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COMMERCIALIZATION IS REQUIRED FOR SUSTAINABLE SPACE EXPLORATION AND DEVELOPMENT

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ABSTRACT

The U.S. Space Exploration policy outlines an exciting new direction in space for human and robotic exploration and development beyond low Earth orbit. Pressed by this new visionary guidance, human civilization will be able to methodically build capabilities to move off Earth and into the solar system in a step-by-step manner, gradually increasing the capability for humans to stay longer in space and move further away from Earth. The new plans call for an implementation that would create an affordable and sustainable program in order to span over generations of explorers, each new generation pushing back the boundaries and building on the foundations laid by the earlier.

To create a sustainable program it is important to enable and encourage the development of a self-supporting commercial space industry leveraging both traditional and non-traditional segments of the industrial base. Governments will not be able to open the space frontier on their own because their goals change over relatively short timescales and because the large costs associated with human spaceflight cannot be sustained. A strong space development industrial sector is needed that can one day support the needs of commercial space enterprises as well as provide capabilities that the National Aeronautics and Space Administration (NASA) and other national space agencies can buy to achieve their exploration goals. This new industrial space sector will someday provide fundamental capabilities like communications, power, logistics, and even cargo and human space transportation, just as commercial companies are able to provide these services on Earth today. To help develop and bolster this new space industrial sector, NASA and other national space agencies can enable and facilitate it in many ways, including reducing risk by developing important technologies necessary for commercialization of space, and as a paying customer, partner, or anchor tenant. This transition from all or mostly government developed and operated facilities and services to commercial supplied facilities and services should be considered from the very earliest stages of planning.

This paper will first discuss the importance of space commercialization to fulfilling national goals and the associated policy and strategic objectives that will enable space exploration and development. Then the paper will offer insights into how government can provide leadership to promote the nascent commercial space industry. In addition, the paper describes programs and policies already in place at NASA and offers five important principles government can use to strengthen space industry.

INTRODUCTION

Perhaps the most important step in discussing why commercialization is a necessary but not sufficient requirement for the affordable and sustainable development and exploration of space is to first define what is meant by commercialization. Indeed, depending upon the perspective, this term and its viable applicability to the space enterprise has many differences in meaning, interpretation, implementation, and acceptability. Thus, for the purposes of this paper, commercialization is defined as the use of

equipment sent into or through space to provide goods or services of commercial value, either by a corporation or government in a climate conducive to expanded private sector investment and involvement in space activities. Indeed, commercial space within this context comprises several different types of commercial activity to include: government or private purchase of products, goods, or services, commercial end-to-end responsibility or total systems program responsibility, partnerships (to include Public-Private Partnerships {PPP}), cooperative or joint research and development, commercially

leveraged government investment (National Advisory Committee on Aeronautics {NACA} model), cooperative development (e.g. Commercial Orbital Transportation Services {COTS} project), contractual purchase (e.g. Commercial Resupply Services), and planning and development (e.g. Commercial Crew Development project) to name just a few. Together, these commercial approaches can and should leverage traditional, non-traditional, NewSpace and commercial space suppliers and support industry entities through committed applications of contracts, Space Act Agreements (SAAs), Broad Area Announcements (BAAs), Small Business Innovative Research (SBIR) grants, plus prizes, challenges, and competitions (e.g. Centennial Challenges, X Prize) as just some of the viable venues for engagement. The common thread woven throughout each of these elements is a focus on return on investment, entrepreneurial innovation, market expansion, and a favorable climate for risk assumption based upon reward potential. From a government perspective, NASA is responsible for executing its missions as assigned while serving as both a steward of the taxpayer's investment and driver for national and international benefit. As the nation continues on a forward trajectory of sustainable exploration and development of the national capabilities, infrastructure, and industrial base to ensure success across the spectrum, commercialization – in all of its facets – is an essential element of our overall strategy and plan.

The following commercial models, some of which have been lightly addressed above, may form the baseline enabling suite from which to approach future commercial space opportunities. Directly excerpted from an October 2008 study Jon Smith of Wyle Laboratories, they include:

- **The Independent Research and Development (IRAD) model:** Where industry makes an investment to provide a service to NASA with the expectation that it will recoup some or all of its investment. This is only allowed when NASA anticipates an acquisition to emerge from the service. Typically, the investments are small, on the order of \$10M, requiring the least investment by both NASA and industry and with a minimum risk to both.
- **The Centennial Challenge Prize Model:** Prizes are offered by NASA for industry

achievement of NASA established goals. No payment is made until goal is reached. Typically, these investments are on the order of \$25M per prize. With these investments, NASA owns “What and Interoperability” and industry owns the “How” and with some level of investment and some level of risk to both.

- **Commercial Orbital Transportation System (COTS) Model:** This investment in a systems development is shared both by the industry member and NASA. The funds are to demonstrate a capability and reliability on an agreed schedule of milestones as required by NASA. The investment level is modest, on the order of \$50M per COTS investment. Typically, there is more than one firm involved with the intent that many suppliers are developed. The COTS model requires that fixed costs are shared with other customers. Again, NASA owns “What and Interoperability,” not “How.” This model requires that substantial investments be made by both NASA and firms and that the risks be shared equally.
- **A New Commercial Use Model:** NASA procures services of new entrepreneurial services using Space Act Agreements and then uses Indefinite Delivery/Indefinite Quantity (IDIQ) contracts to commercialize the Government's operations. Typically, the investment will be on the order of \$150M per procurement. The intent is to develop many service suppliers. In this model, NASA owns the “What” and industry owns “How” and both share equally in the risk.
- **A New Procurement Model:** Here the Design, Development, Test, and Engineering (DDT&E) is paid by NASA for fixed cost contracts with entrepreneurial suppliers for services and data, not hardware. NASA owns the data, not how the data was developed. Typically, this investment level will be approximately \$200M per procurement. NASA pays the full cost, including the DDT&E and operations products, but it is left to the industry member to determine how the products, services, and operations are to be developed. As with the other models, the NASA and supplier share risk.

Government can use these different models, dependent on the specific applications, to provide strong foundation to jump start a new industry in and around space development and exploration.

WHY COMMERCIALIZATION IS NEEDED

Commercialization is required to open the space frontier. Government programs are driven by scientific objectives not by markets and, by far, most humans going to orbit are government employees to do government work. Only when new markets are developed can the costs of space development begin to fall and space begins to open to private businesses and private citizens. New markets will drive innovation and creativity. The government will need to be proactive to enable the commercial space industrial sector to develop and thrive.

Policy as a Foundation

There is a history of direct and progressive emphasis on commercial space at NASA from the President, Congress, and the Administrator. The NASA Space Act of 1958 (as amended) assigns NASA the mission to *“seek and encourage, to the maximum extent possible, the fullest commercial use of space”*. Building on this foundation, the Commercial Space Act of 1998 (P.L. 105-303) states that *“To the maximum extent practicable, the Federal Government shall plan missions to accommodate the space transportation services capabilities of United States commercial providers”*. The NASA Authorization Act of 2005 (P.L. 109-155) directs that *“the Administrator shall...work closely with the private sector, including... encouraging the work of entrepreneurs who are seeking to develop new means to send satellites, crew, or cargo to outer space.”* Adding to this, the NASA Authorization Act of 2008 (P.L. 110-422) states that *“NASA shall make use of United States commercially provided International Space Station crew transfer and crew rescue services to the maximum extent practicable”*. The Presidential Vision for Space Exploration (2004), along with both the Authorization Acts of 2005 and 2008, together defined as the U.S. Space Exploration Policy, lay out a broad statement that *“To exploit space to the fullest extent...requires a fundamental transformation*

in U.S. space transportation capabilities”, and *“the United States Government must capitalize on the entrepreneurial spirit of the U.S. private sector”*, and *“dramatic improvements in the reliability, responsiveness, and cost of space transportation would have a profound impact on the ability to protect the Nation, explore the solar system, improve lives, and use space for commercial purposes.”* Finally, at his Senate nomination hearing (July 2009), NASA Administrator Charles F. Bolden, Jr. encapsulated his vision for commercial activities by stating: *“We can inspire and open the door for commercial entrepreneurial entities to become involved, to become partners with NASA.”*

Fiscal Forcing Function and Driver

Given the global economic downturn, blooming federal budget deficits, skyrocketing healthcare, retirement, benefits, and fuel costs, coupled with an ever-increasing demand for government spending allocations, plus the high inherent costs of challenging human and robotic space exploration, it is absolutely critical and strategically essential to effectively leverage the innovation, agility, and flexibility of free enterprise through the commercial and industrial sector portfolio of resources, talent, and unique capabilities in progressively new and pioneering ways. Foremost to this effort is the development and implementation of a commercial space strategy that is flexible enough to accommodate the wide spectrum of opportunities and players while providing value and benefit to all of the stakeholders and participants. By harnessing the power of the emerging space industry, NASA can focus its limited resources on inspiring and enabling missions to the Moon, near Earth objects, Mars and beyond while making human exploration of space more affordable and sustainable. In the end, long-term sustainability is vitally important to ensure that our strategic national objectives are met. Driven by policy, national, and international dictate, this flexible approach will leverage technology development, precursor missions, terrestrial analog activities, and an integrated and cohesive stepwise buildup approach to both open and sustain a host of important missions. In turn, this forward strategy will further open the space frontier for Americans and our international partners alike, while also addressing top national priorities and

yielding robust benefits for the economy, industry, national security, education and inspiration for the next generation, and vibrant advancements in energy, healthcare, the environment, and transportation – all of which will build a more sustainable and affordable future for the nation.

Space Commercialization: Strategic Objectives

These objectives provide the goals of space commercialization from a government perspective and can assist in determining the types of approaches governments should use to create a strong foundation for space commercialization.

- Open the space frontier for a broader segment of the population, such that increasing large numbers of the American people can play, work, and eventually live in space
- Achieve low-cost and reliable access to space
- Enable responsive space operations
- Ensure best value for the Nation and taxpayers
- Continually pursue improved safety and mission success in an affordable manner
- Produce dual-use benefits for economic and national security
- Sustain existing high-quality jobs and create new high-wage jobs
- Stimulate and enable new commercial space markets, and orbital capabilities beyond access to orbit both in the near and long term
- Enable space-based infrastructure (e.g., propellant depots; orbital transfer services; on-orbit servicing, inspection, repair; orbital debris clean-up capabilities; lunar cargo, navigation and communications, and near-Earth object resource extraction)
- Inspire the next generation of scientists, engineers, teachers, and explorers
- Provide students, scientists, and researchers with new low-cost access to space capabilities
- Produce significant reductions or game-changing innovations in the cost, performance, safety, and/or sustainability of human exploration of space
- Help new markets, capabilities and services become self-sustaining

Global Exploration Themes

Derived from both the Global Exploration Strategy (GES) and NASA's Exploration Themes, the following elements focus the objectives for sustainable exploration enabled and supported by commercial space activities.

- **Human Exploration:** Reduce the risks and increase the productivity of future missions in our solar system by testing technologies, systems, and operations in an off-Earth Planetary environment. Develop the knowledge, capabilities, and infrastructure required to live and work in space, with a focus on continually increasing the number of individuals that can be supported in space, the duration of time that they can remain there, and the level of self-sufficiency for space operations.
- **Scientific Knowledge:** Engage in scientific endeavors to support human exploration and to advance human knowledge and understanding.
- **Economic Expansion:** Create new markets, based upon Suborbital, Low Earth Orbit (LEO), International Space Station (ISS), lunar, cis-lunar, Near Earth Object (NEO), Mars, and other destinations, that will return economic, technological, and quality-of-life benefits to all humankind.
- **Global Partnerships:** Enhance global security by providing a challenging, shared, peaceful, and inspirational global vision that unites nations in collaborative pursuit of common objectives.
- **Public Engagement:** Use a vibrant exploration program to excite the public about space, encourage students to pursue careers in high technology fields, and ensure that individuals enter the workforce with scientific and technical knowledge necessary to sustain exploration.

Commercialization of Space: An Enabler

Government programs are stable and reliable, sometimes at the expense of efficiency and innovation. They can be cumbersome and because many of the programs take many years to be complete, they are often disrupted by the periodic changes within the political system. For example, NASA has not been able to field a new human-rated flight system since the Shuttle, which first flew in 1981, twenty-eight years ago, though there have been many programs that were started but not completed such as, the Space

Launch Initiative, Space Plane, and the X-38 Crew Return Vehicle. As commercial systems become available to private citizens as well as to the government, NASA will be able to reap the benefits of a new system's ability to amortize their cost over a larger customer base. For example, it is estimated that a government developed robotic lander to the Moon to collect engineering data needed for the design of lunar systems would cost upwards of \$100M, however, buying the same data from a commercial company may cost as low as \$10M. The ability of commercial companies to market capabilities to more than just the government allows cost to be spread out over multiple entities and lowered for any specific customer. The market also fosters an entrepreneurial environment and innovative solutions for companies to stay in front of competitors.

Timing: Now is the Time

According to the 2009 Space Report, the global space economy grew 2.5% in 2008, rising by \$6 billion to \$257 billion in worldwide space revenues despite the global economic downturn. Even further, the report noted that only 32% of this global market was driven by government spending, leaving the remainder to commercial expenditures. In the US alone, the Federal Aviation Administration (FAA) estimated that the direct valuation of the commercial space transportation sector was \$23 billion, and \$139 billion when secondary and tertiary industries were included – a value that exceeds 1% of the U.S. Gross Domestic Product (GDP). Within the U.S., the burgeoning growth of entrepreneurial space transportation and space support firms has continued to increase, again, despite the challenging economic environment. Thus, with the commercial space sector poised for expansion and further engagement in the early 21st Century, a timely window of opportunity exists to leverage catalytic stimulus evidenced in the aviation industry in the early 20th Century. Applying the positive lessons learned from the development of the aviation industry driven by government investment, utilization, and enabling policy, coupled with commercial investment, responsiveness, and committed partnership, the U.S. can leverage this same recipe for continued global leadership, innovation, and sustainable operations in space for the future. The current timing is unique in that a combination of multiple competent, well-funded, and capable industry entities have emerged along with a

regulatory environment that is increasingly conducive to commercial engagement and success. True market need and viable opportunities are also helping make the present perhaps the most viable time in history for the increasing commercialization of space.

Although several excellent studies have been done on the potential of commercial space markets, a recent study by ATK showed that several key lunar markets exist for communication and navigation (both orbital and lander missions), data buys (science, precursor, and resource mapping), technology validation, entertainment (internet tele-operated rovers, viewing stations, television specials, etc), educational, as well as special or unique niche markets (memorabilia, personal artifacts, advertisement, spreading of ashes). Importantly, the potential customers include government space agencies, heavy-, automotive-, hospitality-, and manufacturing-industries, energy and resource mining interests, academia supported by private, and governmental sources, the entertainment and tourism industry, and private investment funds. Possible service providers include the communications industry (communication and navigation), Google Lunar X-Prize contestants (lander mission brokers/integrators), commercial and aerospace companies (launch, in-space, and landing systems), as well as international entities. The overall commercial market assessment is positive, but more investment, likely in the form of government support, directed mission allocations, data purchase agreements or requirements expansion is needed to incentivize equity investments and expand the viable business cases.

In summary, space policy in the U.S. strongly supports enabling commercialization of space. NASA should continue to partner with industry to leverage resources and meet strategic objectives both national and global. These partnerships can reduce cost for government missions and now is the best time for government to move more aggressively to support space commercialization.

PRINCIPLES TO STRENGTHEN THE COMMERCIAL SPACE INDUSTRY

In order to address the fundamental principles to strengthen use of commercial space, the barriers to commercial space industry and partnerships

must be addressed. At a top level, these barriers include elements across the technical, economic, policy, regulatory, and legislative spectrum:

- High capital costs
- Availability of equity
- Indemnification and insurance
- Market stability: Demand rate and quantity dynamics
- Customer base: Diverse customer base
- Export control/ International Traffic in Arms Reduction (ITAR) policies
- Technology: Key technologies or capabilities that only the government has (that could/should be made available)
- Culture and perception: Proven, traditional, historical performance, “failure is not an option”, “tried and true”,
- Risk tolerance, safety and mission assurance: policies, regulations, and directives, oversight, insight, quality assurance, inspection, review, analysis, and testing
- Procurement and acquisition regulations
- Legal and regulatory environment
- State, federal, and international law
- Environmental considerations
- Policy considerations: Extracted resources and mineral rights, governance, space traffic management, orbital debris, space tracking and surveillance, launch and re-entry, national vs. multi-national interaction
- Lack of cohesive and integrated National space strategy or space policy across the government

Commercial Partnership Policies and Criteria

In order to identify and evaluate the merit or utility of potential commercial partnerships or commercial engagement activities, NASA uses the following non-inclusive list of criteria to guide its strategic exploration decisions. First, the activities must comply with existing policies and statutes or be dependent upon successful establishment of new policy or statutes. Integral to this effort is the determination that the policy is documented in requirements documents, across other government entities, and that it is widely understood. Applicable government, international, and industry-to-industry agreements are addressed and evaluated. It is very important to choose partners wisely, such that the partnership should help the U.S. achieve our goals and have a reasonable chance of success. In turn, NASA and the U.S. should be a

reliable partner. Moreover, ensuring coordination across the agency and where applicable, across the U.S. government such that there is “one federal voice.” Developing processes to allow complementary actions between commercial, international and technology development partnership opportunities is vital to ensuring an integrated strategy space approach. For execution of the partnership, NASA seeks to be proactive, but flexible. As a matter of course, international versus commercial partner decisions are made considering a broad array of evaluation criteria on a case-by-case basis. Similarly, it is essential to review strategies with key stakeholders regularly through frank and open two-way dialogue.

The NASA Exploration vision with respect to commercial partnerships includes the following key concepts:

- We are leading a global space exploration endeavor. Other countries also have exploration objectives and we are partnered in ways that allow everyone’s objectives to be met
- Existing partnerships are strong, and we are building new ones to strengthen our preparations for ultimate human missions to Mars, leveraging a “build-up” approach along the way with increasingly challenging and fulfilling objectives
- Architecture and supporting systems allow U.S. science and Mars Forward objectives to be met.
- Partners have people, assets, products, services, and contributions that are synergistic with our objectives
- Nations with critical capabilities are coordinated to enhance the robustness of space exploration. Interoperability between commercial, government, and international entities is essential.
- Commercial partnerships exist to enable new markets or enhance exploration mission success
- Public interest and engagement are strong and must be expanded for long-term sustainability and support

With this vision, NASA does the following strategic activities relative to commercial partnerships:

- Lead and engage in development of space exploration architectures, concepts of operations, mission scenarios, and functional capability systems assessments to identify specific cooperation opportunities
- Secure international and commercial contributions to the architectures while integrating them into existing government and industry architectures and systems-of-systems
- Encourage the development of complementary capabilities that will one day be relevant to human exploration beyond LEO
- Pursue near-term science and precursor mission opportunities
- Create conditions that enable commercial partners in sub-orbital, LEO, and Beyond-LEO exploration
- Enable commercial investments that enhance sustainability of the exploration program
- Maximize and promote use of partnerships to mature technologies
- Establish mechanisms to coordinate and implement our partnership strategy including: roles and responsibilities, mechanisms, timelines, and roadmaps

Criteria for NASA (or other Governments)

As a general policy, the following evaluation criteria for government consideration and pursuit of commercial space engagement are recommendations that should be followed for ensuring value while enabling and sustaining the commercial space industry. Given the relative immaturity of a true commercial space market, the following recommendations are focused upon pioneering stimulus or opening of particular sectors, missions, or opportunities. In this sense, they act as enablers or catalysts for growth.

1. Determine the value proposition to NASA and the government.
2. Assess or determine the responsiveness (agility) of the potential options
3. Allocate appropriate market or scope such that government does not compete with industry. Careful consideration of balance between the promotion of competition, innovation, and efficiency should be applied.
4. Is the approach innovative or substantially differentiated by cost, schedule, performance,

value, ease, or some other resource or constraint limitation?

Additionally, the following strategic considerations are important planning drivers.

- Agreements between NASA and commercial partners vary by:
 - Goals: May or may not include private space and/or terrestrial markets.
 - Purpose: Technology development, capability demonstration, association with NASA
- Establish commercial partnership goals and sub-ordinate objectives to include success criteria and appropriate Figures of Merit (FOMs) for evaluation
- Provide a mechanism to receive and review unsolicited partnership proposals
 - Level the playing field for all commercial entities
 - Continuously demonstrates our openness to consideration of ideas that would benefit NASA
 - Answers the question: “How does Company X begin to explore the idea of partnerships with NASA?”
- Actively, vigorously, and continually look for new opportunities.
 - Think “outside the box” and search for both conventional and unconventional solutions.
 - Pursue both evolutionary and revolutionary opportunities
 - Invest near, mid, and long terms potential
- Provide mechanism for reviewing internally generated ideas
 - Incentivize innovation, cost-savings, efficiency, and excellence
- Critically assess and evaluate various Commercial Market Approaches (CMAs)
 - If the activity is intended for a private space and/or terrestrial market, then it should fall under the domain of NASA’s/government’s Commercial Development Policy
 - If the activity is intended for a private terrestrial market only, the more “traditional” agreements may be appropriate
 - If the activity is intended for a government space market, then consider looking at acquisition or procurement, paying close attention

- to Organizational Conflict of Interest (OCI) issues
 - If the activity is focused on the outsourcing of research, test, or developmental proof of concept, then the partnership purpose must be considered.
- Evaluations of the partnership purpose shape the approach:
 - Capability Demonstration
 - May seek NASA funding or expertise
 - Example: COTS Phase 1
 - Technology Development
 - May seek NASA funding or expertise
 - Partner intends to provide a capability in return for visibility
 - What are the applicable laws, policies, and political sensitivities?
 - Some other reason that NASA finds beneficial

As an over-arching NASA principle, commercial partners are welcome and pursued in all aspects of the exploration architecture (as appropriate). Further, non-acquisition partnerships to meet NASA mission needs are encouraged. Codifying this approach, the NASA Exploration Commercial Development Policy outlines the policy to proactively enable development of space markets. Commercial partners are as vital element in all future exploration plans. For lunar exploration, interesting ideas include: lunar data buys, lunar payload delivery, lunar communications and navigation services, High Definition Television (HDTV), fuel depots, lunar mobility, space tourism, commodity re-supply, and participatory exploration. The future is truly exciting and commercial partners can take advantage of the visibility associated with their partnerships to help leverage and expand their future success.

Principles to Strengthen Commercial Space Industry

1. Create true partnerships

The government should not dominate the partnerships. It is not “*the* customer” but is “*a* customer”, and it should lead and support with the appropriate balance while exercising prudent insight, oversight, responsibility and accountability.

To create partnerships the government can execute a continuous process for soliciting information from the private sector to identify potential commercial partnerships. NASA’s Exploration Systems Mission Directorate created a “Solicitation of Commercial Information” (SOI) process (see Figure 1) for both identification and selection as part of a broader Commercial Development process (see Figure 2) in order to provide formal “on-ramps” to receive information from all commercial entities, use information to recommend specific commercial partnership opportunities, including developing a plan to use ISS as a test bed for understanding the scope and issues associated with commercial investments seeking utility and visibility.

To promote public private partnerships, government should:

- Pursue best practices, ideas and concepts to encourage commercial space capabilities,
- Adopt a needs-based approach for identifying near term priorities,
- Establish evaluation criteria,
- Maintain openness to hearing any proposal or idea,
- Pursue risk-based approach to capitalize on new or emerging opportunities
- Create an industry advisory group to ensure that good communication

2. Lower the barriers to entry

The previously discussed barriers to entry in the space industry and related fields represent significant challenges to overcome. Yet, prudent, forward-looking government leadership across the policy, regulatory, and business domains can substantially enable improvement. Integrated alliances, aggressive pursuit of timely solutions, and persistent forward progress are essential to enable commercial sustainability improvements

One approach is to review NASA’s roots as it develops its commercial strategy. Before NASA there was the National Advisory Committee for Aeronautics (NACA), which was instrumental in the development of key technologies. The charter was not to create a government air transportation system, but to study the problems of flight and to identify and resolve the risks that were keeping air travel from being safe and commercially viable. Under the NACA model the government worked closely with industry to fund projects that retired technological risks and

enabled private enterprise to successfully create a new industry. Under this model, NASA would develop and retire the risks of important technologies to enable space industry.

3. Establish tax and investment incentives

Throughout recent history government has used its ability to set tax law as incentive to stimulate new areas of economic growth. Encouraging new businesses to invest in creating new markets in space by providing tax breaks can improve the business cases of those entrepreneurs and help jump start a new industry.

Incentives, like prizes for space-based competitions, have also shown their effectiveness. The excitement of the competition and the eventual winning of the Ansari X Prize followed by the recent successes of the Centennial Challenges program illustrate the important role that prizes can play in motivating new commercial endeavors. The X-Prize competition was the seed for the creation of a whole new industry building up around human sub-orbital flight.

Strategic use of tax breaks and incentives like the use of prizes is a good way for government to leverage funds and encourage investment in new industries.

4. Create policy and laws to protect space investments

There are many complex policy issues such as property rights and liability in space that require government action to reduce risk for new space businesses. Governments should take a proactive stand to settle these issues so that they can reap the benefits when

The current status of private ownership or property rights in space is dominated by policies that were captured in treaties developed during the Cold War. The result is that the principle of

property rights in space is not clearly defined and most likely world governments would not recognize any claims of rights at this time. Individuals or companies interested in developing space resources are at serious risk that their investments would be challenged under the existing framework until the current treaties are modified to support space commercial interests.

In addition, governments can adopt policies that allocate support as necessary in the event the planned customer base is not sufficient to close the initial business case. For example, the government can become an anchor tenant or investor. Governments can also allocate a fractional percentage, specific mission, or data purchases to be executed via a new commercial paradigm that advances the general commercial space industry

5. Create a diverse portfolio

By investing in diverse solutions, multiple approaches to the same function, a robust foundation for space development can be created. For example, if the Shuttle were the only way to service the ISS our planning for ISS utilization over the next few years would look very different. Multiple options for Earth-to-orbit using commercial and government systems provide a robust solution and this same approach can be use in other areas like communications and resupply.

A diverse portfolio creates competition which drives performance up and costs down. It also can provide additional stability for the overall space architecture since it is robust against the failure of any specific system failure. For example, if one launch system fails there are other launch systems that can be called on to complete the needed task.

Commercial Partnership Solicitation, Selection Process

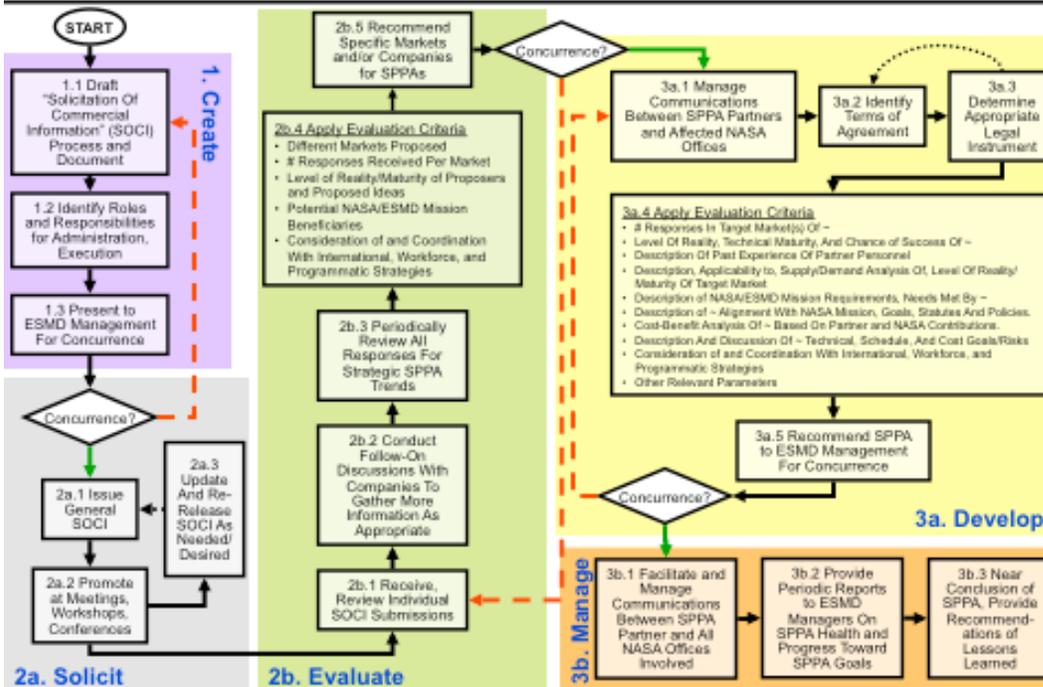


Figure 1. Commercial Partnership Solicitation, Selection Process

The Commercial Development Process

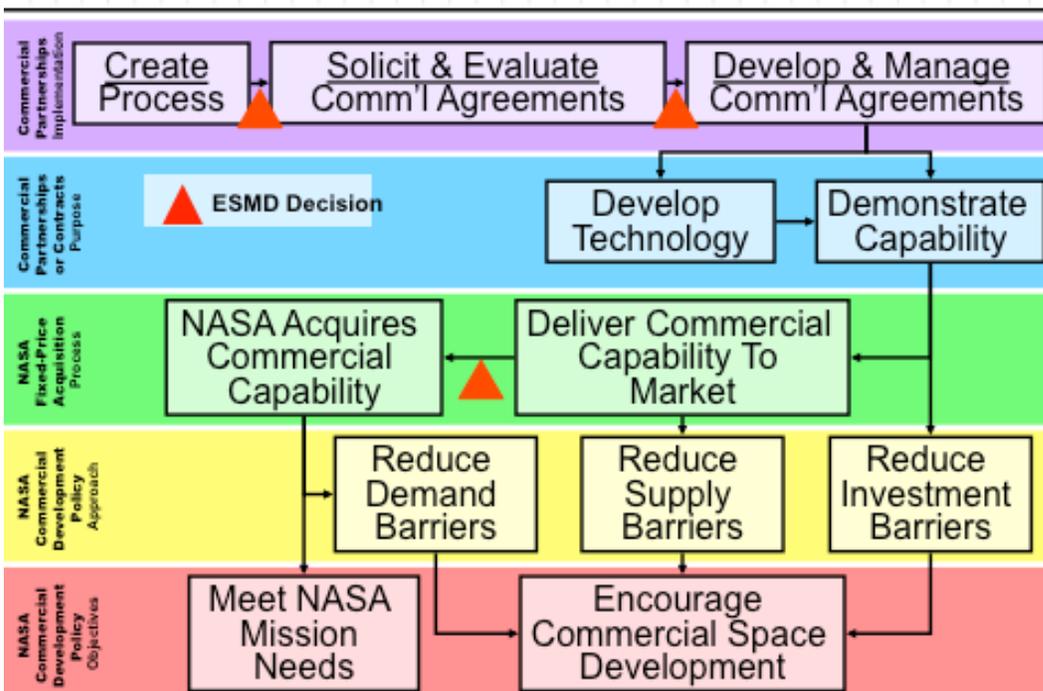


Figure 2: Commercial Development Process

CONCLUSIONS

This paper has focused on the role of government and what it can do to enable the creation of a strong commercial space industry, which is required to meet U.S. goals in space. In fact, without a commercial underpinning the space frontier will remain solely under the purview of government programs which will severely restrict the promise that the vast frontier offers.

By creating a strategic approach involving funding and policy incentives, a broad range of relationships between the space industry and government can be used to jump start the nascent space industry. These relationships can range from the government procuring services such as communication or transportation, as is done on Earth today, to partnerships where government and industry develop new technologies and systems together that are important for space development.

The government is the key to providing a pro-space industry environment and there are many actions that should be taken to provide the foundation that is needed. In this paper they have been summarized into five specific areas of action that can be taken: create true partnerships; lower the barriers to entry; establish tax and investment incentives; create policies and laws to protect space investments; and, create a diverse portfolio. These actions strengthen the ability of companies to be successful and create business cases that will work in space. Hopefully, new markets will arise which enable new businesses and the cycle will one day create a burgeoning commercial sector around space exploration and development. Some of these policies and programs are already in place and are already changing the way the government is approaching its objectives.

For those who are interested in opening the space frontier, it is clear that space commerce is a fundamental building block and it is important that government provide the incentives and environment to let this important new area grow.

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