetings for NASA's ISS-allocated space and at Multilateral Payload Control Board (MPCB) meetings for the international allocated space. As a new stakeholder in the enterprise, the NPO would be represented at the PCB meeting.

AVAILABLE RESOURCES AND ACCOMMODATIONS. In order to facilitate the research planning process as demand rises, it is imperative that available resources and accommodations continue to be made available to research stakeholders such as the NPO. This necessitates coordination between NASA and the NPO to ensure that appropriate and relevant information be maintained in the public web sites or easily available upon request. Since a considerable portion of this information exists on the NASA ISS website, the NPO would work closely together with the ISS Payloads Office on future investments to ensure that redundancies are minimized, accuracies are maintained and linkages are established in an efficient and effective manner.

AVAILABLE EQUIPMENT. The payload development process is more or less complex depending on whether a principal investigator elects to or can use available equipment that is certified and already flown to ISS versus developing new equipment. There are several sources of equipment that have been used on the ISS and are available for future research purposes. Flight-certified research apparatus offers the benefit of knowing that the equipment is already compatible with the ISS requirements. This existing equipment is available at both NASA research centers and through the implementation partners. Each has a list of available equipment that has flown on multiple flights. NASA and the NPO would coordinate closely on future updates to the existing publicly available research equipment database so that users can remain fully informed of all available options to maximize their research value.

INTERNATIONAL BARTERING. The international partners and NASA have historically shared equipment and resources through bartering procedures. The ISS Payloads Office at NASA would represent the NPO in negotiations to the extent that there is a need for the NPO to utilize international resources. Since research-related equipment represents only a small portion of the international bartering scope, the ISS Payloads Office is well positioned to represent the NPO and obtain the most advantageous conditions for advancing U.S. interests.

ISS FACILITIES INFORMATION. The NPO would coordinate with NASA to understand the available ISS facilities and support equipment. As discussed in interviews, NASA plans to provide a website listing outside of their firewall with information regarding the various ISS racks and equipment which will have links to the Interface Control Documents (ICDs). The ICDs contain information regarding the technical requirements and integration to ISS hardware. The NPO's capability to access this information will help to eliminate the need to contact NASA and locate the organization that houses the varying information for the equipment. These ICD documents serve as a valuable resource for implementation partners in the development of new research apparatuses.

NEW ISS FACILITIES OR EQUIPMENT. In cases where new research apparatuses for ISS are essential to advancing a research pathway or to support a compelling purpose, the NPO and NASA Payloads Office would engage in an analysis to determine the research performance requirements of the proposed equipment (value) and subsequent equipment costs (investment) prior to committing to the project.

TRANSPORTATION. The NPO's transportation interface capability enables the NPO to develop and maintain relationships with the commercial transportation providers to the ISS such as SpaceX and Orbital Sciences. NASA retains its role in providing payload, physical, analytical and operations integration during pre-flight, post-flight, transportation and orbital phases. The NPO would not negotiate in regards to the transportation up-mass or down-mass and would not have a role in integrating cargo manifests with any transportation providers. Nonetheless, the NPO would communicate with transportation providers in order to understand their future plans. The NPO would plan the future in-house capabilities required to support a longer-termed endeavor for science in space and this includes the knowledge of future transportation options. If there are potential transportation capabilities that could increase productivity, such as additional powered lockers, then the NPO could identify these as potential options for the ISS

Program to pursue. In the future, the NPO could fund capability enhancements if user demand and funding support were at a level to support increased capability.

POST-FLIGHT TRACKING. The NPO tracks the results of NPO research projects post-flight. Currently NASA collects operational results 30 days post flight and final results one year post flight. NASA also collects information regarding publications or results over time. The NPO would track, report and publish their results as well as meet NASA's requirements for post-flight reporting, so that NASA can continue to maintain an integrated collection of ISS program-wide research results.

EDUCATION. NASA's education program develops and manages STEM ground-based and ISS-based education and research programs. These programs include ground based programs and direct ISS programs. There could be opportunities to coordinate between the NPO and NASA's education office to support educational programs. These possibilities include the potential for the NPO to help identify funding sources for NASA STEM education projects due to the inherent network it develops through the course of its operations. In addition, due to the limited capacity on ISS, as long as there are similar or complementary projects for ISS education, NASA and the NPO could work together to provide a jointly coordinated program portfolio that further supports the objective to maximize the utilization of ISS.

ON-GOING MANAGEMENT. The NPO would continuously manage and update these interface protocols between NASA headquarters and NASA's ISS Payloads Office. As internal processes evolve in the organizations these interfaces may need to be adjusted and updated accordingly.

The assistance most requested in the interviews conducted was a mechanism that enabled a seamless support system for external users. The NPO should aim to provide this support while leveraging the existing capabilities within NASA and the various implementation partners.

NASA Interface – Contractual Relationship

The relationship between NASA and the NPO would be established in a written agreement between the two parties. The choice of legal instrument can have a significant impact on the value creation and return on investment in the enterprise – both enabling its ability to execute its mission and providing the most efficient organizational model. Instruments were evaluated using three main criteria: permissibility, suitability, and best fit for the desired relationship between NASA and the NPO (further described in Appendix J – Cooperative Agreement). Research findings suggest that a cooperative agreement is the preferred instrument.

- **Permissibility:** In the 2008 Authorization Act, Congress gave NASA the discretion to enter into a contract, cooperative agreement, or grant. The Federal Grant and Cooperative Agreement Act can reasonably be interpreted to permit a cooperative agreement, and other agencies in the past have used cooperative agreements rather than contracts in similar circumstances. If there is concern over the propriety of a cooperative agreement under the FGCAA, NASA would have a strong basis for seeking a waiver from OMB.
- **Suitability for NPO Success:** Unlike a procurement contract, a cooperative agreement provides maximum capability for the NPO to meet its programmatic purposes over the long term. As the recipient of a

cooperative agreement, the NPO would be free of the unnecessary requirements imposed by the FAR and other procurement regulations. A cooperative agreement would impose less cost on the NPO and NASA than a procurement contract. In particular, the award of a procurement contract would require the NPO to incur significantly greater cost associated with requirements concerning small business subcontracting, cost accounting, billing, record-keeping, and a wide variety of compliance programs that are not germane to the NPO's objectives.

- **Fit of Instrument with Desired Nature of NASA/NPO Relationship:** Since the principle mission of the NPO is to advance non-NASA uses, but still requires the ability to collaborate and coordinate with the agency, the cooperative agreement is the best fit with the nature of the desired relationship. Whereas a contract requires close control by NASA over NPO activities, and a grant likely would involve minimal collaboration between NASA and the NPO, the cooperative agreement is specifically designed for use when an agency needs some degree of collaboration and coordination without close control.

The analysis concluded that a cooperative agreement is the best fit for an instrument that would add the least administrative burden and cost overhead. It provides for the needed government oversight and serves as a strong foundation for managing the collaborative relationship between NASA and the NPO. NASA has also indicated that a cooperative agreement is the appropriate instrument for a relationship between the agency and an external non-profit entity.

The cooperative agreement would authorize the NPO to enter into agreements with selected users and to select payloads within its allocation based on its prioritization schemas. However, all NPO payloads remain subject to the safety and operating rules of NASA. For exceptional cases, NASA would enter into direct agreements (Space Act Agreement or MOU) with a user where a payload could affect the ISS operating environment, require significant investment from the program to accommodate the payload, or has an unusual design or safety requirement. Users could enter into agreements with implementation partners to assist in payload development and integration. NASA would also enter into a SAA with their implementation partners for exceptional circumstances, if necessary. It is not necessary that NASA enter into direct agreements with either users or implementation partners in most cases. For these rare exceptions, it is essential that the ISS Program directly develop the agreements and in these cases the NPO would serve as a pass-through function.

CURRENT MOU AND SAA HOLDERS. The MOUs and SAAs are current agreements that organizations have with NASA with regards to the ISS-NL "pathfinder" projects where the users are using NASA resources. NASA currently has four MOUs concerning the ISS. The purpose of each MOU was to establish a "framework for cooperation" between the governmental agencies to encourage research and use of the ISS. The MOUs do not impose any significant burdens or obligations on the parties. If the legal structure that is recommended would be adopted, then the NPO would need to enter into appropriate agreements with the current agencies. There is no mechanism by which the existing MOUs can simply be transferred or novated to a non-government entity like the NPO. Instead, the NPO would enter into new agreements with the parties that set forth relevant terms and understandings. Once these agreements are in place, the existing MOUs would no longer serve as the operative agreements setting forth the means by which those agencies would seek to participate in research activities concerning the ISS-NL. Once new agreements between the NPO and the agencies are in place, either NASA or the other parties to the MOUs could elect to terminate the existing MOUs, pursuant to Clause VIII. However, there appears to be little reason for the parties to terminate the MOUs, because of their general and broad nature.

NASA currently has seven Space Act Agreements with non-government entities concerning the ISS. The NPO would enter into appropriate new agreements with NASA and with the users that would replaced the existing SAAs. NASA would terminate the existing SAAs, pursuant to Article 16 in the Agreements. However, all obligations from these agreements would be honored by the NPO. The NPO and NASA would carefully communicate to these agreement holders how their agreements would be upheld and transitioned.

NASA-NPO Cooperative Agreement. The establishment of a NPO to stimulate, develop and manage the national uses of the ISS by organizations other than NASA is a strategic Federal policy initiative of the White House that is enabled through legislation by the Congress[21]. Productivity of the ISS over the next decade has strategic implications that cut across diplomatic, economic, national security, industrial, and educational domains. For these reasons, the cooperative agreement should be coordinated with NASA headquarters.

The development of a cooperative agreement between NASA and the NPO includes the following considerations:

- Many of the elements of the relationship between NASA and the NPO could be derived from existing provisions in Space Act Agreements (including the ability to exchange funds, see (Appendix K – Responsibilities from Representative SAA Agreement), standard agency cooperative agreements, and standard payload integration agreements.
- Given the unique nature of the relationship between NASA and the NPO, it is likely that issues would arise from time to time that the parties will need to resolve and address in writing. The cooperative agreement needs to include a clause permitting written modifications to address additional understandings of the parties involved as the effort progresses and matures.
- The cooperative agreement would set forth the fundamental responsibilities to be undertaken by the NPO and NASA, respectively. Because the nature of the party's relationship can be expected to evolve, the responsibilities would be set forth broadly, rather than with a high degree of specificity.
- The cooperative agreement would specify any limitations to the kinds of agreements that could be entered into by the NPO and its users.
- The cooperative agreement would include cross-waivers of liability, further described in Appendix L – Cross-Waivers with the requirement that the NPO "flow down" this and other key provisions to the user agreements. The NPO would be held accountable for flowing down these provisions whether or not they were actually executed and signed by the users.

Cross-Waiver of Liability Exceptions. Under the model described above, the NPO stands in the contractual chain of liability between NASA, users, and implementation partners. Although a cross-waiver of agreement is applicable, the standard cross-waiver does not apply to the following types of claims: (i) Claims between the NPO and its own related entity or between its own related entities; (ii) Claims made by a natural person, his/her estate, survivors or subrogees (except when a subrogee is a Party to the agreement or is otherwise bound by the terms of this cross-waiver) for bodily injury to, or other impairment of health of, or death of, such person; (iii) Claims for damage caused by willful misconduct; (iv) Intellectual property claims; (v) Claims for damage resulting from a failure of the NPO to extend the cross-waiver of liability to its related entities, including users; and (vi) Claims by a Party arising out of or relating to another Party's failure to perform its obligations under the agreement.

As a result, the NPO or its users could consider insurance for claims that are not covered by the cross-waivers of liability to the extent such insurance is available. There is a third party liability insurance market for space related risks. The perception of the insurance market related to this scenario of third party liability is that the risk is low. However, NPO users may wish to eliminate the possibility of third party liability, which has the potential to be catastrophic by purchasing specialty policies in the range of $5 – 10k per policy. If it is permissible, NASA should consider waiving third party liability in its agreement with the NPO.

In addition, the NPO still faces general liability claims, and claims that fall outside the scope of the cross-waivers. The NPO would purchase insurance to cover the standard liabilities of any business which include, but are not limited to general liability, automobile liability, professional liability, business liability, and workers' compensation and employer's liability.

Rules and regulating mechanisms are required in a host of scenarios that vary depending on the nature of given authorities and the need for autonomy. Establishing rules for the NPO that enable it to achieve the stated purpose (world-class, established, responsive, accessible, innovative, impartial, unconflicted) while providing the appropriate oversight is essential to successful execution.

Asset Requirements

The core ***organizational assets*** in the ProOrbis® Method for any enterprise are human capital, technology capital, and physical capital. Based upon capabilities, organization and roles defined, the following portfolio of assets has been built into the budgetary estimates:

HUMAN CAPITAL ASSETS: The HC required to execute the mission is the best fit between a set of skills and the role requirements. The leadership roles were defined in the Organization Design Section. The leaders will select individuals that match the human capital requirements of the enterprise. The process of defining the role requirements, sourcing and selection is a disciplined process designed to select the best individual for each position.

The human capital required is generally experienced, value-driven, highly collaborative, collegial, cooperative, well-educated, credentialed and networked with an impressive track record in their field of endeavor. They could be in the commercial, government or nonprofit sector and may be located around the country. Candidates would be passionate about the purpose and focus of the NPO and willing to do what is necessary to make the organization successful.

Fit of human capital to requirements is critical to operating the model as designed. Some organizations make the mistake of choosing an individual that is similar to them or select poorly fitting employees into open positions in order to avoid performance issues or to maintain organizational status quo. The "who you know" versus "what you know" culture creates a potentially suboptimal fit-to-role scenario. Organizations "correct" for these mistakes by hiring more professionals, outsourcing company activities or simply not executing. The NPO has a unique opportunity as a *de novo* organization to select the best fit of human capital for the organization.

PHYSICAL CAPITAL ASSETS: Physical capital assets (PC) include the tangible assets of the organization, such as the physical location, furniture and office space. The work space configuration is important as it attracts human capital, enables work flow, and encourages collaboration when required in addition to allowing for private working space when necessary, which saves time and money while conveying the attributes of the NPO's brand.

PC asset requirements:

- Office Space for NPO staff: Both a functional and brand-appropriate space for housing NPO staff. It could also be close to or conjoined with key NASA facilities or close to NASA HQ. It is likely that multiple locations and provisions for non-collocated staff may be required as the best possible staff may not all reside in one physical area. The furniture and desktop technology needs to be functional, state of the art and attractive for the caliber of talent required.
- Meeting and Conference Space: Space is necessary for board meetings or engaging constituencies including funding sources and principal investigators. The meeting space for the board and key external constituencies needs to be an elegant but functional space befitting the NPO's brand as a national stature organization and board.

TECHNOLOGY CAPITAL ASSETS. The technology capability for the NPO would be built to leverage a common technology architecture and platform that supports a small to mid size enterprise. The initial use of outsourced software (considered SaaS – "Software as a Service"), where feasible, would support immediate business operations.

TC asset requirements:

- Support of the workforce through a technology infrastructure that provides office communication and productivity tools.
- A web infrastructure to provide an information portal for members, outreach volunteers, and support the external organizational messaging and communication with prospective members and the general public. Support linkage to communities for the advancement of academic interest and integrity including support for STEM education and online publishing.
- Member relationships management to enable effective membership relations from recruiting and prospecting through tracking of involvement in user groups and other NPO activities.
- Project management to effectively manage the portfolios of projects and research pathways to ensure optimum use of limited resources in managing ideas through to their execution with efficient workflow management and prioritization approaches, including the matching of funding sources to appropriate projects.
- Contract management to ensure an efficient contracting process with satisfaction of party requirements, including the tracking of commitments, milestones, performance and compliance.
- Financial and accounting management to support all fundamental financial accounting and control aspects of the operation ensuring compliance and transparency.
- Human resource management to provide basic payroll processing and an HR database to effectively manage and compensate the employees.
- Grant management to satisfy grantor requirements for tracking funds, accountability and reporting requirements.

- Billing and receipt management to enable the timely request and receipt of research and project funding based on key events such as achieved project milestones so that cash flow is appropriately managed, tracked, and transparent with complete audit ability.
- Scheduling and capacity planning to ensure optimal use of limited up-mass, laboratory, and down-mass resources and equipment such that research values are appropriately prioritized, sequenced, and scheduled.
- Business intelligence to facilitate the integration of information across the organization so that analyses of members, research pathways, projects and project portfolios including their inter-relationships can be well understood and managed to ensure the research mission is fully achieved.

Resourcing and Extended Enterprise

The model features three sets of capabilities required for the initial and ongoing resourcing strategies:

- Main Transform Capabilities– The primary operations of the NPO that enable it to source, prioritize, fund and enable projects.
- Asset Management – The management of the primary assets (read: resources) to execute the positioning such as facilities, human resources, technology and intellectual property.
- Support Capabilities - The support processes such as legal, finance, communications and advocacy.

Due to the finite asset life of ISS, the budget includes the fastest, most feasible start-up timeframe of 90 days. Complete build-out of all the capabilities may take 12-18 months and has been estimated as capital expense for budgetary purposes. The strategies identified are the assumptions of the budgetary estimate which also includes the overall development of the strategy, capabilities, and asset configurations to execute the model.

Due to the finite asset life of ISS and the political and public pressures to see a return on investment, the start-up plan for the NPO is designed as the fastest, most feasible start up timeframe of 90 days.

Internal Resourcing Strategies

To build the start-up organization within 90 days, the requirements and appropriate resources can be committed either through contracts or letters of commitment subject to the funding release for the NPO.

- **Internal Staffing.** The initial configuration of human capital, currently modeled at 30, would need to be identified, recruited and committed. Interim, temporary individuals or consultants could be used in place of regular staff if needed. The leadership team would actively participate in the recruiting of the staff through a defined process to select to the individuals that fit the roles, required cultural imperatives and enabling competencies. The 90 day plan would include intense team building through a defined process to strengthen the team while building out the new capabilities.
- **Technology.** A higher caliber contract CIO could be required to develop and execute the TC strategy and implementation to support the first year of operations until it could be smoothly transitioned to internal staff. This individual would set up the initial TC configuration to support the staff. This could likely be a multi-location configuration and would include the ability to use technology when face-to-face is not required or possible.

- **FACILITIES.** The NPO is a national organization and could reside in multiple locations to achieve its mission. The 90 day start up includes the use of office space at a number of existing and properly outfitted locations and may reside permanently in several locations to best support the staff and principal investigator requirements. This would also function to best leverage the existing assets and enable a national presence.

External Sourcing Strategies

The internal staff of the NPO is a lean assemblage of critical staff, focused on the strategic aspects of the NPO's purpose and objectives. Third parties are essential during the initial years of operation to accelerate the drive to operations and later to keep the team lean. Capabilities can be transferred in-house to the extent that they are well-developed, transferable and could be executed better by internal staff.

The model includes a robust extended enterprise of resources to extend its capabilities, cover variability in work load and provide support during the formative years of the NPO. These external capabilities include:

- External search firms: National search firms to search for candidates that meet the role requirements and other aspects of the NPO to provide a national pool of candidates. Because of the breadth of skills and disciplines, multiple firms may be required to get the best pool of candidates.
- Board consulting firms: Support for a new NPO board to assist with start-up operations.
- Law firms: National stature law firms to support the initial set up including the development of the basic agreement formats and protocols, and establishment of the intellectual property management capabilities. The law firms would also support the NPO during peaks in activity. These firms would have experience in non-profits, government and other forms of contracting and agreements, intellectual property and other patent experience in addition to experience with the industrial applications of R&D. Because of the nature of the NPO, different firms could be used for different purposes based upon their expertise and fit with the legal support requirements of the NPO.
- Facilities and Ground Support: The NPO could partner with existing organizations that have facilities and other resources to support the NPO's operations. The ideal partners would have an existing set of facilities that could support research activities, house NPO staff and accommodate staging and ground development of projects.
- Technology: A consulting firm to develop and implement the NPO's technology capability.
- Marketing and Communications: An external marketing and communications firm to support the development of materials and protocols for external communications, branding and other materials for members and funding sources. In addition, an external firm would be used to provide capabilities or extra capacity that is not needed in-house.

Measures and Metrics

The measures required to manage the performance of the NPO must be comprehensive and value oriented. Measures are designed to ensure accountability at all levels – from the organizational to the individual performance requirements. It is important to construct measures that set clear accountabilities within the NPO.

The measures developed for an organization are a reflection of their objectives and definition of "what is good". The objective of this model is to maximize value and therefore use value-based measures are used to identify and recognize the value that is created.

Research Outcomes. The analysis included examination of measures used for agencies that conduct research and national laboratories. Many interviewees described the definition of "good" scientific research as the number and type of publications for research and number of citations referring to those publications, which are activity-based measures. The recently introduced STAR METRICS program (Science and Technology for America's Reinvestment) is a good example of an outcome-oriented measure set for federally funded research (Appendix S). The impetus for the program was the recognition of a lack of measures in government agencies that measured federally funded research results, which was consistent with our findings. This program is led by NIH, NSF, and OSTP and is currently in development of Phase II of the program, which is a collaboration to create measures that have four areas of focus: economic impact, workforce impact, scientific knowledge impact and social impacts[23]. The table outlines some of the ways contemplated for measuring each of these impacts, which demonstrate a move towards more value-based measures for indicating the impact of federally-funded research.

STAR METRICS[22]	
Economy	"Patents and business start-ups"
Workforce	"Student mobility into the workforce and employment markers"
Scientific Knowledge	"Publications and citations"
Social Outcomes	"Long-term health and environmental impact of funding"

Figure 24

Enterprise Dashboard. The model employs a comprehensive set of measures that are designed to provide indications of how the enterprise is performing (current operations indications), how it has performed (historical), and how it may perform (models for the future). The NPO enterprise design is integrated with the capabilities to collect key information (e.g. experiments portfolio data sets), which allows for the NPO to have a strong command of data for analysis purposes.

The measures are developed using a ***dashboard*** approach designed to describe, explain and predict outcomes of the NPO to ensure that it is meeting the value maximization objective (Figure 24). Descriptive measures describe what is happening with the performance of the enterprise. Explanatory measures explain why something is happening. Predictive measures predict what may happen in the future.

A dashboard is comprised of six categories of measures: 1) overall value measures, 2) positioning & strategic objective level measures, 3) portfolio objectives, 4) capability performance and, 5) organization measures and 6) individual measures. Dashboards need to be integrated in order to be able to explain what is happening in the organization or predict future outcomes. The way that a dashboard integrates is by causally linking the measures from overall value to the individual performance level.

Integration. Unless both the enterprise design and measures are integrated it is not possible to analyze the source of potential issues or predict future outcomes. Business processes are not isolated, so therefore the poor performance of one capability could result in the lack of performance of another capability. For example, the Strategy & Planning capability produces a collection of strategies for the rest of the capabilities. If a particular capability is not executing its strategy as expected then the issue could be that it either received a bad strategy or that they did not execute the strategy well.

Overall Value (Tangible and Intangible). The overall value measures describe total value estimated and achieved (tangible and intangible). The intangible value calculations use the valuation frame described in the Value Dimensions Section. Intangible value is typically characterized in net terms and reflects the impact of the activities of the enterprise on the factor.

Positioning and Strategic Objectives. The positioning measures characterize the progress towards executing the purpose and focus of the NPO, as well as the objective level measures of the enterprise. One of the measures for meeting the positioning is full utilization of the national laboratory allocation of ISS. Full utilization would not be achieved immediately, but measuring the progress towards this objective would give an indication of whether the NPO is on track to achieve it.

Portfolio Objectives. Portfolios are collections of assets or capabilities. Each portfolio has a functioning objective based on the requirements for achieving the positioning. Portfolios are the throughput of the capabilities and therefore serve as a measure of effectiveness. For example, the fundraising portfolio's functioning objective is to have a mix of funding sources that support the portfolio of projects with its varying scientific disciplines, interests and objectives.

Capability Performance. The collective organizational capabilities are what the organization "can do". Each individual capability therefore needs to have clear definitions of what it is required to do, which can be described as the throughput of each business process. For example, the marketplace capability matches projects and funding sources and the throughput is the portfolio of projects matched with funding sources. Once it is known what a capability is required to do then it can be measured to see if each capability is producing the throughput required. Were there enough projects matched with funding to fulfill the available capacity for a particular flight? This is an example measure of effectiveness. The other relevant measures for the capability's performance include its efficiency and cycle time. Efficiency is a measure of the amount of resource used (e.g. how many hours of an individual or group of individual's time) to produce the throughput. Cycle time measures the time it takes to produce the throughput. A capability may produce the required throughput, but if it arrives after it is needed or utilizes five times the resources that contemplated then there is an issue to be addressed.

Organization and Individual Performance. The organizational measures assess each group's ability to execute its assigned capabilities and initiatives. For example, the Strategy & Planning group accountable for the developing the NPO's research pathways and prioritization process needs to be able to evaluate projects using economic valuation techniques by understanding scientific and education tangible and intangible values. Assessing the performance of this group as a whole includes assessing the accuracy of the valuations completed by comparing project results against the initial prioritization value. Each organizational group includes individuals at various seniority levels that are required to execute various parts of a capability. Individual measures assess the performance of the individuals as compared to the role requirements.

The following table provides a description of the kinds of measures the NPO would need to measure to demonstrate the performance of the ISS-NL research outcomes as well as the NPO's ability to manage its operations.

Type	Measures Requirement	Calculation Samples
Overall Value– Intangible (U.S. Economic Interest, Education , Security, Life on Earth or Space , Leadership in Space)	Dimensionalize the net value of research or educations created as a result of ISS-NL projects	• Value to American people generated from the unique activities of the NPO minus amortized investment of the ISS-NL stakeholders (Net Value) • Net Value of contribution ISS technology makes to products and services revenue and related tax revenue from the profits • Net Value of the improvement to human capital stocks
Positioning	Performance against the functioning objectives of the enterprise	• Performance against the NPO BOD, congressional mandates and NASA requirements (such as the Ratio of Utilization % of the ISS-NL allocation to NPO investment) • Tangible Value to Investment Ratio • Net Value • Growth rate in net Value
Strategic Objectives	Indicators of progress toward key strategic goals	• Ratio of appropriated to NPO-generated funding • Ratio of NASA to NPO Educational Funds • Projected Value of Research Pathways in Development
Portfolio Objectives	The value created by the investment in NPO resources. Operational Efficiency	• Ratio of total ISS-NL research funding to NPO Investment • Ratio of total ISS-NL research value created to NPO Investment • Ratio of education programs funded to NPO investment

Preliminary Budget

It is contemplated that the NPO would receive governmental appropriations in the formative years of operations. Therefore, a fifteen million dollar appropriation has been assumed to support the NPO from 2011 through to 2015. The NPO generated funds (revenue) are legally permissible and have been designed to reflect the value of the offerings being provided to NPO users. To the extent that there are any "profits" made by the NPO, the NPO would use the funds to support ISS programs or projects. The NPO generated funds have been estimated using the pricing of offerings (products and services) provided to NPO members and expense increases are scaled to the offerings provided. The source of the NPO generated funds include: success fees, special royalties, membership fees, fundraising contributions, and non-member subscriptions to the NPO journal. In this model, the fundraising contributions directly support ISS-NL research and programs.

Budget 2011 - 2020												
	2011*		2012		2013	2014	2015	2016	2017	2018	2019	2020
Estimated Sources of Funds*												
U.S. Government Appropriations		$15,000		$15,000	$15,000	$15,000	$15,000	$0	$0	$0	$0	$0
NPO Generated Funds		$0		$2,892	$5,860	$11,180	$15,451	$20,217	$24,991	$29,085	$32,540	$37,321
Subtotal		$15,000		$17,892	$20,860	$26,180	$30,451	$20,217	$24,991	$29,085	$32,540	$37,321
Total Cost of Operations*	**Cap-Ex**	**Op Expense**	**Cap-Ex**	**Op Expense**	**Ongoing Operating Expenses**							
Fundraising, Education & Membership Outreach		$145		$391	$563	$574	$807	$825	$894	$965	$1,044	$1,129
Marketing & Communications	$500	$0		$200	$210	$221	$232	$243	$304	$364	$400	$460
Legal	$250	$93		$100	$105	$105	$105	$105	$105	$105	$105	$105
Other Administrative Expenses	$1,482	$402	$1,059	$751	$1,201	$1,487	$1,732	$2,057	$2,375	$2,658	$2,873	$3,209
Human Capital (Strategies, Recruiting, and Salaries)	$1,000	$4,425	$200	$6,637	$6,836	$6,836	$6,836	$7,042	$7,253	$7,470	$7,694	$7,925
Physical Capital (Lease for facilities, equipment, furniture, etc)	$360	$341	$67	$505	$505	$505	$505	$505	$505	$505	$505	$505
Technology Capital (Strategy, infrastructure build, 3rd party set-up)	$2,223	$258	$864	$470	$470	$470	$470	$470	$470	$470	$470	$470
Totals	$5,814	$5,663	$2,190	$9,054	$9,890	$10,199	$10,687	$11,247	$11,906	$12,537	$13,092	$13,803
	$11,478		$11,244									

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NPO Grant Funding	$3,000	$3,556	$4,079	$6,123	$7,170	$5,231	$6,318	$7,447	$8,702	$10,057
External Funding (Matched in NPO marketplace or already funded)	$0	$11,670	$23,600	$45,900	$65,650	$85,600	$93,770	$101,350	$107,550	$114,700

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Funding for ISS-NL Research Projects	$3,000	$15,226	$27,679	$52,023	$72,820	$90,831	$100,088	$108,797	$116,252	$124,757

**1000s*

The following are some key factors and assumptions used in formulating the budget.

We have assumed that the NPO would begin operations in fiscal year 2011 for at least 8 months of on-going operations. Fiscal years 2011 and 2012 break out the start-up and capital expenditures. The capital expenditures include the investments necessary to develop the initial marketing materials, standard legal agreements and legal infrastructure, recruiting cost for initial staff and development of staffing strategies, purchase of initial furniture and equipment, implementation of technology and other administrative start up costs such as costs for incorporation and fees for initial set up and design.

The asset and asset management investments are reflective of the optimal asset mix contemplated for the NPO operations. The NPO design is human capital intensive, which is further described in other areas of this study.

The grant funding awarded by the NPO would be provided to recipients to support the projects along a research pathway as well as education projects. The NPO grant funding consists of funding provided by NASA as well as funds raised by the NPO to award directly as grants.

The external funding line item describes the funding that the external private and public sources would provide to fund research. This money does not actually flow through the NPO, but is indicative of the possible amount of investments for research that could be done leveraging ISS resources. This consists of funding that is either matched using the Marketplace or funding that supports projects that would selected that have already been funded by a sponsoring organization

This preliminary budget has been constructed using market data, results from interviews, and ProOrbis' experience in transforming businesses to develop a practical model for a self-sustaining enterprise.

Self-sustainment is in keeping with the goals of value maximization as well as the intent of the 2005 NASA Authorization Act to "increase utilization… through partnerships, cost-sharing agreements, and other arrangements that would supplement NASA funding of the ISS"

Conclusion

The model for this enterprise is both effective as an operation and has the ability to be self-sustaining with a relatively modest cost profile (less than fourteen million dollars per year). Once up and running it can attract total funding for research and education projects of well over one-hundred million dollars per year (cost of research). Not all of these research funds would flow through the NPO, but it is a good indication of the volume of activity the NPO can manage.

The value of the research managed is a result of the nature of the projects and how they add value to the American people. These numbers could and should easily be in the billions of dollars (value of research). Estimating this value through the valuation frames and monitoring results through a comprehensive dashboard will create accountability and provide vital information for designing better, more valuable projects over time.

Message from the Authors

The International Space Station is a remarkable human endeavor. There are those who argue that it has already returned substantial value to the American people based on its triumph as one of the world's great engineering feats and as a symbol of international peaceful cooperation. It is arguably one of the county's most valuable assets for sparking the imagination and interest in science, technology, math and engineering. Perhaps that is enough; but it was not the objective of this study.

Our goal was to maximize the value of the investments in ISS using the ProOrbis® Method. In for-profit firms this approach benefits the shareholders. In this model, the results are designed to benefit the American people. They are the shareholders of ISS.

Maximizing value for them was not a matter of ease or expediency. Indeed, if this were easy, it would have already been done. In fact, this is a challenging management undertaking and more sophisticated approaches were needed to solve for all of the variables and to develop a practical model. The result is a very carefully architected, lean, fully integrated enterprise. Seemingly small changes could dramatically affect the efficacy of the model and balloon the cost profile.

This is not to say that there are not similar challenges throughout government and that some of these approaches would not be useful for solving a host of intractable issues. Just remember, that every organization presents a unique assemblage of assets and opportunities. Therefore a solution that works well for one circumstance may not work in another.

This is the strength of the ProOrbis® Method. Comprehensive frames and microeconomics allow us to apply our approach to the specific conditions of an organization and come up with a remarkable result for that particular organization for a particular time in its history. This is the optimal model we could formulate with the information we have. Could this have been done years ago? We do not know, but we do know that it can be done now.

ISS is an asset with a useful life. Every month that goes by that it is not being fully utilized with value-creating projects, the American people lose value. There is no doubt that delay is destroying value. We hope this model will help to accelerate the implementation of a new management organization to seize the opportunities to create the next frontier of science that will deliver results for the American people.

It has been a genuine honor and privilege to be a part of this project.

Appendices

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Appendix A - The ProOrbis® Framework and Credentials

The ProOrbis® Framework is a strategic paradigm that defines the value-oriented architecture for an enterprise including business strategy (positioning), operations design (capabilities), asset portfolios (including tangible and intangible assets) and asset management. The Framework classifies and connects all the activities of the enterprise into a fully integrated, interoperable system that links value to the investment the enterprise makes in its **own** capabilities. This evolution of the concept of productivity can dramatically improve performance for publicly traded, private, non-profit, and governmental enterprises.

ProOrbis® Enterprise Applications are the tools and techniques configured to real business situations and designed for a particular client need. These Applications transform segments of businesses, individual businesses, portfolios of businesses, and extended enterprises by taking a systematic and comprehensive approach that links to value. Using the best of what a client currently has, strategies are created that leverage the strengths and identify gaps for a fast, high ROI transformation. Projects are architected from strategy through execution — designed to build the client's capability throughout their transformation to sustain improvements.

ProOrbis® Informatics Applications are deployed in a wide variety of tools designed to support more intelligent decision-making. ProFrameware™ is the newest application for on-going decision support that leverages the client's existing data and information technology into a new capability that fully integrates their spatial, process flow, and/or data array modeling using the ProOrbis® Framework. Our comparative tools put an organization's performance into a context — over time, against industry peers, or against a supply chain. Fully narrating the analysis for both traditional and ProOrbis® Signature Measures provides managers with insights to effectively use comparative data.

ProOrbis® Licensed Application Development is an innovative way to engage ProOrbis management scientists to develop a unique Application for a company's ongoing use. Whether to build new internal capabilities (such as strategy and planning) or for new commercial services to offer to the market, ProOrbis has a variety of opportunities for collaboration that can improve performance. This is especially useful for complex extended enterprise networks that need interoperable and highly integrated operations.

ProOrbis collaborates with universities, trade groups, publishers, think tanks and government institutions to advance the recognition, accounting, valuation, and management of the world's tangible and intangible assets. The mission is to help design companies and economies that create a more productive, sustainable world.

ProOrbis® Method: Defined

The **ProOrbis® Method** is comprised of the comprehensive Framework and real-world Applications.

- **The ProOrbis® Framework** is a combination of strategic and analytic concepts with a project approach that offers a comprehensive, integrated, and value-oriented paradigm for managing the ROI of the tangible and intangible assets of an enterprise.
- **ProOrbis® Applications** are tools and techniques configured to real business situations that are designed for particular client needs. These Applications produce strategies, plans, and change facilitation designed to execute - resulting in dramatic improvement. The ProOrbis® Framework is applied to each enterprise through a licensed Application which is customized for each client. Highly skilled ProOrbis certified staff design projects to create a high return on the client's investment in the Application project. This can range from designing projects that clients can execute on their own, to facilitated projects in which ProOrbis develops tools for the client to use, to heavily resourced projects for our clients who do not have project resources available. All ProOrbis projects are a world-class development experience for the internal staff involved which creates significantly enhanced capability within the company. Advanced Optimization Applications are available for clients who have completed an Application and have the requisite capabilities to use more advanced ProOrbis® Methods.

Project Approach ProOrbis® Applications are fully integrated and linked to value and therefore they create systemic improvements. As ProOrbis and clients work through any challenge, the project approach employed begins with high level architectures in all areas of the model and then drills down to more detailed designs. Change management is not a "separate event", but is built into the process. This integrated approach ensures that decisions are made in the right order, the links to value are always present, and that remarkable shifts occur with speed and discipline — creating excitement, momentum for change, and real-world results.

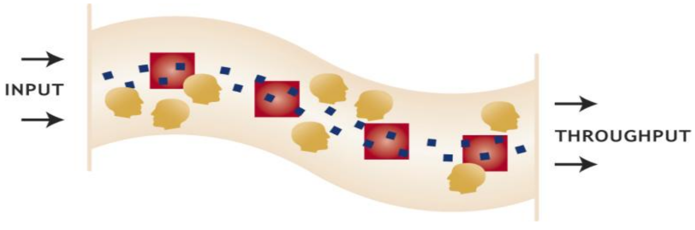
Client Profile ProOrbis clients are generally leaders in their categories, often with a long track record of success. They range in size and nature, but are often complex, global businesses with a wealth of expertise. ProOrbis brings a new perspective to help them meet the next challenge – dramatic growth, productivity improvement, or migration to a new market by uncovering opportunities and a path to seize them. A ProOrbis project is ideal for senior executives who are new to their positions and need a fresh, comprehensive perspective as well as established executives who are staging for a major shift in the organization's growth or profitability.

ProOrbis® Framework

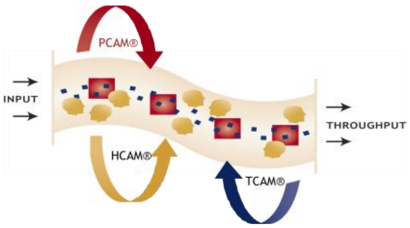
Market Positioning Market Positioning is essential to the understanding of how and where a business creates value. By discovering the areas where an organization's market opportunities intersect the organization's capabilities, clients are able to better identify the market space into which offerings (products and services) are best positioned. The future positioning is determined by trending the market and establishing the requirements for the organizational capability shift. This provides a transformation trajectory for the organization's offerings and capabilities — a clear, actionable business strategy.

Organizational Capability Organizational capability is everything the organization *can* do; on it's own or through its extended enterprise such as shared services, suppliers, alliances, partnerships, etc. The organization's capability is comprised of three core assets – physical capital (PC), including all tangible assets; technology capital (TC), including product technology, R&D, information technology and process technology; and human capital (HC), including employees and contract staff. An asset, tangible or intangible, is any productive means the organization materially controls that can be used to create value. These three core assets are combined (by process technology) into production functions that are designed to take *Inputs* and produce valuable output – *Throughput* – which are the offerings designed to execute the positioning. Since the assets *in combination* create the organization's capability, then return on the asset investments of the enterprise (R) can be calculated:

$$\frac{\text{Throughput - Input = Value of the Assets}}{\text{Investment in Human, Physical, and Technology Capital}} = R$$



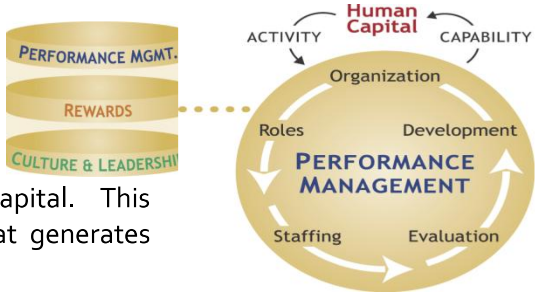
Asset Management



An Asset Portfolio is a collection of assets. Asset Management is the organizational capability that manages the lifecycle of the portfolio including: strategy, planning, organizing, acquiring, maintaining, upgrading, and divesting. There are three principal asset management capabilities: **Human Capital Asset Management (HCAM®), Technology Capital Asset Management (TCAM™), and Physical Capital Asset Management (PCAM™).**

All assets in the enterprise are either in the business of creating Throughput or creating Assets. Therefore, there is no "overhead." Assets derive their value from the organizational capability for which they were acquired. Therefore, the investment in assets has a value — and therefore a ROI.

Although this approach addresses the performance of all tangible and intangible organizational assets, human capital is the most misunderstood and "under-worked" asset ; creating significant opportunities for productivity improvement in most organizations, industries, and countries.



Human Capital Asset Management (HCAM®) HCAM® is the management system that produces the right human capital to do the work required to execute the capability. This is a fully integrated approach to the performance management, rewards, culture, and leadership designed to optimize the ROI in human capital. This paradigm clarifies *how* to make investments in human capital that generates value in business terms.

Dashboards One of the hallmarks of the ProOrbis approach is world-class analytics, particularly in the measurement of tangible and intangible assets and value. Dashboards are fully integrated with analytics designed to describe, explain and predict performance to inform decisions and track results. The dashboard cascades from equity market performance, to the return on both tangible and intangible assets, to the performance of plans and programs that manage assets. Dashboards are used for highest organizational view to the individual level.

ProOrbis History

ProOrbis is a small business founded in 1998. They have been a member of WBENC (Woman Business Enterprise National Certification) since 2006 and have had a GSA Schedule 874 MOBIS (Mission Oriented Business Integrated Services) contract since 2003 to deliver services to Federal Government clients.

All ProOrbis products and services are built on ProOrbis' proprietary methodologies that were developed by the Principal, Jeanne DiFrancesco. ProOrbis has developed an entire suite of unique and trademarked applications of these methodologies. ProOrbis consultants apply these methodologies to a wide range of real world issues (see ProOrbis Business Description). These methodologies may only be employed by ProOrbis and licensed clients, partners, or vendors.

ProOrbis' clients are licensed and trained to use the application developed specifically for them, which often leads to performance improvements even while a project is underway. This is different from many consulting organizations that do not transfer capabilities to the client. Also, unlike other consulting organizations that focus on cost reductions, ProOrbis methods provide tools for value creation and return on investment.

Credentials

Ms. Jeanne DiFrancesco is the Principal of ProOrbis, LLC. She holds an MBA from University of Pennsylvania: Wharton School of Business and an interdisciplinary undergraduate degree from the College of William and Mary. She is the author of the ProOrbis® Framework, the breakthrough strategic paradigm and economic techniques for managing the investments in and value of both tangible and intangible assets to make investments that achieve dramatically improved returns. She has over 25 years of executive and strategic level experience with leading companies in health sciences, electronic materials, investment banking, insurance, financial operations, power generation, logistics, the U.S. Federal Government, and the Department of Defense.

Ms. DiFrancesco authored a course for the Institute of Management Accounting (IMA) on "Valuation and Accounting for Intangible Assets", and has participated in Financial Accounting Standards Board activities to set standards for U.S. and international accounting.

Ms. DiFrancesco speaks frequently at conferences and is an expert advisor for various groups. She has worked with: The Human Capital Institute (HCI), The American Nuclear Society (ANS), The Conference Board, Institute of Human Resource Information Management (IHRIM), the Brookings Institution, Drexel University, The Harvard Club, and continues as a long-time guest lecturer at the Wharton School.

ProOrbis Publications

- "The Power of Prediction: Improving the Odds of a Nuclear Renaissance". Montgomery Research, The Utilities Project Volume 8. May 2008.
- "The Liability of Cost Cutting: A CEO's New Challenge". Montgomery Research, The Utilities Project Volume 7. May 2007.
- "Workforce Renewal: A CEO's Strategic Imperative". Montgomery Research, The Utilities Project Volume 5. May 2005.
- "Managing Human Capital as a Real Business Asset". IHRIM Journal. March 2002.
- "Human Productivity: The New American Frontier". National Productivity Review. Summer 2000.

Publications Featuring ProOrbis

- Barney, M and McCarty, T. "The New Six Sigma". Prentice Hall. 2003.
- Osterland, A. "Decoding Intangibles". CFO Magazine. April 2001.
- Barney, M. "Macro, Meso, Micro: Human Capital". The Society for Industrial and Organizational Psychology. September 2001.
- Financial News Network. 2000.

Appendix B - **Post-Shuttle Transportation Capabilities**[25]

		Up Mass		Down Mass	
		Internal	**External**	**Internal**	**External**
Human and Cargo	**Soyuz**	*Powered: Special accommodations only *Late Load *Racks: None *Items up to 5 kg in vehicle containers *Larger items installed in special transport frames	None	*Items up to 5 kg in container under crew seat *Special container available for larger items if only two crew on return	None
	Dragon	*Powered: Double MLE *Late Load: *Racks »3300 kg mass	Trunk capability	*Powered: Double MLE *2500 kg return *Early destow at dock available	None
Cargo Only	**Progress**	*Powered: Special allowance only *Late Load *Racks: None *Items up to 8-10 kg in vehicle containers *Larger items installed in special transport frames	None	None	None
	Cygnus	*Powered: Double MLE *Late Load *Racks »2000 kg mass (standard) »2700 kg mass (expanded)	None	None	None
	ATV	*Powered: None *Late Load »Up to 10 CTBEs late access »Late Load = 50 kg/2 CTBE max »Late Exchange = 1 to 1 bag replacement (mass & size) *Racks »Up to 8 passive racks »Type A (Jules Verne) racks carry up to 19 CTBEs in standard CTBs »Type B (Integrated Light Rack) may carry up to 24 CTBEs in standard and nonstandard CTBs	None	None	None
	HTV	*Powered: None *Late Load *Racks » Up to 8 passive racks » Forward Bay: ISPR compatible » Aft Bay racks fixed: HTV Resupply Rack	Exposed Pallet	None	None

Appendix C - **Bayh-Dole Requirements**

The Bayh-Dole requirements, along with the policy objectives are codified in 35 U.S.C. § 200-212 and summarized below::

Application Applies to inventions made by universities, non-profit institutions and small businesses that have received federal money to fund their research where the invention was "conceived or reduced to practice in the performance of work under a funding agreement".

Disclosure and Statement Requirements Inventors must disclose their inventions to the federal government in a reasonable time after the invention is disclosed to administrative personnel responsible for patent matters.

- Failure to notify the government may result in title passing to the government, however this happens infrequently.
- All patent applications must contain a statement that "the invention was made with government support and that the government has certain rights in the invention".

Assignment

- Universities/non-profits/small businesses are obligated to have written agreements with their employees requiring disclosure and assignment of inventions.
- These entities may not assign ownership of inventions to third parties, except to patent management organizations.

Government License

- Although the inventor or her employee may elect to retain title to the invention, the funding agency retains a nonexclusive, nontransferable, irrevocable, paid-up world-wide license.
- Generally only has an affect on a patentee when the government is a significant customer.

Compulsory License

- The Act also provides for "march-in rights," whereby the federal government can require the inventor to grant reasonable licenses to third parties under certain circumstances.

Revenue Sharing

- Universities must share a portion of any revenues received from licensing the invention with the inventor(s). Any remaining revenues received after expenses must be used to support scientific research or education.

U.S. Manufacture and Small Business Preference

- Products produced with the use of a federally funded invention must qualify as substantially manufactured in the United States.
- Except where infeasible, patentees must grant licenses to small business firms.
- .

Grant Proposals as Prior Art

- Grant proposals become public upon grant and are indexed and abstracted in online databases. Unless an applicant takes steps to protect the confidential information therein, litigators may use the grant proposals themselves as prior art against patentees.

Appendix D - **University Technology Transfer**

The following is a summary of considerations for working with University's and their Technology Transfer Offices.

a) University Organized Research
   i) Organized research means research and development activities of an institution that are separately budgeted for on a project-by-project basis. Organized Research includes:
      (1) Sponsored research
      (2) University research – i.e. all research and development activities that are separately budgeted and accounted for by the institutions under an internal application of institutional funds, including endowments.

b) University Intellectual Property (IP) Ownership
   i) Researcher's responsibility to disclose patentable IP in exchange for research funding
   ii) A University's policy dictates who owns the IP
      (1) In most cases, faculty created IP owned by the University
      (2) University usually determines what should be patented
      (3) If university decides not to patent, policies typically give the inventor the right to file for patent protection without university ownership
      (4) Federally funded research, Bayh-Dole Act applies
   iii) Remuneration to inventors:
      (1) Usually, faculty share in the consideration for licensing technology, usually in the form of cash or equity (due to lump sum payments for license fees, milestone payments or running royalties).
      (2) If a researcher is a company founder, then he or she often receives equity stake or consulting fees.
      (3) Bayh-Dole requires Universities to share royalties with inventors where research is subject to the Act
      (4) Some universities have provisions for large pay-outs to inventors under certain circumstances

c) Typical University IP Along the Research Pathway
   i) Organized research results in inventions
   ii) Inventor submits an invention disclosure (in a prescribed format) to the university's technology transfer office (TTO)
   iii) The invention is maintained in secrecy until a patent application is filed or a decision is made not to file for patent protection
   iv) The TTO evaluates whether to file a patent
      (1) If no patent is filed, the inventor may be given the right to file the patent and own the patent free of any claim by the University
   v) Patent application is filed
   vi) Research may be published
   vii) Proof of concept research is undertaken
      (1) TTO may be looking to shop the technology for potential licensee
      (2) Consideration may be given to forming a university spin-out
   viii) The technology is licensed to a third party

(1) The university may receive up-front payments, milestone payments, equity, and (upon commercialization) royalties

(2) If a spin-out then the University may acquire a small equity stake

(3) The company will likely seek financing from various sources

ix) Research continues

x) New patent applications filed

xi) Patents issue

xii) Translational research (if appropriate) undertaken

xiii) Regulatory approvals received (where appropriate)

xiv) Commercialization and product sales

d) Valuation of University Technology

i) Valuation varies among industry (physical sciences vs. biotech) and universities. Most may rely on market data (other comparable deals), the amount of savings, the contribution of the technology to the product, the 25% rule, and some will even use Monte Carlo Simulations and the like. Multiple methodologies are used in most cases, but most university technology transfer professionals realize that valuation is also limited by the acceptance of the negotiating party and their best alternative to no agreement."

(1) Bhakuni, Nila, From Conception To Commercialization—University Technology Transfer Practices In The United States, Les Nouvelles (June, p.62)

e) Typical Technology Transfer Office Roles

i) Managing new invention disclosures

ii) Oversight of patent filing decisions

iii) Seek out licensing opportunities

f) Sponsored Research Ownership and Licensing of IP

i) University research sponsored by federal agencies, foundations and for-profit companies.

ii) Federal Agency Sponsored Research

(1) Heavily regulated

(2) University retains ownership of IP, subject to Bayh-Dole Act and university's own IP policies

(3) Data generated from the research is subject to FOIA public right to federally sponsored research data

iii) Non-Federally Sponsored Research

(1) Sponsored research is typically university research sponsored by federal agencies, foundations and for-profit companies.

(2) Each sponsor establishes its own terms, conditions and policies for its awards.

(3) At the outset the university grants an option to negotiate a license for IP created in the sponsored program, however, specific financial terms to the license are not usually made prior to invention

iv) University retains title to IP; not assigned to sponsor; policy rationale may include:

(1) IP generated may be based in part upon prior research and use of facilities and equipment not funded by the sponsor

(2) Sponsor may want or need to use existing IP owned by the University in connection with the sponsored research

(3) University facilities may have been built/enhance through tax exempt bonds; the bonds may lose status if facilities are used for a private, rather than public purpose

g) University Cost Sharing Arrangements
   i) Cost sharing is the portion of a sponsored project not borne by the sponsor (i.e. the University's share of the cost of research)
   ii) Occurs when either the sponsor requires or the university commits funds beyond the award
   iii) Primarily required by Federal sponsors
   iv) Obligation must be met through use of non-Federal funds
   v) Only recipient's direct costs are allowable as cost sharing
   vi) Universities will typically have policies related to cost sharing
   vii) Federal flow through funds may not be used as a cost sharing source without prior approval from the Federal sponsor and the flow through sponsor.
h) Federal Flow through Funds
   i) Federal flow-through funds are awards to a university from a state or local government agency or other non-Federal agency that are funded, in whole or in part, by federal agencies.
   ii) If a university is a sub-recipient of these awards, the university must follow Federal guidelines, as well as award guidelines, in administering the funds.

Appendix E - **Intellectual Property Considerations**

The following is an expanded description of the issues, requirements and interpretation of United States law, rules and regulations and confirmation of specific activities and documentation that are important to understand when analyzing research projects that may go to the ISS-NL.

CONSIDER AND VERIFY INVENTORSHIP/OWNERSHIP ISSUES ASSOCIATED WITH THE PROJECT. Confirm the correct inventorship has been determined and ensure a declaration claiming inventorship and the corresponding assignments by the inventors to the employer or rightful owner of the invention have been signed. Also confirm that the assignments have been recorded in the United States Patent & Trademark Office ("U.S.PTO").

The inventorship determination for the claimed invention must be correct. Inventorship of a U.S. patent application must be accurately determined but it can be corrected if there is no deceptive intent in the original determination of the inventorship (U.S.C. § 116 and 37 C.F.R. §§ 1.48.). If it is not correct, the claims of a patent may be invalid and the patent held to be unenforceable. Additionally, an assignment of the invention from each inventor must be secured via an assignment document which should be recorded in the U.S.PTO. All transactions of the patent rights must involve the employers, if they are now the owners of the patents through the inventors' assignments.

Should an additional person be added as an inventor at a later time after filing the patent application, who is not under an obligation to assign his rights in the patent to an employer, this belatedly added inventor could assign at least his U.S. rights in the entire invention to a third party to the detriment of the prior owner/assignee. This type of dispute would cloud the actual ownership of the patent application, and resulting patent, and may affect the employer's ability to secure exclusivity to and develop and productize the invention. Having exclusivity to an invention translates into possibly securing better investment and funding sources.

Under U.S. patent laws, rules and case law[26], inventorship has two components: (1) conception and (2) reduction to practice. An inventor must contribute to the conception of the invention as claimed. An inventor is the person who thought of the idea of the invention and had a definite plan to execute it. The conception requirement determines most inventorship questions. Reduction to practice may be actual or constructive. Actual reduction to practice occurs when an invention is constructed and operating. Constructive reduction to practice occurs when a patent application is filed.

Generally all employers, including governments, universities and companies, utilize employment agreements which should include a broad statement that requires assignment of inventions to the employer as a condition of employment. The employment agreement is an overriding safeguard but for each patent application filed, the employer should conduct an inventorship investigation and prepare patent application assignments for each inventor to sign. In addition to assigning rights in the specific patent application, it is preferred that the assignment contains language that also includes the inventors' assignment of all future patents or patent applications world-wide derived from the specifically identified patent/patent application. In the absence an employment agreement which controls ownership of invention as a result of employment, the ownership may be subject to varying state laws dealing with intellectual property ownership (e.g., works for hire).

CONFIRM THAT CLAIMS OF A PATENT APPLICATION COVER THE PRODUCT/METHOD. A patent confers a "negative right" on the owner for the right to prevent others from making, having made, using, selling, offering to sell or importing a product or method. So it is important to confirm that the claims of the patent application (and eventually the patent) cover the inventions of the project work and results. By confirming the connection between claim scope and product/method, the patent application will hopefully be more valuable, and thus will attract more and better funding sources.

OBTAIN INFORMATION REGARDING ANY PUBLIC DISCLOSURE OF THE PROJECT PRIOR TO FILING A PATENT APPLICATION. If a patent application has been filed prior to the project coming to the NPO for prioritization, it is important to request information on the following disclosures made prior to the filing of the patent application:

- any public disclosures by the researcher of the project or of related research to the project in any documents including patent applications, posters or oral presentations
- any disclosure to third parties where the communication was not subject to a confidentiality agreement
- any public disclosures by third parties that are similar to the research area of the project

If such disclosures are very similar to or the same as the claimed subject matter o the researcher's filed patent application, these disclosures may be a barrier to obtaining a patent. In the U.S. a patent application must be filed no later than within one year after the first publication, offer for sale or commercial use, for these activities not to block later patenting of the disclosed invention. The one year "grace period" is similarly applicable so that should any third parties publish information similar to the subject matter of the project, such publication would not prevent patenting in the U.S. But the majority of the foreign patent laws allow the use of publications by the inventor and/or third parties to reject the patent application, even if the publication is made one day prior to the filing of a patent application. Therefore, knowing about these publications and addressing these issues early on is important in making the project potentially more attractive to funding sources.

MAINTAIN CONFIDENTIALITY OF THE PROJECT IF A PATENT APPLICATION HAS NOT YET BEEN FILED BY THE RESEARCHER. The NPO staff collecting the information and reviewing the project research should maintain confidentiality of the disclosure for some set period of time to allow the filing of a patent application by the researcher if this is desired. A process for maintaining such confidentiality should be adopted. It may be necessary to have the NPO staff sign a confidentiality agreement with the researcher. Additionally, it may be necessary to have the funding sources also sign a confidentiality agreement.

MATERIALS WITH BIODIVERSITY ISSUES. Depending on where they were originally obtained, genetic resources[27] utilized in the projects may be subject to underlying ownership rights, requirements for prior informed consent to utilize the resources and/or benefit-sharing obligations. These underlying ownership rights could be national/federal, state, municipal, territorial, tribal and/or private. More than one entity may have co-ownership rights in a single genetic resource. Due to the extreme sensitivity of some entities to what is generally termed "bioprospecting" or "biopiracy" of their sovereign rights to genetic resources, it is very important to establish clear title to the underlying genetic resources so as to avoid ownership disputes and possibly international incidents that could tarnish the reputation of the NPO and the other individuals or organizations associated with a relevant project.

Initially a determination should be made as to whether or not the genetic resources fall within the Convention on Biodiversity (CBD). While the United States is not a signatory to the CBD, more than 150 governments have signed the international treaty. The objectives of the CBD are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding. If a determination is made that the genetic resources involved with a project are subject to the CBD or some other ownership rights due to their place of origin, then an investigation and report regarding ownership and title to the resources could be required before approving the project for prioritization.

INVENTION OCCURRING ON ISS. There may be issues with ownership of inventions made in low Earth orbit on the ISS. It seems likely that experiments that are planned on the "ground" by the researcher and his co-inventors(s), if applicable, and packaged for placement on the ISS and performed on the ISS would not change the initial pre-ISS inventorship determination. According to U.S. laws, for "joint inventorship" to occur the joint inventor must have contributed to the conception of the invention. Merely assisting in the reduction to practice by experimentation is not sufficient for ISS crew to become inventors of the experiments that they perform on the ISS even if ISS would run additional (unplanned but related) experiments. This scenario is highly unlikely given the limited crew time resources presently available. Thus, ownership of an invention will likely remain with the researcher and any joint inventors as determined prior to the performance of the experiments on the ISS because it is unlikely that the inventorship will change as a result of any experimental activities performed on the ISS.

But should any further invention be considered to have taken place on the ISS, 35 U.S.C. §105 of the United States patent statute explains that any invention made in outer space on a "space object or component thereof" which is owned or is under the control of the United States is considered to have been made within the United States, unless otherwise provided by an international agreement to which the United States is a party.

In accordance with Article 5 of the Intergovernmental Agreement (IGA), each country is to register as space objects the flight elements that it provides to the space station and that the country will retain jurisdiction and control over all of the elements it registers and over personnel in or on the ISS who are its nationals.

Additionally, Article 9 of the IGA dictates that "for the purposes of intellectual property law, an activity occurring in or on the Space Station flight element shall be deemed to have occurred only in the territory of the Partner State of that element's registry, except that for European Space Agency (ESA)-registered elements any European Partner State may deem the activity to have occurred within its territory."

OBLIGATIONS PLACED ON IP BY OWNER OR PREVIOUS FUNDING SOURCE. The review and consideration of any obligations placed on the intellectual property by the owner or by previous funding sources can contribute to the attractiveness of the project if these obligations are in compliance.

EMPLOYERS Generally funding of basic research at universities comes from the university operating funds, individual grants applied for by faculty/researchers or university grants, or private or public funding sources or foundations set up to fund certain departments or institutes at the university. Obligations that are attached to the receipt of funding sources are varied.

Employers of the inventors generally require the assignment of the intellectual property as a requirement of employment if invented using the employers' resources and related to the inventor's responsibilities. In this way, the employers become owners of the intellectual property and control it. This is a requirement if the federal funding was used in whole or in part where the invention was conceived or reduced to practice using federal funds. Should the inventions be licensed, developed and ultimately developed into industrial R&D applications, both the employer, such as a university or company, and the inventor(s) will receive compensation. If the employer is a university, generally, these proceeds are shared with the inventors or with specified university departments. This information is readily available for universities because their intellectual property policies are available online.

If the employer is not interested in patenting an employee's invention, the employer may return the employee's invention to him or her to file for a patent application and attempt to license the invention on his or her own. In fact, some employers, such as some universities, have policies in place that require this to be done. In these circumstances, the employer may retain a small percentage of future royalties should the invention ever become an industrial R&D application.

But if the employer is a company, the inventor who works in research and development is regarded as having been "hired to invent," with the salary received as consideration for this work. In these cases, inventors may receive a small cash award generally less than $500.

RESTRICTIONS AND REQUIREMENTS OF GOVERNMENT FUNDING. The Bayh-Dole Act is United States legislation directed to any intellectual property that arises from federal government funded research. The Act is a set of regulations that implements federal patent and licensing policy regarding "Rights to Inventions Made by Nonprofit Organizations and Small Business Firms," which is codified at 37 CFR Part 401.

The Act allows the transfer of exclusive control over many government funded inventions to non-profit organizations, including universities, and small businesses, for the purpose of further development and commercialization. In exchange for retaining the title in the invention, the organization or small business is required to comply with certain enumerated filing and reporting activities and a restrictive non-assignment provision.

The federal government, however, retains a non-exclusive, non-transferable, irrevocable, paid-up license to practice or have practiced the invention on its behalf throughout the world and also retains "march-in" rights to license the invention to a third party, without the consent of the patent holder or original licensee, where it determines the invention is not being made available to the public on a reasonable basis.

But in reality, the government's "march-in" rights have never been exercised. March-in petitions have been filed by third parties but they have always been denied by the federal agency for a number of reasons. Particularly, in *In Re Petition of CellPro, Inc.* CellPro petition NIH and argued that The Johns Hopkins University ("JHU") and its licensee, Baxter Healthcare, had failed to commercialize certain stem cell technologies and that JHU should be forced by NIH to license its patent to CellPro. NIH denied this petition because JHU had licensed the invention to Baxter Healthcare who had applied to the Food and Drug Administration for approval. NIH was not convinced that JHU's patents needed to be licensed to CellPro for health and safety reasons. Another reason NIH provided was that the march-in decision would have a negative effect on federal efforts to commercialize federally funded research.

Two other petitions to NIH to exercise its march-in rights were denied on various grounds but both of these petitions asked NIH to march-in to control the prices of drugs. NIH refused and basically stated that it should not address the issue of drug pricing.

Further, Bayh-Dole requires that a licensee holding an exclusive license to a product produced with the use of a federally funded invention must qualify as substantially manufactured in the United States. Waivers may be granted but it must be shown that efforts were made to find a company that would manufacture in the United States or that manufacture in the United States would not be economically feasible.

Also patentees must preferably grant licenses to small business firms (less than 500 employees) provided these firms have the resources and capabilities to market the invention.

However, large entity companies that have provided research support that led to invention may be awarded a license. There is no evidence that the United States government has ever enforced these provisions.

It is important to verify that the researcher and its employer have complied with the reporting requirements of this Act.

Non-U.S. Countries "March-In" Policies. Some countries other than the United States have requirements that within a certain time period after a patent is granted in that country, the patentee must provide evidence in the form of statements or activities confirming commercial use. If this information or activities are not provided to the satisfaction of the countries' patent office, third parties can "march-in" and market the product regardless of the patent rights.

The various intellectual property attachments, considerations for previous funding sources and applicable laws and regulations will have an impact on the attractiveness and appropriateness for various potential funding sources. This understanding is imperative in matching the right funding sources with projects in the marketplace.

Appendix F - **Inventions in Outer Space on the ISS-NL**

OWNERSHIP AND CONTROL OF THE INTERNATIONAL SPACE STATION. The International Space Station (ISS) is governed by an Intergovernmental Agreement (IGA) between the 15 member states including, The United States, Canada, Japan, Russia and 11 European Countries (Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom), collectively known as "the European Partner". The IGA, discussed in more detail below, allows each member country to extend their national jurisdiction to the space station and specifically to the elements and laboratories they provide on the space station. These elements/laboratories are assimilated to the territories of the member countries. Therefore, the ISS can be viewed as a conglomeration of distinct and separable jurisdictions on one structure, so that an invention made in the U.S. portion of the ISS would be viewed as being made within the United States while an invention made in a Japanese laboratory would be viewed as being made within Japan.

INTELLECTUAL PROPERTY CONSIDERATIONS FOR INVENTIONS MADE IN SPACE. According to 35 U.S.C. § 105(a), any invention made in outer space on a "space object or component thereof" which is owned or is under the control of the United States is considered to have been made within the United States, unless otherwise provided by an international agreement to which the United States is a party.

We construe "space object" to include the International Space Station. Therefore, if an invention is made within the ISS National Laboratory allocation, this invention would be deemed to have been made within the United States for the purposes of U.S. Patent Law.

Additionally, 35 U.S.C. § 105(b) provides that any invention made on a "space object or component thereof" that is carried on the "registry" of a foreign sate in accordance with the Convention on Registration of Objects Launched into Outer Space, are considered to be made by the United States if agreed upon specifically in the international agreement between the U.S. and the state of registry.

INTERGOVERNMENTAL AGREEMENT. An Intergovernmental Agreement (IGA)[28] concerning cooperation on the civil international space station was signed on January 29, 1998 between the United States and 14 other governments.

In accordance with Article 5 of the IGA, each country is to register as space objects the flight elements that it provides to the space station and that the country will retain jurisdiction and control over all of the elements it registers and over personnel in or on the ISS who are its nationals. Additionally, Article 9 of the IGA dictates that "for the purposes of intellectual property law, an activity occurring in or on the Space Station flight element shall be deemed to have occurred only in the territory of the Partner State of that element's registry, except that for ESA-registered elements any European Partner State may deem the activity to have occurred within its territory."

CONVENTION ON REGISTRATION OF OBJECTS LAUNCHED INTO OUTER SPACE. The United Nations requires UN member states to provide the UN with information on any launchings of any material into outer space. The UN has maintained a registry of launchings since 1962 in accordance with General Assembly resolution 1721 B (XVI). The Registration Convention provides that each state should furnish (i) the name of the launching state; (ii) an appropriate designator of the space object or its registration number; (iii) date and territory or location of launch; (iv) basic orbital parameters; and (v) general function of the space object.

Thus, in accordance with 35 U.S.C. § 105(b), if a selected experiment is launched by another country, i.e. Russia, and is a part of a Russian registry with the UN, it should be considered whether that launch is one specifically agreed upon between the U.S. and Russia to be a multi-country launch with the experiment, and therefore the invention, belonging to the United States.

INVENTIONS DEEMED TO HAVE BEEN MADE OUTSIDE THE U.S. Some countries require that any invention made within their jurisdictions must be filed as a patent application within their countries prior to applying for patent protection abroad. The United States, European Union, and Japan do not require that inventions be filed in their country of origin first. However, in accordance with Article 35 of Russian Patent Law, any invention that is developed in Russia should be first filed in Russia and that a patent application may be filed in another country only after three months from the date of filing in Russia. Canadian Patent Laws have a requirement similar to the Russian requirement for inventions made by Canadian government employees only.

Therefore, if a selected invention is deemed to have been made in Russia under Articles 5 or 21 of the IGA or due to its UN registration, it would be important for any patent protection to be filed in Russia at least three months prior to the filing of a patent application in any other country, including the United States. Failure to do so could result in civil and/or criminal penalties.

Appendix G- **CRADA**

A CRADA (Cooperative Research and Development Agreement) is an agreement between a private company and a governmental agency to work together on a research project. The following is an overview on the protocols for using a CRADA:

- CRADA must benefit each party to the agreement.
    - Advance the research
    - Prototype development
    - Commercialization
    - Product improvement
    - Positive Public Relations
- Technology developed with public funds transferred to the private sector for commercial use or developed by private sector transferred to the federal government for federal government use.
- National laboratory may license, assign or waive its rights to intellectual property.
- National laboratory may grant patent license for invention to collaborating "other business entity," such as federal agencies; state/local government; corporation/limited liability corporation/partnership; foundations; non-profit organization; individual person.
- National laboratory may grant patent license to funding source for invention made prior to CRADA.
- National laboratory may accept, retain and use funds, personnel, services, equipment and property from the funding source and can provide personnel, services, equipment and property to funding source towards the conduct of research & development efforts consistent with the efforts of the laboratory.
- Special consideration is given to small business funding sources.
- Preference is given to CRADAs which manufacture the product in the United States.
- Typical CRADA term is 3 to 5 years.
- Research results are exempt from Freedom of Information Act (FOIA) disclosure for 5 years.
- Requires public recognition of federal laboratory.

Appendix H - **User Fees for Use of NASA and ISS Resources**

User Fees for Use of NASA and ISS Resources. Most users and implementation partners will need to have at least some access to NASA resources, including access to or use of NASA personnel, expertise, services, equipment, information, intellectual property, or facilities. Users and implementation partners may need access to NASA test facilities, specialized knowledge about payload development, or personnel who can provide assistance with research concepts. As set forth, all users and implementation partners will also need NASA to provide assistance with payload integration and to arrange for payload launch, processing on the ISS, and payload and data return.

As a threshold matter, there is no doubt that NASA is statutorily permitted to make its resources available to users. The GAO has stated as a general principle that: "It is fundamental that Federal agencies cannot make use of appropriated funds to manufacture products or materials for, or otherwise supply services to, private parties, in the absence of specific authority therefor." See 28 Comp. Gen. 38, 40 (1948). Here, the 2005 NASA Authorization Act provides such "specific authority" by directing the NASA Administrator to ". . . seek to increase utilization of the ISS by other Federal entities, and the private sector through partnerships, cost-sharing agreements, and any other arrangements. . . ." P.L. 109-155 § 507(b)(1).

The following is an analysis for government and non-government users for whether:

- NASA is obligated to charge the NPO, other government agency users, or non-government users for the use of NASA resources, or
- whether it should levy charges as a matter of policy even if it is not obligated to do so.

Non-Government Users

Whether NASA is Obligated To Charge User Fees. According to the GAO, "A user fee may be defined as a price charged by a governmental agency for a service or product whose distribution it controls, or any charge collected from recipients of Government goods, services, or other benefits not shared by the public". See Principles of Federal Appropriations Law (3d ed.), Vol. III, at 12-143.

The general federal statute that governs user fees provides:

> The head of each agency (except a mixed-ownership Government corporation) may prescribe regulations establishing the charge for a service or thing of value provided by the agency. Regulations prescribed by the heads of executive agencies are subject to policies prescribed by the President and shall be as uniform as practicable. Each charge shall be:
>
> (1) fair; and
>
> (2) based on—
>
> (A) the costs to the Government;
>
> (B) the value of the service or thing to the recipient;

(C) public policy or interest served; and

(D) other relevant facts.

While the statute permits an agency to impose user fees, it does not impose any requirement that an agency must impose such fees (31 U.S.C. § 9701(b). *See Aeronautical Radio, Inc. v. United States,* 335 F.2d 304, 307 (7th Cir. 1964), *cert. denied,* 379 U.S. 966 (1965). Nor are we aware of any other statute would obligate NASA to charge non-government entities any user fees.

It is possible to conclude that NASA cannot charge any user fees at all to potential users of the ISS-NL, because it has not promulgated regulations concerning such fees. *See Alaskan Arctic Gas Pipeline Co. v. United States,* 9 Cl. Ct. 723, 732–33 (1986), *aff'd,* 831 F.2d 1043 (Fed. Cir. 1987) (issuance of regulations a "condition precedent"). A simple policy statement to the effect that fees will be charged for special services has been held too vague to support fee assessment. *Diapulse Corp. of America v. FDA,* 500 F.2d 75, 79 (2nd Cir. 1974). Here, NASA does not appear to have promulgated regulations concerning such fees to potential users of the ISS-NL.

NASA INTERNAL POLICY. NASA has promulgated an internal policy that sets forth guidelines to be used by the agency in determining whether to charge user fees. *See* NASA Policy Directive NPD 1050.1I, Authority to Enter into Space Act Agreements. The policy distinguishes between the following types of Space Act Agreements:

- Reimbursable Agreements are Agreements wherein NASA's costs associated with the undertaking are reimbursed by the Agreement Partner (in full or in part). NASA undertakes Reimbursable Agreements when it has unique goods, services, and facilities not being fully utilized to accomplish mission needs, which it can make available to others on a noninterference basis, consistent with the Agency's missions.
- Nonreimbursable Agreements involve NASA and one or more Agreement Partners in a mutually beneficial activity that furthers the Agency's missions, wherein each party bears the cost of its participation, and there is no exchange of funds between the parties. Since Nonreimbursable Agreements involve the commitment of NASA resources, the respective contributions of each Agreement Partner must be fair and reasonable under the circumstances. . . . (See NPD 1050.1I ¶¶ a & b.)

In a Guide promulgated in accordance with this Policy (*See* NPD 1050.1I ¶¶ a & b.), NASA further explained, "It is appropriate to use a nonreimbursable SAA where NASA and its partner(s) are performing activities collaboratively for which each is particularly suited and for which the end results are of interest to both parties". *See* Space Act Agreements Guide, NASA Advisory Implementing Instruction 1050-1A, § 1.4.

It appears that NASA should conclude, under its internal policy, that it should enter into Nonreimbursable Agreements with ISS users, on the ground that the purpose of these agreements is "a mutually beneficial activity that furthers the Agency's missions."

POLICY CONSIDERATIONS. It would appear contrary to Congressional intent for NASA to charge fees for potential users of the ISS-NL. In the 2005 NASA Authorization Act, Congress directed the Administrator to "seek to increase the utilization of the ISS by other federal entities and the private sector". P.L. 109-155 § 507(b)(1). In the 2008 NASA Authorization Act, Congress contemplated that NASA should include in its budget plan the projected amounts to accomplish the objectives supporting the users of the ISS-NL. There is no indication that Congress anticipated NASA would charge user fees to non-governmental users of the ISS.

Moreover, imposition of user fees would discourage many potential users from utilizing the ISS-NL. Unless the fees were nominal in amount and fixed in advance, many users would likely conclude the potential fees could make the potential investment uncertain and unattractive. Since the ISS-NL is a national resource with a limited lifespan for potential use, it would be unwise to impose any kind of charge that would discourage full utilization of the resource.

Government Users

WHETHER NASA IS OBLIGATED TO CHARGE USER FEES TO OTHER GOVERNMENT AGENCY USERS. The Space Act, Pub. L. No. 85-568, provides NASA with the authority to provide resources to other government agencies without seeking reimbursement. The Act gives NASA the authority:

> to use, with their consent, the services, equipment, personnel, and facilities of Federal and other agencies with or without reimbursement, and on a similar basis *to cooperate with other public and private agencies and instrumentalities in the use of services, equipment, and facilities*. Each department and agency of the Federal Government shall cooperate fully with the Administration in making its services, equipment, personnel, and facilities available to the Administration, and *any such department or agency is authorized, notwithstanding any other provision of law, to transfer to or to receive from the Administration, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies or equipment*.

It appears that this provision provides NASA with the authority to provide services and supplies to other government agency users on a non-reimbursement basis (P.L. 85-568, § 203(c)(6).

Absent this provision in the Space Act, the government-wide Economy Act, 31 U.S.C. §§ 1535-1536, which addresses the circumstances in which one agency may ask another to provide goods or services, might be read to require a user agency to order services from NASA, and to require NASA to charge the user agency for services provided. Given the language in the Space Act, however, it is unlikely that the Economy Act would be deemed to apply.

Moreover, the internal NASA policy discussed above, NPD 1050.1I ¶¶ a & b, applies to government agencies as well as non-government entities. NASA should conclude, under this internal policy, that Nonreimbursable Agreements are appropriate for government agencies seeking to use the ISS, because the object of these agreements would be "a mutually beneficial activity that furthers the Agency's missions."

POLICY CONSIDERATIONS. Imposition of user fees might discourage other government agencies from use of the ISS, but probably not as significantly as non-government users. Especially if the fees were transparently calculated and fixed in advance, other agencies might not view the fees as a substantial impediment to use of the ISS.

If NASA were to seek reimbursement for services, it would likely do so seeking to recover its "actual costs." Payment under the Economy Act, either by advance payment with subsequent adjustment or by after-the-fact reimbursement, must be based on "the actual cost of goods or services provided". 31 U.S.C. § 1535(b). This is a flexible standard, according to the GAO, which has stated that the "actual cost" standard in a given case should be "primarily for administrative consideration, to be determined by agreement between the agencies concerned". 22 Comp. Gen. 74, 78 (1942). The GAO has further explained:

> In general, the reimbursable costs usually consist in large measure of direct costs—expenditures incurred by the performing agency which are specifically identifiable and attributable to performing the transaction in question. As stated, 57 Comp. Gen. at 682: The Economy Act clearly requires the inclusion as actual cost of all direct costs attributable to the performance of a service or the furnishing of materials, regardless of whether expenditures by the performing agency were thereby increased.' One element of direct cost is the salary of employees engaged in doing the work. 12 Comp. Gen. 442 (1932). This means gross compensation (14 Comp. Gen. 452 (1934).). It includes, for example, the accrual of annual leave. 32 Comp. Gen. 521 (1953); 17 Comp. Gen. 571 (1938). Another common element is the cost of materials or equipment furnished to the ordering agency or consumed in the course of performance.

In addition to direct costs, it has long been recognized that actual cost for Economy Act purposes includes as well certain indirect costs (overhead) proportionately allocable to the transaction. *E.g.*, B-301714, Jan. 30, 2004; 22 Comp. Gen. 74 (1942). (Refer to Principles of Federal Appropriations Law (3d ed.), Vol. III, at 12-39).

From a policy perspective (See id. at 12-40), we believe it would unwise for NASA to attempt to recover all of its direct and indirect costs from users, whether they are government or non-government users. The calculation of all such costs could be extremely complicated, and could result in extremely high fees. Thus, if any fees are to be charged, they should have the following characteristics:

- Set far in advance, so that users know the potential fees with certainty;
- Not designed to recapture all direct and indirect costs; and
- Not be set so high as to discourage use of the ISS-NL.

Appendix I - **501(c)(3)**

PUBLIC CHARITIES. There are three general types of public charities: (i) statutory public charities, which are specifically named in the IRC based on the activity in which they engage (e.g., churches, schools, hospitals, governmental units); (ii) publicly supported charitable organizations, which normally receive a substantial percentage of their funding from public sources, such as grants, donations and income from activities related to their exempt purposes; and (iii) supporting organizations, which qualify as public charities because of their close supporting relationship to another public charity.

PUBLICLY SUPPORTED CHARITY. Based on our analysis of the three types of public charities, a *publicly supported charity* or a *supporting organization* meets the requirements for the NPO operations. The IRC provides two different mechanical tests for determining if a charitable organization is publicly supported. The first test is described in IRC 509(a)(1) and 170(b)(1)(A)(vi) (the "509(a)(1) Test"), and the second is described in IRC 509(a)(2) (the "509(a)(2) Test").

TAX EXEMPTION. A 501(c)(3) organization is exempt from federal income tax (except for income from an unrelated trade or business) and may be exempt from state and local income and franchise taxes, sales and use taxes, and real and personal property taxes.

TAX DEDUCTION. Contributions to a 501(c)(3) organization from individuals and taxable entities are generally tax deductible. In general, charitable entities will provide grants only to other tax-exempt charitable entities. As explained below, all 501(c)(3) organizations are further classified as either a "public charity" or a "private foundation." The distinction between whether a 501(c)(3) is a "public charity" or "private foundation" affects the amount of tax deduction available to individuals and taxable entities for contributions of property other than cash. Private foundations also are subject to certain limitations with regard to their ability to provide grants to charities that are not public charities.

STATE CHARTER. The state law charter needs to contain the following provisions: (i) its purposes must be limited to those described in IRC 501(c); and (ii) it must have a dissolution clause that permanently dedicates the corporation's assets to section 501(c)(3) purposes.

IRS APPLICATION. The NPO would need to file an application for recognition of exemption from the IRS on Form 1023 within 27 months from the end of the month in which the state charter is filed. Depending on the jurisdiction in which the organization's office is located, and the activities in which it will engage, it may also need to register for tax purposes (e.g., as an employer) and apply for exemption from state income and franchise tax, state or local sales and use tax, and real and/or personal property tax.

CHARITABLE FUNDRAISING. Since the NPO would engage in charitable fundraising (i.e., soliciting charitable contributions), it may also need to register in the state in which its office is located and in the states whose residents are being solicited.

Appendix J - **Cooperative Agreement**

In the 2008 Authorization Act, Congress provided that NASA could enter into a contract, cooperative agreement, or grant to govern the relationship between NASA and the NPO. Research findings suggest that a cooperative agreement is the preferred instrument.

Permissibility

- **The 2005 and 2008 NASA Authorization Acts Permit a Contract, Cooperative Agreement, or Grant.**
  - Congress has expressly granted to NASA the authority to use a contract, grant, or cooperative agreement, through the Authorization Acts of 2005 and 2008. The 2005 Act directed the NASA Administrator to ". . . seek to increase utilization of the ISS by other Federal entities, and the private sector through partnerships, cost-sharing agreements, and any other arrangements". P.L. 109-155 § 507(b)(1). The Act further provided that the Administrator "may" (not "must") enter into a contract with a non-governmental entity to operate the ISS National Laboratory, subject to applicable federal laws and regulations. *Id.* § 507(b)(2). By this language, Congress clearly contemplated that the Administrator could enter into any type of suitable arrangement, including a standard procurement contract or other arrangements.
  - Even more clearly, the 2008 Authorization Act contemplates that NASA has the authority to enter into a contract, cooperative agreement, or grant. That Act provided for the Plan being developed by NASA to: "identify the organization to be responsible for managing United States research on the International Space Station, including a description of the relationship of the management institution with NASA (e.g., internal NASA office, contract, cooperative agreement, or grant)". This language provides authorization for any of the types of instruments listed.
  - These Acts appear to provide the NASA Administrator with the discretion to use a contract, cooperative agreement, or grant, regardless of any other statutory provision, including the Federal Grant and Cooperative Agreement Act (FGCAA). The GAO has recognized that certain Acts of Congress can be read to exempt programs from the FGCAA. *See, e.g.*, B-279338 (Jan. 4, 1999) (construing statute to permit Interior Department to use contract rather than grant).

- **The FGCAA Permits a Cooperative Agreement***.*
  - Aside from the 2005 and 2008 Acts, the FGCAA permits use of a cooperative agreement. The FGCAA mandates use of a contract when the "principal purpose of the instrument is to acquire . . . property or services for the direct benefit or use of the United States Government". 31 U.S.C. § 6303. A cooperative agreement is mandated when "the principal purpose of the relationship is to transfer a thing of value to the . . . recipient to carry out a public purpose of support or stimulation authorized by a law of the United States". Id. § 6305. As the GAO has stated: "The key question is: Is the principal purpose to serve the immediate needs of the federal government, or is it to provide assistance to a non-federal entity in serving a public purpose?" Comp. Gen. B-227084, Dec. 19, 1988, 1988 WL 228372.
  - Here, it would be reasonable for NASA to conclude that the "principal purpose" of the relationship is to permit the NPO to carry out the public purpose of stimulating and managing use of the ISS-NL, as directed by the NASA Authorization Acts of 2005 and 2008. Whenever a federal agency enters into a

cooperative agreement with another entity, the agency realizes some benefit. But the mere existence of a federal benefit does not preclude the award of a cooperative agreement; otherwise, no cooperative agreement could ever appropriately be awarded.

- In an analogous case, 61 Comp. Gen. 428 (1982), the GAO agreed with the DOE's decision to use a cooperative agreement with a private company to design and construct a prototype solar parabolic dish, because the primary purpose was to encourage development and early market entry, even though secondarily the technology would eventually have governmental applications.
- We do not believe that a cooperative agreement is impermissible merely because the NPO would assist NASA in meeting some of its own mission requirements (such as coordination with other federal agencies). Whenever a federal agency enters into a cooperative agreement with another entity, the agency realizes some benefit. But the mere existence of a federal benefit does not preclude the award of a cooperative agreement; otherwise, no cooperative agreement could ever appropriately be awarded.

- **NASA Has Broad Discretion in Selecting the Appropriate Instrument**. The NASA Administrator is given broad discretion to make the determination of whether a cooperative agreement or procurement contract is the appropriate instrument. The GAO has occasionally reviewed agency determinations, and will uphold any agency determination that it finds to be "reasonable." E.g., Bloomsbury West, Inc., B-194229 (1979). Here, there appears to be a reasonable basis for an award of a cooperative agreement. Even if there is also a reasonable basis for an award of a contract, NASA's decision to use a cooperative agreement would not be subject to challenge.

- **NASA's Internal Handbook Supports Award of a Cooperative Agreement**.
  - NASA has issued an internal "Grant and Cooperative Agreement Handbook" that supports the award of a cooperative agreement here. The Handbook, at § 1260.12(f), provides:
    - "Two essential questions must be asked to ensure that a grant or cooperative agreement is the appropriate instrument. The first question is: Will NASA be directly harmed in furthering a specific NASA mission requirement if the effort is not accomplished? The answer to this question must be "no." The second question is: Is the work being performed by the recipient primarily for its own purposes, which NASA is merely supporting with financial or other assistance? The answer to this question must be "yes." If these criteria are met, then the effort is not a NASA requirement, and can then be considered as to whether it supports or stimulates a public purpose.
  - Under these criteria, the mission of the NPO is not principally a NASA requirement. First, NASA will not be "directly harmed" if the ISS-NL is not utilized by other federal agencies and private sector users. Second, the work to be performed by the NPO is for the benefit of the NPO and the non-NASA users of the ISS, with financial and technical support from NASA, not for the use of NASA.
  - The Handbook also provides:
    - "In applying the principal purpose test, it must be determined whether the Government is the direct beneficiary or user of the activity. If NASA provides the specifications for the project; or is having the project completed based on its own identified needs; or will directly use the report or result of the project for a scheduled NASA mission, then, in most cases, the principal purpose is to

acquire property or services for the direct benefit or use of NASA, and thus, a contractual relationship exists. However, there may be cases where NASA expects to derive some incidental use or benefit from funded activities. In fact, any extramural expenditure that furthers the Agency's goals or mission can be said to be of benefit or use to the Government. But not every expenditure produces for the Government a benefit or use that is direct; i.e., immediate, uninterrupted, or specific. Where an expenditure will produce a benefit or use that is only indirect in nature, a grant or cooperative agreement may be used."

- Again, under this standard, a cooperative agreement is the most appropriate instrument. NASA will not (indeed cannot effectively) provide the specifications for the NPO, and will not use the "result of the project for a scheduled NASA mission." By definition, the NPO will never be involved in any NASA uses of the ISS, or provide project results to be used in a scheduled NASA mission. Even though NASA may derive an "incidental" benefit from the NPO, in the form of coordination with the non-NASA ISS users, a cooperative agreement remains the most appropriate instrument.

Historical Precedent Favors Use of a Cooperative Agreement. On many occasions in the past, agencies have used cooperative agreements rather than procurement contracts or grants in similar circumstances. On each occasion, the agencies have determined that the principal purpose of the relationship was to effectuate a public purpose, even though in each case the agency itself also secondarily received a benefit as well. We believe these serve as useful models for the relationship to be established between NASA and the NPO, in which the primary goal is to coordinate all non-NASA research on the ISS.

- In 1993, the National Science Foundation used a cooperative agreement to transfer the management of nongovernmental portions of the Internet to a private company, Network Solutions, Inc. In recognition of the need for increased public access to the Internet, the NSF transferred the authority to register .com, .org, .net, and .edu domain names to Network Solutions, and assign IP addresses to those domains. That agreement was intended to open up a federal resource for public use, in recognition of the need for "effective, efficient and ubiquitous registration services." Domain name registry responsibilities were later expanded to include the Internet Corporation for Assigned Names and Numbers ("ICANN") under a cooperative agreement with the Department of Commerce in 1998. Other domain registry services have since been added, but Network Solutions and ICANN continue to manage domain name registrations.
- The NSF entered into a cooperative agreement with the University of Minnesota in 2002 under which the University agreed to manage the National Center for Earth-Surface Dynamics. The agreement provided that the University would create and administer educational activities at the Center, increase public participation in the activities of the Center, and provide mechanisms for coordination and knowledge sharing among groups using the center.
- In 1988, the Department of Defense entered into a cooperative agreement with The Nature Conservancy (TNC) for the maintenance of biological diversity on property owned by DOD. Recognizing that preservation of natural resources was not its primary area of expertise, DOD agreed to give TNC access to DOD land and provide broad access to information about rare species on its property. TNC agreed to identify DOD-owned property with unique natural significance and to manage the protection of those areas to preserve rare species.

- The Library of Congress entered into a cooperative agreement with Microsoft to create a more interactive experience for visitors and share more of the Library's content. Under the agreement, users will be able to access books and articles previously unavailable to the public, and teachers will be able to use Library resources in their programs.

- **If There is Any Legal Doubt, NASA Can Seek an Exemption from OMB to Permit Award of a Cooperative Agreement**
  - The FGCAA authorizes OMB to exempt a transaction or program of an executive agency from its application. 31 U.S.C. § 6307(2). Thus, if NASA concludes that the FGCAA requires use of a contract, it can seek an OMB exemption from the FGCAA. Here, for the policy reasons identified below, NASA would have a compelling case that a cooperative agreement should be awarded rather than a contract.
- **As Between a Cooperative Agreement and a Grant, the FGCAA Likely Mandates a Cooperative Agreement**
  - Assuming the FGCAA is applicable here, it may require use of a cooperative agreement rather than a grant. The statute provides that when "substantial involvement is expected" between the agency and the recipient when carrying out the contemplated activity, then a cooperative agreement rather than a grant must be employed. See 31 U.S.C. § 6305. Here, it is likely that the interaction between NASA and the NPO would be "substantial," so it is likely that a cooperative agreement rather than a grant must be employed.

Suitability of Instrument for NPO Success

Putting aside any consideration of legal requirements, we have concluded that a cooperative agreement is the preferable instrument to govern the relationship between NASA and the NPO based on consideration of the suitability of the instrument for the NPO's ability to achieve long-term success in its mission.

- **A Cooperative Agreement Provides the NPO with Capabilities Necessary for Mission Success.**
  - The crucial advantage of a cooperative agreement is its freedom from the statutory and regulatory structures of the federal procurement system. Recipients of cooperative agreements are not subject to the vast number of regulatory requirements in the FAR or NASA FAR Supplement (NFS) that would govern a procurement contract. The standard FAR and NFS clauses and requirements will constrain the NPO's ability to enter into appropriate and flexible arrangements with the public and private sector users of the ISS-NL.
  - In particular, the NPO will seek funds from non-NASA users of the ISS, including other government agencies, educational institutions, foundations, for-profit companies, and others. A cooperative agreement structure will afford the NPO far greater options and capabilities in entering into agreements with such entities, and in maximizing receipts from such entities. As an example, the DOD found that over a 5-year period, recipients of assistance agreements contributed $1.39 in cash or in-kind contributions for every dollar provided by the agency. See GAO, DOD Research (GAO/NSIAD-96-11) (March 29, 1996).

- **A Contract Would Constrain NPO Activities Because of the Necessity for NASA-Dictated Mission Requirements**

- For NASA to award a procurement contract, it would need to craft detailed Statements of Work and performance specifications governing the multi-faceted activities of the NPO. Inevitably, such documents will afford the NPO fewer operational options than would be available if the NPO operates under a cooperative agreement structure. The NPO itself will be in a far better position to identify the specific goals to be achieved and the work to be performed in furtherance of those goals.
- It will also be difficult for NASA to administer effectively a procurement contract with the NPO over the ten years or longer that the NPO would be in operation. The NPO will be in a better position than NASA to assess over the upcoming decade the work to be performed, as conditions change in the future. To provide a few examples, the NPO will be in a better position to assess: how to drive interest in and demand for the capabilities of the ISS-NL; the types of research that might be conducted by non-NASA entities; the competing needs of those entities; and how the ISS-NL can best accommodate the needs of these entities.

Cost Considerations Favor a Cooperative Agreement or Grant

- Funding the NPO through a procurement contract rather than a grant or cooperative agreement would impose significantly greater cost on the NPO. Because of the mandatory FAR and NFS requirements that are imposed on recipients of a procurement contract, the NPO would need to establish far more complex internal systems and controls in order to comply with such requirements. Among other things the NPO would need to comply with requirements concerning small business subcontracting, complex cost accounting, billing, and record-keeping requirements, and compliance program requirements.
- Moreover, we believe that a cooperative agreement would impose fewer costs on NASA. First, NASA would not need to undertake the tremendously difficult, time consuming, and therefore costly task of dictating the detailed activities of the NPO. With a procurement contract, NASA would continually need to keep Statements of Work (SOWs) and performance requirement updated. Second, NASA would have an obligation to assess performance against SOW and performance parameters. These activities would require a significant amount of effort, time, and cost, all of which are better expended on efforts within NASA's core mission, including NASA's own use of the ISS.

Use of a Cooperative Agreement Will Encourage Widespread User Participation

- A cooperative agreement structure will likely encourage more widespread participation with the NPO among entities that otherwise would be unwilling to enter into government contracts or other agreements with a government contractor. Our tentative discussions to date with prospective users indicates that at least some private-sector users would be more willing to participate in the ISS-NL if the NPO is not subject to the restrictions imposed by the FAR and other procurement regulations. The DOD has experienced a similar phenomenon; it found that 42 percent of recipients of cooperative agreements were firms that traditionally had not performed research under contracts with DOD. GAO, DOD Research (GAO/NSIAD-96-11) (March 29, 1996).

Considerations of Timing Likely Favor Award of a Cooperative Agreement

- We understand that the process of awarding a procurement contract is typically more lengthy and cumbersome than the process of awarding a cooperative agreement. Moreover, the ongoing administrative processes associated with procurement contracts are lengthier and more cumbersome (including processes for auditing, approval, and issuing changes in scope of work) than the processes associated with cooperative agreements. The NPO will be more likely to achieve long term success if it is able to execute swiftly and effectively. Overall, we believe that a cooperative agreement will permit the NPO to execute its mission more swiftly and efficiently.

Fit of Instrument with Desired Nature of NASA/NPO Relationship

A cooperative agreement provides the best "fit" with the nature of the desired relationship to be established between NASA and the NPO.

- **Use of a Cooperative Agreement Would Permit NASA to Coordinate Closely with the NPO**
  - A cooperative agreement provides NASA with the ability to closely coordinate its activities with the NPO, unlike a grant. Here, it is essential that the NPO work alongside NASA in ensuring maximum use of the ISS NL. In this regard, the Office of Technology Assessment noted: "Coordinating the activities of the various institutions that need to be involved in technological innovation is likely to provide much of the basis for the substantial Federal involvement that characterizes the cooperative agreement." See "Applications of R&D in the Civil Sector: The Opportunity Provided by the [FGCAA]," at 28 (June 1978).

- **Use of a Procurement Contract Would Permit Close Coordination, but Would Constrain NPO Options and Capabilities**
  - Use of a procurement contract would likely also permit coordination between NASA and the NPO. However, as discussed in Section B above, a procurement contract has many undesirable features that would have the effect of constraining the NPO's ability to achieve success.

- **Use of a Grant Would Likely Not Afford NASA Sufficient Ability to Coordinate with the NPO**
  - A grant is an appropriate instrument only if there were to be no "substantial involvement" between NASA and the NPO. 31 U.S.C. § 6304. We believe a grant would therefore be an undesirable instrument, because it might lead to insufficient coordination and cooperation between the missions of NASA and the NPO.

Appendix K - **Responsibilities from Representative SAA Agreement**

The fundamental responsibilities to be undertaken by the NPO have been described in detail in other sections of this report. The types of responsibilities to be set forth would likely include the following:

- Identify and enter into appropriate agreements with users that have an interest in research and development on-board the ISS-NL
- Identify sources of funding for unfunded or underfunded research and development projects
- Enable users in multiple industry and educational sectors an opportunity to conduct research and development within available ISS-NL space
- Ensure that all payload development and all activity aboard the ISS-NL is conducted in accordance with NASA payload requirements
- Provide a selection process to appropriately prioritize users
- Identify appropriate implementation partners for users early in the payload development process, and provide users with a standard form agreement by which they can retain the implementation partner
- Provide NASA with operational reports on all payloads flown by users
- Create a community of interest by promoting the use of ISS for potential projects

The fundamental responsibilities to be undertaken by NASA would include the following representative SAA agreement provided by NASA:

- Assist the NPO in identifying users with an interest in research and development on-board the ISS
- Assist the NPO in identifying sources of funding for unfunded or underfunded research and development projects
- Provide technical assistance to users to ensure that all payload development and activity aboard the ISS is conducted in accordance with NASA payload requirements and other requirements
- Provide users selected by the NPO with manifested space on appropriate launch vehicles
- Identify and make available ground-based pre-flight and post-flight resources at launch and landing sites, including Space Life Science Lab resources at NASA's discretion or access to Space Station Processing Facility resources, as appropriate
- This will include access to needed facilities and personnel as required to set up labs, and operate and conduct work for each space flight mission for pre-flight and dost-flight payload recovery and processing
- Provide users selected by the NPO with appropriate launch vehicle and ISS resources to allow users to effectively conduct research and development on the ISS, which resources and support are to be specified in writing in advance of any payload launch
- Provide users access to NASA's inventory of cold stowage systems;
- Enter into appropriate SAAs with implementation partners for payloads to be flown

Appendix L - **Cross-Waivers**

NASA is obligated to implement the cross-waiver requirement in Article 16 of the intergovernmental agreement entitled, "Agreement among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America concerning Cooperation on the Civil International Space Station (IGA)." Article 16 of the IGA establishes a cross-waiver of liability for use by the four governments and their related entities, and requires that this reciprocal waiver of claims be extended to contractually or otherwise-related entities of NASA by requiring those entities to make similar waivers of liability. Thus, NASA is required to include IGA-based cross-waivers in agreements for ISS-related activities. See generally 14 C.F.R. § 1266.101.

The terms of the cross-waivers of a standard IGA liability (14 C.F.R. § 1266.102) are intended to encourage the utilization of the ISS by ensuring that all entities and persons involved in ISS-related activities, including the relevant member nations, all persons with whom they contract, and all payload developers, cross-waive certain (but not all) claims for damages against each other. The net effect of the IGA and these cross-waivers is that many (but not all) claims for liability are foreclosed. As NASA has explained, "The fundamental purpose of requiring cross-waivers is to establish boundaries on liability to encourage space and aeronautical projects and other joint endeavors. Cross-waivers promote such endeavors in two ways. First, the potential for litigation is lowered because each party agrees up front to assume responsibility for specified damages it may sustain. Second, insurance costs are reduced by sharply restricting the types of legal claims that may be brought by participating entities against each other". Space Agreements Act Guide at 40-41.

SEC. 602. INTERNATIONAL SPACE STATION NATIONAL LABORATORY ADVISORY COMMITTEE.

(a) ESTABLISHMENT.—Not later than 1 year after the date of enactment of this Act, the Administrator shall establish under the Federal Advisory Committee Act a committee to be known as the ''International Space Station National Laboratory Advisory Committee'' (hereafter in this section referred to as the ''Committee'').

(b) MEMBERSHIP.—

(1) COMPOSITION.—The Committee shall be composed of individuals representing organizations who have formal agreements with NASA to utilize the United States portion of the International Space Station, including allocations within partner elements.

(2) CHAIR.—The Administrator shall appoint a chair from among the members of the Committee, who shall serve for a 2-year term.

(c) DUTIES OF THE COMMITTEE.—

(1) IN GENERAL.—The Committee shall monitor, assess, and make recommendations regarding effective utilization of the International Space Station as a national laboratory and platform for research.

(2) ANNUAL REPORT.—The Committee shall submit to the Administrator, on an annual basis or more frequently as considered necessary by a majority of the members of the Committee, a report containing the assessments and recommendations
required by paragraph (1).

(d) DURATION.—The Committee shall exist for the life of the International Space Station.

Appendix N- **Board Fiduciary Duties**

The duty of loyalty requires each governing-board member to: (a) act in a manner that he or she reasonably believes to be in the best interests of the charity, in light of its stated purposes; and (b) to handle situations involving actual or potential conflicts of interest in a manner consistent with applicable law and the organization's conflicts of interest policy.[29] The duty of care requires each governing-board member (a) to become appropriately informed about issues requiring consideration, and to devote appropriate attention to oversight; and (b) to act with the care that an ordinarily prudent person would reasonably exercise under similar circumstances.[30]

In general, a member of the board need not be personally financially liable for a claim based on any action taken, or failure to take action, in the discharge of that person's duties except for (1) unjust gain to that person or (2) injury to the charity resulting from (a) a conflict of interest transaction or conduct in violation of the Ethics in Government Act (pursuant to its federal charter)or the relevant state law conflict of interest standard (or the NPO's conflict of interest policy) and that inured to the benefit of that person or a related party; (b) an intentional breach of the duty of loyalty or a breach of the duty of care due to lack of good faith in acting or failing to act; (c) a knowing and culpable violation of criminal law; or (d) unlawful distributions from the ISSNL (the distribution of "profits" to private persons or entities, including the payment of unreasonable compensation)[31]. To reduce the risk to appointed board members, the NPO should agree to purchase Directors' and Officers' liability coverage for the liability of non-profit board activities.

Appendix O - **Ex-Officio Regulations**

Ex-officio members selected would need to ensure that this assignment meets the rules of its agency. For example, according to NASA ethics regulations "a NASA employee, other than a special Government employee, shall not engage in outside employment with the following: (1) A NASA contractor, subcontractor, or grantee in connection with work performed by that entity for NASA; or (2) A party to a Space Act agreement, Commercial Launch Act agreement, or other agreement to which NASA is a party pursuant to specific statutory authority, if the employment is in connection with work performed under that agreement".." 5 CFR 6901(c). In this context, the definition of employment is broad.

In the absence of specific Congressional authority, employees of a governmental agency need to be aware of the ethical guidelines as described by the Office of Government Ethics prior to accepting an ex officio position (See generally (5 C.F.R. §§ 2635.801-809). Executive branch officials are subject to various limitations on the outside activities in which they may be involved. An employee may not have outside employment or be involved in an outside activity that conflicts with the official duties of the employee's position. An activity conflicts with official duties if it is prohibited by statute or by the regulations of the employee's agency, or if the activity would require the employee to be disqualified from matters so central to the performance of the employee's official duties as to materially impair the employee's ability to carry out those duties. Presidential appointees to full-time, non-career positions generally are prohibited from receiving outside earned income. Also, certain other non-career employees are subject to monetary limitations on the amount of outside income that they may earn. Thus it is doubtful that an agency official could accept any compensation for service. Employees could engage in fundraising in an official capacity. It is not clear that government officials serving as "ex officio" members of the NPO Board would be viewed as fundraising in their official capacity, unless they were specifically appointed to the position by Congress. An agency employee needs to also comply with any "agency-specific requirement for prior approval of outside employment or activities," presumably including service as an ex officio board member as prescribed by the electronic code of Federal Regulations (5 CFR 2635.801(b)(2).

Appendix P - **Conflict of Interest Policy**

The conflict of interest policy is standard for a Non Profit Organizational structure. It defines a conflict of interest, interested persons, financial interest, duty to disclose and proceedings guidelines, in addition to protocols for violation of the policy. There are a variety of situations that raise conflict of interest concerns including financial interests and personal conflicts such as business transactions with family members. In order to avoid conflict of interest from the board members the NPO will establish a conflict of interest policy amongst its board members and key leadership to mitigate any possible conflict.

POLICY REQUIREMENTS. In order to manage these potential conflicts of interest, this policy mandates protocols that mitigate these potential risks. The policy would require that board members are obligated to disclose any potential conflicts as soon as they arise and each person should be required to sign a conflict of interest disclosure statement upon joining the board. Annually thereafter the individuals need to completely discloses any material facts about the potential conflicts possessed. The annual conflicts of interest disclosure statement is a document that represents that the individual does not have any conflicts with family members or their own financial interests as they relate to the NPO and to the extent that there are conflicts requires the individual to disclose details. The NPO could develop strategies that mitigate any potential conflict issues. As topics arise needing decisive action the board members then would have the ethical obligation to recues themselves if there is a foreseen conflict. The board might need to hold an annual review of the conflict of interest reports to keep the issues up-to-date in addition to avoiding any possible future conflicts. Additionally, should any conflicts arise, the disinterested board members and directors could review the issue to determine the most appropriate response. These actions may be contemplated within the conflict of interest policy and as such should be enacted. Lastly, the policy would need to include the ramifications for violation of the policy.

BEST PRACTICES. Additionally, best practice suggests that "an insider transaction with a tax-exempt organization of any other transaction involving a conflict of interest should not be approved by the board of directors in the absence of a written opinion from an independent and competent third party as to the fairness of the transaction. If a so-called excess benefit transaction has occurred, the board should take prompt action to correct it and to impose safeguards against similar transactions in the future".[32] Additionally, it is recommended that "the positions of chief executive officer, board chair and board treasurer are held by separate individuals[33]" to separate these responsibilities and mitigate the potential financial conflicts of interest.

Appendix Q - **Stipends**

A majority of 501(c)(3) nonprofit organizations do not pay stipends for service to members of the organization's board of directors, rather they may be reimbursed for reasonable expenses incurred to attend meetings. Nonetheless many nonprofit organizations do compensate their directors. The most recent publicly available Form 990 for Battelle Memorial Institute indicates that its directors received compensation, approximately $90,000. Likewise, The Mitre Corporation appears to have paid its directors approximately $40,000 during its most recently reported tax year. Other examples of 501(c)(3) entities that pay the board of directors are RAND Corporation, SRC, Inc., Southwest Research Institute, CNA Corporation, The Aerospace Corporation, Analytic Services, Inc. and Institute for Defense Analyses. However, if compensation is paid, the applicable standard for the amount of compensation that can be paid states that the compensation not be more than "reasonable compensation". In general, reasonable compensation is an amount that is not more than what similar organizations would pay for similar services in similar situations.

Appendix R – **Governance – Audit**

The board's responsibilities include the following for overseeing the audit process and duties to perform for itself or delegate to an audit committee:

- Retaining and terminating the engagement of the independent auditor
- Reviewing the terms of the auditor's engagement at least every five years
- Overseeing the performance of the independent audit
- Conferring with the auditor to ensure that the affairs of the organization are in order
- Recommending approval of the annual audit report to the full board
- Overseeing policies and procedures for encouraging whistleblowers to report questionable accounting or auditing matters of the organization
- Approving any non-audit services performed by the auditing firm
- Reviewing adoption and implementation of internal financial controls through the audit process
- Monitoring the organization's response to potentially illegal or unethical practices within the organization, including but not limited to fraudulent accounting.

Appendix S - **STAR METRICS**[34]

The STAR METRICS initiative (Science and Technology for America's Reinvestment) is a program aiming to develop measures on the effect of scientific research using a common framework. This is a multiagency cooperation lead by the National Institutes of Health, the National Science Foundation and the White House Office of Science and Technology policy. This initiative expects to develop outcome-oriented performance measurements. The metrics are measured in two phases.

- The first phase tracks federal science expenditure from the American Recovery and Reinvestment Act and its impacts on job creation.
- The second phase aims to develop measures of the impact of science investment in four areas:
  1. Economic Growth - by measuring patents/business start ups
  2. Workforce outcomes - measuring student mobility into the workforce and employment markers
  3. Scientific knowledge - evaluating publications and citations
  4. Social outcomes - measured by long-term health and environmental impact of funding

The following is additional information and sample measures in each of the categories that the initiative aims to address.

ECONOMIC IMPACT.

- "Progress over time of companies started with university IP (investment capital raised; payroll taxes paid; new markets accessed)
- Faculty/staff consulting with industry (compensated and uncompensated)
- Alumni employment paths/progress (using social media data to track employment of graduates in region; size of firm; job position, for example)
- Impacts on industry of university research, technical or technological assistance
- University investments in technology transfer/commercialization operations" [35]

WORKFORCE OUTCOMES.

- "Numbers of graduate students, and undergraduate students supported by science funding over time
- Numbers of other positions supported by science funding over time
- Numbers of positions supported by science funding over time" [36]

SCIENTIFIC KNOWLEDGE. Approaches for Measures.

- "Work with existing approaches that track scientific achievement. One of the most notable of these is the ORCID (Open Researcher and Contributor ID) project
- Draw on new networking approaches, such as the NIH funded "Facebook for Scientists" VIVO project, which create automated webpages and biosketches. VIVO Team Research
- Use the least burdensome approach possible: simply require researchers to obtain a web page, with a specific URL, and for that web page to contain an RDF or XML tag that indicates that it is acting as a researcher

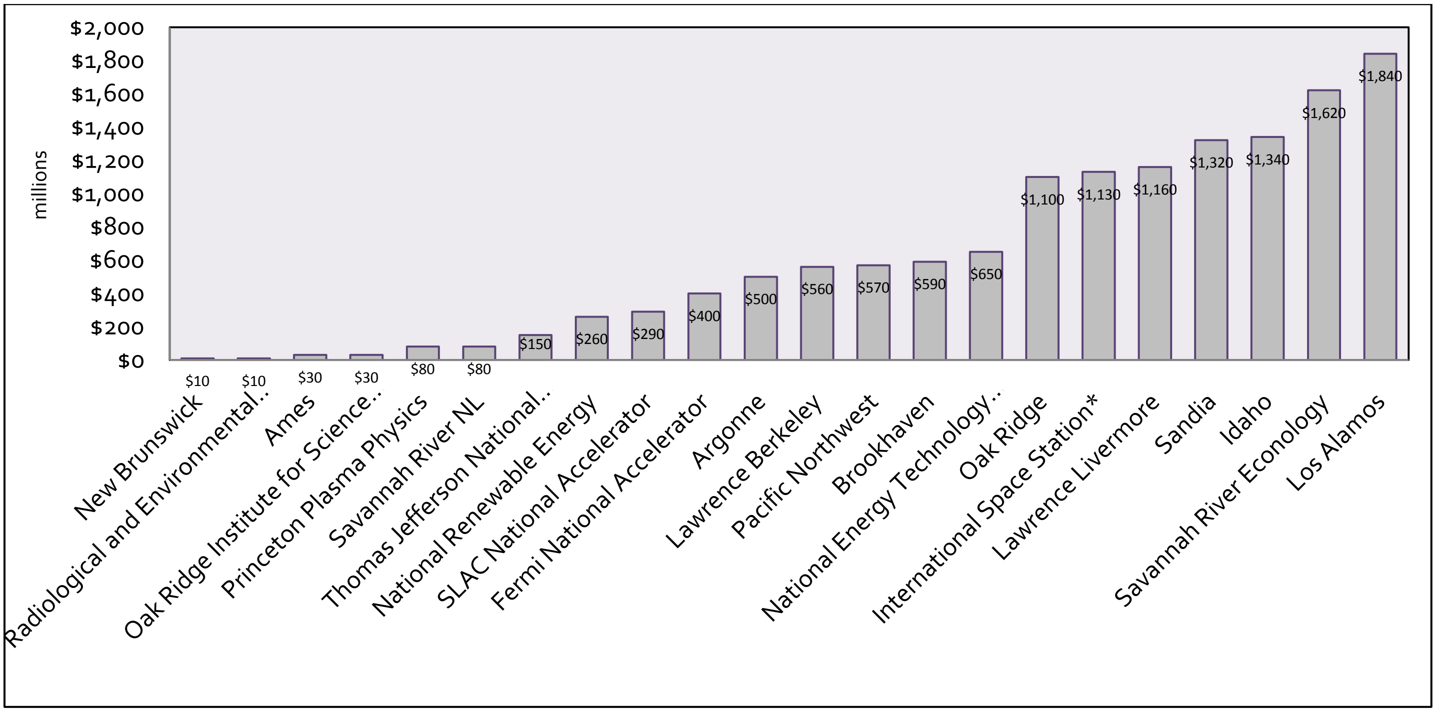
identifier. This page could be a personal web page, an institutional web page, a web page on the proposed ORCID service or on any other service.

- Use existing databases of scientific publications to automate the creation of biosketches and scientific achievement. Ask researchers to verify the accuracy of the results. Two examples include the very successful Brazilian Lattes platform"[37]

SOCIAL OUTCOMES.

- "There are many methods of valuing publicly funded knowledge, but most of them rely solely upon qualitative assessments, such as committee reviews and case studies. As pointed out in the SOSP roadmap (see below) various agencies have begun efforts to develop complementary quantitative methods designed to address the value question within their own context. For example, DOE has begun to develop risk assessment and modeling tools that could provide insights into the value of a mixed portfolio of energy efficiency investments.
- NIH counts the reductions in the direct and indirect costs of illness, as well as reductions in intangible costs due to increases in longevity in better quality of life. In addition, NSF's SciSIP program has funded researchers who are attempting to document the benefits from publicly funded international collaboration in bio-fuels, as well as the contributions of foreign graduate students and post-doctoral students to knowledge creation and discussion.
- The SOSP interagency group finding was that although determining the value of publicly funded knowledge is a critical outcome measure for Federal science agencies, the analysis is largely agency specific. Many of the tools are of uneven quality and the broader discourse is often anecdotal. Many open research questions remain. For example, is it possible to develop a full systems approach to mapping science, technology, and innovation? Is it possible to put in place a complete accounting of intangible assets and their contributions to science and technology outcomes to create an overall scientific measure of return on investment? How can the community develop more inclusive measures to capture the spillover effects between scientific discovery and technological innovation, particularly among universities, companies, and government laboratories?"[38]

Appendix T – **U.S. National Laboratory Budgets**



We studied the budgets of the other national laboratories[39]. This table depicts the appropriations for each of the national laboratories for fiscal year 2010 as indicated by the Department of Energy for its FY 2011 Congressional Budget Request for the laboratory and site office. We have adjusted the ISS budget to reflect the anticipated national laboratory allocation of the ISS (50%) and have added the proposed $15M management expenses contemplated in this design.

Some interviewees were under the impression that the ISS national laboratory would involve a much larger investment than the other national laboratories due to its unique location in low Earth orbit, but in fact the operating budget for the ISS-NL is comparable.

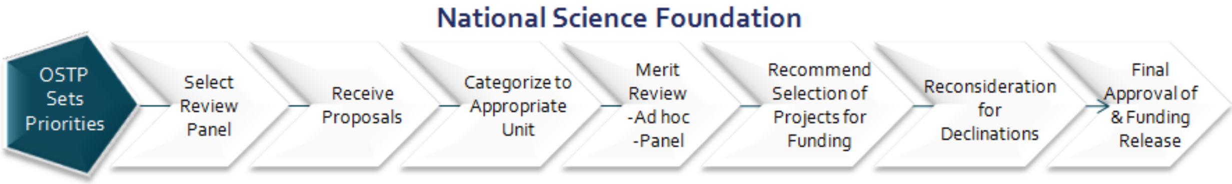
Appendix U – NIH and NSF Scientific Merit Review Criteria[40][41]

The National Institute of Health (NIH) receives policy guidance from the Department of Health and Human Services. Its mission is to support science and the pursuit of knowledge to improve health and reduce illness. Their process for issuing grants begins with concepts for the solicitation of research application by the NIH staff. The executive committee prioritizes these concepts based upon scientific merit and the organization's mission. The NIH then issues funding-opportunity announcements to solicit proposals. As the applications enter the NIH, they are evaluated by a standing board of scientists who set up appropriate reviewers for the bundled applications. The reviewers then create a score for each project based upon criteria such as project significance, innovation approach and environment as well as the investigator's qualifications. The reviewers provide their scoring to each other and then discuss their rationale for their scores. They are then given the opportunity to revise their scores based upon the discussion. The initial scores provide a basis for further review by an advisory board. Their input is given to the Director of the appropriate NIH institute who makes the final decision on funding. The PI then receives notice of an award and funding is released. When a project is rejected, the researcher has one opportunity to revise the proposal for reconsideration.

NIH Review Criteria

- Overall Impact. Reviewers will provide an overall impact/priority score to reflect their assessment of the likelihood for the project to exert a sustained, powerful influence on the research field(s) involved, in consideration of the following review criteria, and additional review criteria (as applicable for the project proposed).
- Scored Review Criteria. Reviewers will consider each of the review criteria below in the determination of scientific and technical merit, and give a separate score for each. An application does not need to be strong in all categories to be judged likely to have major scientific impact. For example, a project that by its nature is not innovative may be essential to advance a field.
- Significance. Does the project address an important problem or a critical barrier to progress in the field? If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved? How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?
- Investigator(s). Are the PD/PIs, collaborators, and other researchers well suited to the project? If Early Stage Investigators or New Investigators, or in the early stages of independent careers, do they have appropriate experience and training? If established, have they demonstrated an ongoing record of accomplishments that have advanced their field(s)? If the project is collaborative or multi-PD/PI, do the investigators have complementary and integrated expertise; are their leadership approach, governance and organizational structure appropriate for the project?
- Innovation. Does the application challenge and seek to shift current research or clinical practice paradigms by utilizing novel theoretical concepts, approaches or methodologies, instrumentation, or interventions? Are the concepts, approaches or methodologies, instrumentation, or interventions novel to one field of research or novel in a broad sense? Is a refinement, improvement, or new application of theoretical concepts, approaches or methodologies, instrumentation, or interventions proposed?
- Approach. Are the overall strategy, methodology, and analyses well-reasoned and appropriate to accomplish the specific aims of the project? Are potential problems, alternative strategies, and benchmarks for success presented? If the project is in the early stages of development, will the strategy establish feasibility and will particularly risky aspects be managed? If the project involves clinical research, are the plans for 1) protection of human subjects from research risks, and 2) inclusion of minorities and members of both sexes/genders, as well as the inclusion of children, justified in terms of the scientific goals and research strategy proposed?
- Environment. Will the scientific environment in which the work will be done contribute to the probability of success? Are the institutional support, equipment and other physical resources available to the investigators adequate for the project proposed? Will the project benefit from unique features of the scientific environment, subject populations, or collaborative arrangements?

Source: National Institutes of Health website



The National Science Foundation (NSF) receives its policy direction from the Office of Science and Technology Policy at the White House. Its mission is to promote the progress of science. The NSF process begins with the selection of reviewers based upon the reviewer's own professional publications and presentations from various fields of science and engineering. The NSF receives approximately 40,000 proposals a year that are categorized into appropriate units for review. Each proposal is reviewed by a panel that scores the proposal under certain criteria and the panel provides a written critique. In cases when a small number of proposals are being reviewed they can be performed online by the selected external reviewers. When there are a large number of proposals competing, they can have a panel meet in person for up to two days to complete the reviews. The input from the panel is reviewed by the program officers who then make a recommendation to the division directors who then make the final decisions on funding. An unsuccessful applicant may ask for reconsideration although reconsideration is rare.

NSF Review Criteria

1. What is the intellectual merit of the proposed activity? How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

2. What are the broader impacts of the proposed activity? How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

Source: National Science Foundation website

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Endnotes

[1] (Augustine 2009)
[2] (Mould and Braukus 2008)
[3] (Chaplain, 2009)
[4] (Chaplain, 2009)
[5] The Vision dictates NASA's focus to on space exploration by sending humans to the Earth and Mars while also studying the effects of space on humans (The Vision 2004)
[6] (National Aeronautics and Space Administration Authorization Act of 2008 2008)
[7](Committee for the Decadal Survey on Biological and Physical Sciences in Space Studies Board; National Research Council 2010)
[8] (Committee for the Decadal Survey on Biological and Physical Sciences in Space Studies Board; National Research Council 2010)
[9] (Committee for the Review and Evaluation of NASA's Precollege Education Program 2008)
[10] (Committee for the Decadal Survey on Biological and Physical Sciences in Space Studies Board; National Research Council 2010)
[11] (Committee for the Decadal Survey on Biological and Physical Sciences in Space Studies Board; National Research Council 2010)
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[13] (Committee for the Decadal Survey on Biological and Physical Sciences in Space Studies Board; National Research Council 2010)
[14] (National Aeronautics and Space Administration Authorization Act of 2008 2008)
[15] (GAO 2009)
[16] (Augustine 2009)
[17] Lawrence, Barbara, Outi Flynn, and Kathleen Fletcher. *The Nonprofit Policy Sampler*. Washington, DC: BoardSource, 2006. Print.
[18] (National Aeronautics and Space Administration Authorization Act of 2008 2008)
[19] (Orszag & Holdren, 2010)
[20] (Department of Energy - Access to High Technology User Facilities at DOE National Laboratories)
[21] (Public Law, 2005)
[22] (Sciences 2010)
[23] (Sciences 2010)
[24] (Sciences 2010)
[25] (NASA, Visiting Vehicles Overview, 2010)
[26] U.S.C. § 116; 37 C.F.R. §§ 1.41 and Manual of Patent Examining Procedure (MPEP) Sec. 2137.01.
[27] Kerry ten Tate and Sarah A Laird (2000) The Commercial Use of Biodiversity, Earthscan Publications Ltd., pg. 1.
[28]SPACE STATION - Agreement Between the United States of America and Other Governments, Signed at Washington January 29, 1998 with Annex and Arrangement Between the United States of America and Other Governments Signed at Washington J January 29, 1998; also referred to as the Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station.

[32] (Lipman, 2006)
[33] (Lipman, 2006)
[36] (Sciences 2010)
[37] (Sciences 2010)
[38] (Sciences, 2010)
[39] (Department of Energy, 2010)
[40] (National Institutes of Health, 2010)
[41] (National Science Foundation, 2010)