A Comparative Study of the Great Powers' Space Policies

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ABSTRACT: Current manned space efforts are heavily invested in areas where cooperation is a key concern. The International Space Station program consists of seven international partners, and there is a renewed push to send unmanned probes to the moon in preparation for future sustained manned missions. Cooperation in space endeavors, much like in any area of international policy, has its own benefits and challenges that are unique to each participant and this comparative analysis will present the view of these benefits and challenges from the perspective of each of the great space powers. This research evaluates each of the great space powers, Russia, the United States, and China, in terms of its potential for successful international cooperation. A country tends to view its manned space program either from a political perspective, stressing national security and international prestige; or from an economic perspective, stressing industry growth and profit generation. It is believed that a country with the economic view of its program is more open to international cooperation, whereas a country with the political view will be less inclined to work with partners. Methodologically, the paper first presents a historical view of each of the great space powers’ manned space programs. This is followed by a look at current efforts and future plans, and finally, a look at the potential for international cooperation. Each nation’s unique situation, in terms of the benefits and challenges it must consider in choosing to undertake expanded cooperation, are discussed.
Introduction

International cooperation in manned space exploration is becoming increasingly important. The potential benefits and the large costs inherent in these endeavors encourage countries to work together to complete projects that no single state would want to undertake alone. A well known example is the International Space Station (ISS), a project that sixteen international partners (Brazil, Canada, Japan, Russia, and the United States along with 11 others working under the framework of the European Space Agency) are working on and others have expressed interest in joining (Catchpole, 2008, p. 13). So far, the capability to launch human beings beyond the Earth's atmosphere is a challenge that only three countries have successfully undertaken: Russia, the United States, and China. Each of these manned space programs reveals its host state's interest in national security and international prestige, or in acquiring economic advantages. Given these different perspectives, how does each country view international cooperation in manned space?

It is important to note the factors that have been omitted in this analysis. First, the dichotomy between the political and economic perspectives is a simple one, but it is meant to help provide an overview of the tendencies of each manned space program with regard to international cooperation, as well as their likely near future trends. Within each program, both perspectives are evident, and many factors, both political and economic, determine their trajectory. A third perspective—that of the military—should be considered in a future analysis. Second, other manned space programs exist besides the three noted above (for example the European Space Agency's program); however, these programs are linked to those of Russia, the US, or China because no other country possesses an independent manned launch capability. Although this study does not stress these factors, it should be noted that they are present nonetheless.

This analysis focuses on the perspective toward which a country's manned space program leans, either political or economic (the independent variable), and that program's openness to international cooperation (the dependent variable). For the space programs of Russia, the US, and China, an analysis has been performed by looking into their recent histories and near term future plans to determine 1) each state's perspective, 2) the level of international cooperation at the present time, and 3) their plans for international cooperation in the future. The hypothesis is that these states' concern for economic gain will lead to greater international cooperation.

Significance of Political and Economic Perspectives for manned Space Cooperation

From a theoretical viewpoint, a comparative analysis will provide a framework from which to understand manned space programs. Comparison will show the variables at play in the creation and implementation of policy in this field, and how these variables differ or remain the same among different national programs. In the future, more states are certain to join the club of manned space participants. Many of these states will lack the resources to operate self-sufficient programs, and for this reason, an understanding of how cooperation in manned space exploration can best be achieved is of acute theoretical importance.

In manned space programs, the benefits of international cooperation include the economic benefit of specialization of labor to allow for more efficient use of resources, the creation of international goodwill and the spillover effect to other facets of international relations, and the financing of complex missions that no one country could undertake alone. Significant challenges exist as well in terms of national security and military concerns. Space technology is of dual use: a rocket that can launch a human into orbit can also send a nuclear warhead around the globe. This comparison analyzes each of the states with indigenous manned space programs and considers how they approach the great balancing act in space policy between economic-industrial growth and national security concerns, since the pursuit of these two aims often conflict.

In the 1980s, (especially in the US with the Space Shuttle, which was intended to fill numerous functions, including those of a military craft, a civil exploration and science craft, and a commercial launch vehicle), the central debate concerned the goal toward which human space efforts should be directed, or as John M. Logsdon noted, At stake is the relative emphasis to be given to military, economic,
Joan Johnson-Freese and Roger Handberg define the concept of space development as one that is central to the debate:

A space development perspective defines space as another area for capital investment from which some level of return must be secured in order to fund other programs and continue the program itself into the indefinite future. No socially funded program can survive indefinitely unless it provides some modicum of benefit to the society. . . . It is simply a more realistic approach. (1997, p. 239)

They then raise another concern from a political and national security perspective, stating,

There also remain areas of activity of which the government has a continuing interest in maintaining total control, for national security reasons. The current political environment decreases the scope of these reasons, but some do remain. Missile warning is perhaps one such area. . . . That is good too, in terms of satisfying the self-perpetuation needs of the DOD [Department of Defense] research and development establishment and the DOD space operations mission. These are significant considerations for one does not wish to resurrect such capacities in the midst of crisis. (1997, p. 241)

Essentially then, the question becomes whether to focus one’s space program on the side of industrial and economic benefits, or on the side of political advantages, stressing national security and military concerns. Or, more realistically, what are the opportunity costs of focusing heavily on one side and what is a useful balance between the two that allows a program to attain maximum benefits?

The United States and Russia work together, with others, on the International Space Station, the first large-scale international space project. China has expressed interest in working with both Russia and the United States on the station and other projects, but it remains to be seen if that will occur (Catchpole, 2008, p. 349). US national security and military concerns keep China from being accepted into the ISS project (China seeks space, 2006). Along with China’s recent entry into manned space endeavors, other programs are scheduled to begin or be expanded in the near future, including those of the European Space Agency, Japan, and India. Each state will have to decide its particular mix of the political and economic perspectives on its activities, and with each, comes the potential for increased weaponization in space. A comparative analysis of these programs brings to light the areas in which competition and cooperation can be expected, and can act as a guide for future programs. Space holds the potential to be a future goldmine as well as a battlefield, and due to this fact the necessity of such research becomes apparent.

The Manned Space Programs

The focus of both Russia’s and the United States’ current manned space programs is the International Space Station, on which these countries work, along with Brazil, Canada, Japan, and many members of the European Space Agency. In accordance with the 2006–2015 Federal Space Program, the Russian contribution to the station is to be completed in 2011 and serviced with crews until 2015, with the creation of a new station after that year (Zvedre, 2006). The US National Aeronautics and Space Administration (NASA), operating under the 2004 “President’s Vision for [US] Space Exploration” calls for completion of the ISS by 2010 and servicing it until 2015 (A renewed spirit of discovery, 2004). The American space agency has, operating under the vision, begun its implementation with Project Constellation. The Constellation vehicles will service the ISS and enable manned lunar exploration and possibly Martian exploration (Constellation, 2009).
Throughout much of the 2000-2010 decade, Russia planned to continue upgrading the Soyuz and Progress vehicles, with the European Space Agency (ESA) as a partner. As a future replacement, after 2010, both Russia and the ESA were to work jointly on what was known as Kliper (Kliper history, n.d., Enter Europe section), and then the Advanced Crew Transportation System (ACTS) as a future vehicle (ACTS, 2008, Approaching crossroads section). In January 2009, however, Russia and Europe decided to terminate their partnership and work on their own future manned space vehicles. From this point on, the Russian spacecraft has been known as the Prospective Piloted Transport System (PPTS), and is projected to enter service in 2017, after the US Orion spacecraft (PPTS, 2009, Development of the PTK NP (PPTS) vehicle section). Russia also operates unmanned Progress resupply ships to the ISS, and, in light of the upcoming retirement of the US Space Shuttle fleet, plans to upgrade Progress to be capable of returning cargo to Earth and to develop an orbital tug known as Parom (Spacecraft, n.d., Manned spacecraft section).

In the current situation, these manned efforts are being complemented by unmanned lunar exploration to pave the way for manned lunar exploration in approximately 2020. The Russian effort consists of the revival of Luna-Glob, an old lunar exploration mission from the late 1990s that never materialized, to be launched later in 2009 (Lunar probes, 2009, Luna-Glob section). The United States launched the Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) on June 18, 2009, which began its unmanned precursor missions to the moon (Lunar spacecraft launch, 2009).

China, as noted in the State Council's Information Office's report “China's Space Activities in 2006,” plans to continue the Shenzhou manned program. Its purposes include:

- To enable astronauts to engage in extravehicular operations and conduct experiments on spacecraft rendezvous and docking; and to carry out research on short-term manned and long-term autonomously orbiting space laboratories, which is of certain application scale, and carry out follow-up work of manned spaceflight. (2006, p. 8)

China has made no secret of its movement toward building manned orbital outposts, with two separate space station programs in the planned phase: a short-term use military station and a longer-term Mir style station planned for the end of the next decade (Covault, 2009).

China, like Russia and the US, is also pursuing robotic lunar exploration plans leading to future manned missions, with Chang'e I, China's first lunar orbiting spacecraft, having launched in October of 2007 (Solar system exploration, 2009, Chang'e 1 section). According to Ye Peijian, chief designer on the Chang'e project, plans call for a second spacecraft in 2010, a lunar rover by 2013 and a sample return mission by 2017. Yu also stated that discussion of a manned mission to the lunar surface centers around the 2025-2030 timeframe (China considering, 2009).

International Cooperation

The Russian space program, in recent years, has sought international cooperation with almost any partner it could find for the benefit of securing additional funding. The United States, in its effort to make its current plans a reality, has been advised in numerous reports to seek out partnerships with other countries and private industry to alleviate program costs. In this regard, both countries already demonstrate excellent records of cooperation in space. After 2010, use of the American Space Shuttle will cease and, for a gap of four to five years before Project Constellation is online, Russia will provide the primary, and potentially only, means of reaching the ISS (Schwartz, 2008). This partnership is becoming more and more an arrangement of necessity, and not just of convenience, although it causes a large amount of domestic political fighting in the US. Russia is also exploring partnerships with Europe, Japan, China, and India on various facets of manned and unmanned space exploration. China has only been a player in manned space exploration for five years, but is catching up quickly and has sought opportunities for international cooperation. The capability to launch crewed spacecraft into orbit has given China added credibility as a partner in space exploration. Although the Chinese have expressed interest in participating on the International Space Station project, the United States has balked at that request due to the fear of China's military accessing advanced US technology. Thus China has put its energies into the creation of the Asia-Pacific Space
Cooperation Organization (APSCO), whose convention was signed in 2005 and began operation in 2008, an organization of seven member countries and a handful of other interested states of which China is the most powerful (Asia-Pacific, 2008).

The benefits to this unprecedented wave of international cooperation are many. Primarily since space exploration is expensive, pooling resources allows member countries to participate in missions that no one country could undertake alone. Division of labor allows countries to specialize in what they do best, with the hope of bringing costs down. Finally, side benefits such as international goodwill should not be overlooked.

The challenges in this effort, however, are considerable. For the United States, issues dealing with the dual-use nature of space technology and the critical pathway problem come to the fore. The United States is particularly sensitive to the dual-use issue, since it fears its own technology getting into the hands of terrorists or hostile countries. In fact, Congress must approve amendments to the Iran Nonproliferation Act (INA) of 2000 for NASA to purchase Russian space hardware and services to the International Space Station (Clark, 2005). Had these amendments not passed, NASA might have lost the ability to send American astronauts to the International Space Station after the Shuttle retires, as well as the continued danger of driving other partners, such as Europe, away (Abbey & Lane, 2005, pp. 18-19). The INA is intended to enhance national security, but laws such as this have tradeoffs, and, in this case, the tradeoff is international trade and cooperation. This is especially so with the creation of restrictive laws such as the International Traffic in Arms Regulations (ITAR) and the INA, which make it difficult for NASA and US businesses to cooperate with other countries. A paper by the Center for Strategic and International Studies that analyzes the progress in China’s and Japan’s space programs in 2007 states,

In Earth Observation (EO), China is continuing its engagement with Brazil on joint development of hyperspectral sensors for EO platforms. China’s advances in space, including their growing ties with other space faring nations, seem to suggest that the application of International Trade in Arms Regulation (ITAR) to space – a US export control regulation originally intended to isolate China technologically – has been effective only in isolating the US. (Faith, 2008, p. 2)

Another important issue in space cooperation is the critical pathway issue. The critical pathway refers to mission milestones that are absolutely required to make a mission successful. Traditionally, even when cooperating on a mission, both Russia and the United States have avoided allowing partners to participate on any aspect of the mission that was part of the critical pathway, thus allowing the senior partner control over success of the mission itself. Before the Space Shuttle Columbia disaster in the United States, Russia was criticized for having responsibilities on the ISS project that were in the critical pathway. However, Russia’s position allowed the station to continue to be serviced during the years that the US shuttle fleet was grounded after Columbia. The traditional model of having only one state in the critical pathway (and running the mission) and partners performing non-critical tasks would have resulted in further delays, and potentially the end, of the ISS project during this period (Soyuz TMA-2, n.d., Impact of the Shuttle tragedy section). Both Russia and the United States have been responsible for critical mission undertakings on the ISS, most importantly in that both countries’ launch vehicles are needed to construct the station. From a political perspective, multiple partners in the critical pathway necessitates that each partner cede some sovereignty and security to the other, and critical decisions must be made by all parties. However, this situation is seen to be closer to true international cooperation, in which multiple countries are responsible for critical parts of the mission, not simply a senior partner responsible for all critical mission aspects and junior partners who can be removed from the program at any time. China has yet to undertake a mission in which partners are in the critical pathway since national prestige continues to factor highly in its space program. Its attempts to join the ISS program, however, show that it understands, to some extent, that it must be flexible on this point.

Space militarization is also an issue, and, according to the 2006 US National Space Policy, the US reserves the right to protect its space assets (U.S. national space
The 2007 destruction of a US satellite in orbit by China made it clear to the US how vulnerable these assets are (Chinese anti-satellite test, 2007). China's space program is still very much linked to its military, and the United States has concerns about the Chinese military benefiting from US technology.

Wortzel, in his article in Ad Astra, discusses engagement with China based on the engagement of the United States with Russia during the Cold War, which could serve as a model for US-China cooperation in the future. He believes the ISS program would be a good one on which to cooperate with China, but cautions that engagement needs to be undertaken carefully. The United States, according to the article, should neither help nor hinder China's space program. Any partnership should be that of equals. In the end, he notes that, although both China and the United States officially affirm that space is for peaceful purposes only, both are aware of the military uses of space. Cooperation between these nations at this point would require heavy monitoring, but would also allow for a pooling of resources that would be beneficial to both sides (Wortzel, 2005).

Russia, whose current mindset on space is economically oriented with a surprising lack of concern over the dual-use nature of space technology, has the most potential for cooperation. Russia has made an enterprise of taking “space tourists,” or paying customers, to the International Space Station (Catchpole, 2008, p. 10). This effort was initially rejected by NASA, and the United States has rejected this practice, citing disruption of the station construction schedule, lack of adequate training, and an inadequate $20 million price tag as reasons why such flights should be cancelled (Berger & Saradzhyun, 2001). Although this difference of opinion has strained the two countries’ relationship on the ISS project, they are dealing with the difference without the project disintegrating. Russia bristles against differences in projects in which it does not have complete control. One of the compromises on the ISS project was that the orbital inclination of the station should be at an angle that made it easier for the United States to launch to the station. Russia is already planning to build a successor to the ISS and stated in the 2006-2015 Federal Space Program that its orbital inclination will be higher, and thus easier for Russia to launch into (Zvedre, 2006).

Finally, challenges arise from simply trying to manage an international project. Culture clashes can arise from differing work ethics, such as that of American astronauts who work together with mission control and spacecraft designers in giving input on a mission, whereas in Russia, mission control has complete authority and cosmonauts simply obey orders (Catchpole, 2008, p. 5). Different needs and opinions on how to accomplish a task can make or break a mission. To solve this predicament, each country could plan its own separate missions and share its benefits. The Moon has begun to host spacecraft from Japan, China, the United States, India, and Russia. Each mission should accomplish the objectives that its host country requires and then share the data for mutual benefit. A network oriented international effort to prepare the moon for future human exploration is currently being proposed by the United States. Called the International Lunar Network (ILN), it would consist of separate nodes operated by each country, yet work together as a networked system to share data and the use of multiple scientific instruments (NASA hosts international meeting, 2008).

The Political Perspective

Space programs generally begin as military programs, which is the case for Russia, the US, and China, and political, military, and security issues arise when dealing with space policy. Of these states, only China's manned space program is still attached to its military, the status of which continues to damage its effort to partner on the International Space Station project. The destruction of satellites with ballistic missiles by both China (in 2007) and the United States (in 2008) also increase the distrust between the countries (Satellite strike, 2008). Only Russia, it seems, is not driven by the fear of technology transfer, or is at least less driven by it than by the need for money.

A current concern with the political and military aspect of space is the fear of space weaponization. Many treaties stress the “peaceful uses of outer space,” and in February, 2008, Russia and China proposed a new international treaty that would prohibit the use of weapons in space and the use of anti-satellite weapons (Spencer, 2008). Weaponry in space is a very complex issue, and may be
seen as a move by Russia and China to keep US military power in check. China, and Russia especially, want to halt US plans to create a ballistic missile defense shield. China, however, sends mixed messages about that effort when it conducts an anti-satellite (ASAT) weapon test while calling for a treaty to ban them.

It is highly likely that the recent increase in space activity will also increase military use of space and the creation and use of space weapons. An ever-growing number of space assets are continually launched into orbit and their importance in both civilian and military operations warrants their protection. Since the early 1990s the United States has shown, in more than one conflict, that its military relies on satellites to operate, and now Russia and China have the ability to destroy those satellites.

The political and military issues involved in space cooperation must be studied carefully. Placing too much stress on national prestige and security can lead to forms of isolation for a country's space program, and certainly military concerns are the primary factor prohibiting China from participating on the ISS project. As well, it must be understood that space will ultimately be no different from any other “geographic” area, and the various space-faring states will have the same military concerns for the defense of their assets and for the use of weapons that would provide enhanced power and advantage, whether those assets are in space or on the ground. International cooperation is commonplace between these states despite the reality of arms and armies, and cooperation in space will continue to grow even as the military use of space grows as well.

The Economic Perspective

The economic perspective of making space operations profitable, or affordable, has been a concern since the post-Apollo era, when the superpowers ceased using space to prove the validity of their economic systems. Even so, the first experiment in commercialization, which came from the Russians, was not performed until 1999, when the Mir space station was sold to an American investor creating the company MirCorp. MirCorp planned to run the station as a commercial entity, but these plans did not bear fruit because the Russian government chose to de-orbit the station in 2001 under pressure from NASA to fully support the International Space Station (Harvey, 200, p. 68). Beginning with the first space tourist, Dennis Tito, in early 2001, Russia began a program of sending paying customers to the International Space Station. For Russia, this sort of commercialization in their national space program is a necessity. It allows the country to run a program that is as capable—perhaps more so—as the United States’ program at a fraction of the cost. Necessity. It allows the country to run a program that is as capable—perhaps more so—as the United States’ program at a fraction of the cost.

Neither the United States nor China contributes to this sort of commercial activity within their programs. In fact, NASA's response to Tito’s flight evinced a complete disdain for the idea. Before the flight, NASA alerted Russia that it would receive a bill for any damage to equipment or worker morale that Tito caused, prompting Tito to sign a release to be held personally liable for any damages. Following his safe return, according to an article written by Yuri Karash, “the rhetoric from Washington, D.C. has grown intense, with [then] NASA chief Dan Golden implying Tito is not an American patriot and US Sen. Barbara Mikulski (D-Maryland) likening the Russian’s recent behavior to that of a ‘pimp’ (Karash, 2001, p. 2). For the United States, the “national” in national space program continues to be meaningful. Only patriotic astronauts are sent into space, not paying tourists. For China, with such a new program, only military officers become astronauts. Both of these countries stress nationalism and security over economic advancement in space, but they do so at their own expense.

The future of space commercialization, however, does not lie in the hands of any national space program, but in the private sector. In June 2004, Mike Melvill became the first commercial astronaut by flying the SpaceShipOne spacecraft developed by Scaled Composites on a suborbital flight (Boyle, 2004). A second flight in October of that year earned Scaled Composites the $10-million Ansari X-PRIZE, and ignited the private space tourism industry (Foust, 2005). In 2005, Scaled Composites and Virgin Group created The Spaceship Company to build a new spacecraft, SpaceShipTwo, and the company Virgin Galactic plans to use the craft to send paying tourists on suborbital trips into space. As of May 2009, components of SpaceShipTwo are in the testing phase (Virgin Galactic, 2009). In 2006, Spaceport America in New Mexico, the planned location for Virgin Galactic flights and other private space endeavors, became an active spaceport (David, 2006). In the future, it is likely that state-run manned space
programs will partner with private enterprises as much as with each other.

Even China, whose programs are still very much a part of its military, is seeking private funding for its future moon missions (China’s Moon program, 2007). It is likely the countries benefiting most from future space operations are those whose governments create an environment in which private space activity is welcome.

A Prescriptive Framework

Currently, only Russia, the United States, and China have the capability to launch manned space missions. A handful of other countries have experience operating unmanned spacecraft, have partnered with one of these three countries on manned missions, and have future plans that include manned launch capability. Japan runs an unmanned lunar exploration program to support future plans for manned exploration (Selenological, 2009). India launched its own unmanned lunar probe in October 2008 (Jayaraman, 2008). The European Space Agency operates several unmanned exploration missions to various celestial bodies and is weighing the costs and benefits of building its own manned capability (Seidler, 2008). Finally, several countries are presently working toward creating indigenous programs for launching satellites, and partnering with the major space powers in those efforts. A comparative analysis between space programs should provide a useful understanding of how these upcoming powers may be able to survive on these new worlds. Within the next twenty years, human colonies can be operating on the Moon, and plans will be underway for a human presence on Mars. In the future, the potential exists for commonplace travel in LEO and cislunar space (the space between Earth and the Moon) by tourists, as well as cislunar space (most likely LEO and the stable Lagrange points) used to sustain space stations with many new technologies. The manufacturing of spacecraft or components in orbit would lessen the need for expensive launches of these components from the surface of Earth. Solar power satellites will allow for the collection of solar energy in orbit, which could then be sent to Earth and the Moon. Finally, the collection of resources from the Moon and other celestial bodies will complement the use of resources on Earth and allow for the growth of human civilization on these other worlds. The challenge will be to make these first outposts beyond the Earth self-sustainable and profitable, both in terms of their capacity to further the spread of humankind and to alleviate some of the problems now facing Earth: over-population and the use of Earth’s finite resources.

Conclusion

Humanity will one day spread throughout the cosmos, and the manned space efforts of today are infant steps toward that future. Only three countries currently have the ability to launch manned craft, but that exclusive club will include more members in the very near future. Now is the time to set the ground rules that will allow this effort to provide the maximum level of benefits.

Countries that only see the political, military, and security aspects of space are looking through a narrow lens,
and their efforts will make needed cooperation in space more difficult to achieve. These countries focus only on their little piece of geography here on Earth and see space as an asset to protect this geography. The programs that concentrate only on long-range missiles and spy satellites are not concerned with space as a place, but only as a means for more advanced weaponization for their terrestrial space.

On the other hand, some countries see space as a place where humans should strive to learn to live: a place, or more accurately, many other worlds in which Earth is simply one. This view encourages humanity to learn about Earth’s place in the cosmos and how that place can be protected. It also allows for a future in which the resources of other worlds can be used to lighten the load of humanity on Earth and to sustain a growing human presence. This view realizes that the future of humanity depends on these other worlds, and a framework is needed now to plan for this inevitability. This view is much more focused on the economics needed to create a sustainable space presence.

Russia’s manned space program stresses the economic view over the political to a greater extent than both the United States and China. Russia is the only state, so far, that has actively courted space tourists to pay for time in orbit. Even so, Russia struggles with international cooperation, as the failure of its attempt with the European Space Agency to build a joint space vehicle shows. Despite this failure, Russia continues to seek partners to help it bolster its programs.

The United States sacrifices a portion of the economic view for one that puts greater stress on national security. The US fears space technology being used against it by enemy states or terrorist organizations, and because of this fear, does not seek to work with some partners that Russia does. It is more likely that the US will embrace commercial manned space enterprise through its private industries rather than through its state-run programs.

China’s program has the largest political view of the three, and is essentially a military program. China looks to partner with more advanced space powers in order to advance its own level of technological sophistication, and with lesser partners to build networks in which it sets the agenda. At the present time, neither the Chinese government nor any of its private businesses has any firm plans for manned space commercialization.
References


**Endnotes**

1. The ESA partners are Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

2. In the 2010–2011 timeframe, the Space Shuttle fleet is planned for retirement, creating a gap of 4-5 years in which the US will not have an indigenous manned launch capability. During this time, the Shuttle replacement, Project Constellation, will be built for use beginning around 2015. The vehicles of this new project will be much closer to the Apollo vehicles that brought astronauts to the moon in the 1960s and consist of two launch vehicles (rockets) known as Ares I and Ares V, a spacecraft known as Orion, and a lunar landing module known as Altair.

3. China, Bangladesh, Iran, Mongolia, Pakistan, Peru, and Thailand are members. In addition, Indonesia and Turkey have signed the APSCO convention.

4. The critical pathway refers to those parts of a mission that must be completed (equipment built, data collected, etc.) to ensure that a mission is successful. For example, if a particular piece of scientific equipment must be utilized on a mission, building and installing it on a spacecraft is considered to be in the critical pathway. Sharing the data obtained by that instrument with another party would not be in the critical pathway. This concept and the problems that can arise from it will be discussed in further detail later.