U.S.-China Economic and Security Review Commission
Hearing on *"China's Space and Counterspace Programs"*
"Implications for the United States"
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I would like to thank the members of the U.S.-China Economic and Security Review Commission for inviting me to participate in today's hearing on "Implications for the United States." Daily, I am engaged in the study of American space policy generally but with particular focus on military space and international space policy including China and Europe.

My testimony today provides a net assessment of the U.S. and Chinese civilian space programs, discuss possible cooperation and assess the impact of China's space program upon the U.S. and the global community presently and into the future.

>Both China and the United States operate full scale space programs although the U.S. generally is much more active in space science including different forms of astronomy, Earth science and planetary science. The US civilian space program arose in an atmosphere of competition with the Soviet Union with a strong sense of national security driving the effort, space "firsts" were the priority but that ran down across the 1970s after the U.S. made successful landings on the lunar surface. The United States became engaged in a strong space science and astronomy effort once Apollo ended in 1972 with a continued focus on human space exploration. The international competitive tone of the American space program continues despite some setbacks.

The U.S. space program is in a state of flux. The commercial aspect is entering an era of opportunity with the rise of independent commercial launch options and expanded uses of space based applications especially navigation, remote sensing and communications. These resulted from the gradual removal of Cold War era security restrictions on nonmilitary space operations. The government side of the program is presently in a situation where budget realities are severely impacting future operations even though in areas such as planetary science and astronomy ongoing exploration is occurring at the edge of the solar system, on Mars, and in the galaxy beyond as new worlds are discovered.

In terms of public perceptions, China's space program appears to be moving ahead of the United States. But, upon closer examination, while the Chinese space program is making great strides across the spectrum of space activities but essentially China is still catching up to the original space pioneers, the United States and the Soviet Union, now Russia. Psychologically, momentum appears to be moving in China's favor with the possibility of actually moving ahead of the United States over the next two decades. The U.S. technological advantage is being challenged but has not been over taken up to this point. The strongest challenge actually appears to be relative to the U.S. GPS system which is the dominant navigation system at this time.

So, any net assessment has to specify a time line involved with the obvious reality that the farther out you go the less accurate the judgment. Over the next decade, despite some U.S. issues, China is still running behind but can rapidly catch up over the next two decades as the U.S. space program runs down unless some major changes occur or a new sense of urgency enters the equation.

Americans assume continued U.S. superiority but that is a thin margin that will require reinvigoration. One must note however China's program has not (at least publicly) suffered a major setback in terms of a flight loss with crew deaths, that will not change the technological aspect but may change the psychological and public momentum.

>China, since the 1970s after the departure of Mao Zedong, has envisioned their space program as a tool through which other states can be engaged, circumventing any U.S. objections. At first, their cooperative activities were with members of the Soviet bloc rather than globally. More recently, China's space program is part of their "charm offensive" in order to acquire allies or at least influence neutrals globally. States otherwise excluded from outer space activities can partner with China to acquire access in the form of useful space applications. The joint China Brazil Earth Resources Satellite program initiated in the 1980s represents one example of those efforts where China consciously uses its space assets especially launch vehicles, the Long March family, to engage in cooperative activities with other economically advancing and challenged states. Chinese Long March vehicles have carried satellites to orbit for Venezuela and Nigeria, both influential states in their regions. With more developed space states, China have linked up especially with the Europeans. For example, China invested in the early Galileo navigation system and more recently just agreed to a robotic program with the European Space Agency. More recently, China has become visibly active in joint programs with the European Space Agency and individual states such as France. Examples include a robotic mission with ESA and several efforts in astronomy with France, the latter having encountered problems with U.S. International Traffic in Arms Regulations (ITAR) policies which prohibit or limit use of U.S. technology with certain states without formal U.S. consent.

The United States and China do not directly cooperate due to U.S. congressional actions banning such cooperation. Restrictions were originally driven by events after World War 2 and further hardened by the Korean War. After President Richard Nixon's opening to China in 1972, subsequent establishment of formal diplomatic relations in 1979, cooperative activities came slowly or not at all. U.S. policy has consistently placed severe restrictions on transfer of militarily relevant space technologies. In addition, the U.S. and other states agreed upon the Missile Technology Control Regime which expanded the restrictions further and brought other states (now 34) to agree on limits on what missile technologies could be sold or transferred to nonmembers. ITAR restrictions were somewhat loosened in the late 1980s-early 1990s in the context of allowing launch of U.S. comsats on Chinese vehicles but generally remained in force.

By 1998, concerns were raised about satellite technology transfers occurring during post-accident investigations involving Chinese launch vehicles carrying U.S. comsats. In response, ITAR restrictions were further tightened, shutting out launches on Chinese vehicles. Further restrictions occurred after 9-11 and only now are those restrictions being loosened but not removed. Congress explicitly banned cooperation between NASA and China. The pressures for an easing of ITAR restrictions came from industry.

With reference to China, the concern was that the Chinese were surreptitiously accessing U.S. technologies for their military and economic advantage. Given the technological disparities existing earlier, that was not an unreasonable fear. Concern about cyber-attacks keeps one vigilant and skeptical but circumstances have changed at least partially. Over the past decade, China has

consistently demonstrated the independent capabilities for conducting space operations in LEO and at the Moon. This work appears to have been indigenous rather than imported from elsewhere. Concerns about industrial espionage especially through cyberattacks are realistic and not inconsequential but the circumstances may be changing with regards to civil space activities.

Therefore, I would suggest opening the possibility for cooperative space activities between NASA and China on at least a limited basis. This would be particularly fruitful in conducting space station operations since the ISS is projected to terminate around 2024 with no follow on program in sight. Commercial options may arise but are still problematic at this point in time. China is proposing to complete its next space station around 2022 although slippage is always possible and likely. China has publicly said the Chinese Space Station would have international partners, mirroring the ISS as it presently exists. The United States has consistently argued that China must become an integral part of the international order; cooperative space activities are one facet of such outreach and in fact is least threatening to U.S. security and economic wellbeing. China is demonstrating the ability to operate its program in outer space without others participating which is the criterion for joining the space club as a major member, one of three who have sent humans into outer space.

>Assessing whether there exists a "space race" between the US and China is simple: no. A space race implies there are at least two parties involved in the competition. The United States does not directly responded to the Chinese space program's expanding activities especially human space activities. Instead, the US posture has been of isolating China in terms of participation in the International Space Station (ISS). For the United States, domestic considerations dominate the development of our space program. Budget concerns for example come in two forms: one is a concern with the federal deficit which leads to a statist position as demonstrated by the NASA budget over the past decades (see attached Table 1); and two, a continuing political-technical disagreement over where the next NASA human launch vehicle, the Space Launch System, should go. The disagreement boils down to the Moon first position and the "flexible path" as embodied in some variant in a crewed mission to an asteroid. These factors reduce any competitive response to China's space program with the recognition that there appears little political interest in engaging in such a competition. Furthermore, the U.S. is committed to a significant commercial engagement in outer space initially in Low Earth Orbit (LEO) and eventually farther out. So, the U.S. space program may look less capable than China's program in certain aspects because some has been farmed out to the private sector.

China's space program is an instrument for achieving and sustaining international prestige, as a symbol of military power, and an instrument for economic development. International prestige is critical for China as it strives to assume what they perceive as their proper role in world affairs as one of the dominant powers. Regionally, space activities become an instrument for signaling their superiority to Japan, its major regional rival. The result from China's perspective is a twofer: equality with the United States and superiority in the Asia-Pacific realm. All of this creates tensions with others both globally and especially regionally but for domestic political reasons that is an acceptable cost.

Launching satellites, space stations, and crewed vehicles to space are important symbols of Chinese military and economic power. In a manner similar to the Soviet Union in the earliest days after Sputnik, launching peaceful space payloads symbolically is the equivalent to launching

ballistic missiles. Its signals that China possesses significant military capabilities. So, for China, a "space race" is underway – one in which China races to accomplish the same "space firsts" achieved by the Soviet Union and United States in the first decade and a half of the space age. The race is to acquire international attention and respect, the military aspect remains more muted but present in the background. One should point out that China's race to space is much more leisurely than occurred across the 1960s. In one sense, their margins for failure are much narrower, for China "failure is not an option" unlike the early space age when failure was expected as new technologies came on line. Prestige wise, China benefits from its successes but that is always fragile given the possibilities that a flight failure may occur especially in human spaceflight.

For the United States, by 2030, the question of where to go in terms of human space exploration will be decided and the exploration process under way or else the U.S. will have withdrawn from any significant role in conducting exploration of outer space by focusing its energies on robotic missions. The reality is that the U.S. and Chinese human space exploration programs may both confront the reality that space may prove too harsh an environment given existing technologies. Remember NASA is only now sending an astronaut to the ISS for a year and then will evaluate that individual with their twin to assess the amount of damage inflicted by the space environment. If China lands on the Moon, the question will be what are their long term plans for that location?

>The 2007 destruction of an obsolete Chinese weather satellite drew much world attention because the Chinese military appeared to be unaware or indifferent to the proliferation of orbital debris and its consequences. A subsequent U.S. shooting down of a descending satellite produced much less debris which reentered the atmosphere quickly. Recent estimates show that China despite the relative newness of its accessing Earth orbit has become the leader in creating orbital debris, reflecting their lack of systematic programs for disposal of obsolete satellites and space craft. NASA for example has deorbited various satellites when their missions ended and before the vehicle ran out of fuel to allow for a partially controlled descent. For example, when the ISS ends its effective lifespan, it will be deorbited into the Southern Pacific under hopefully controlled conditions. One estimate by the Russians was that China has contributed 40 percent of the debris in orbit with the U.S. and Russia around 25 percent each despite much longer space histories in terms of launches and satellites in orbit. Explosions of Long March vehicles after their payloads were orbited have occurred at least 4 times leading to the spread of debris as a result. China established mitigation policies but implementation has been slow, reflecting a relative lack of priority.

For all space states especially the United States with its large array of satellites, orbital debris is a major concern both commercially and militarily while the ISS has routinely been moved in orbit to avoid large pieces of orbital debris including entering the Soyuz vehicle on station as a lifeboat. If China does not become more conscious of orbital debris impact on space operations, the reality could be a significant decline in the ability of states to operate in space especially in low Earth orbit. Economically, the U.S. GPS system could be disabled and efforts at exploring space could be severely damaged. Ironically, China pushes for international agreements against weaponization of outer space with the argument in part about the debris catastrophe such a conflict would generate. That same effect could be accomplished just by lack of care in disposing of obsolete or otherwise useless space hardware. UN efforts to limit debris proliferation have the usual problem

of being obsolete but the U.S. and others have already demonstrated that mitigation can be achieved in absence of removal.

>China since the 1980s has pursued commercial activities initially through their China Great Wall Industry Corporation. Their Long March launchers represent a potentially strong competitor internationally. Earlier, they failed due to several launch accidents resulting in deaths among the local population. Those accidents combined with U.S. ITAR restrictions reduced their role in the global marketplace given American dominance in comsats at that time. In reality, their domestic launch manifest was growing, providing a means by which to reestablish Long March reliability. They launch a few non-Chinese payloads but the potential is growing because of the cooperative activities mentioned earlier. Their move in this sector may be adversely impacted by changes in the launch marketplace if SpaceX proves as successful and cost efficient as appears to be happening. Chinese technologies are improving such as in satellite construction but competition is also rising. For example, India and Japan are as their new launch systems and satellites are becoming available.

The most significant immediate Chinese commercial challenge to the United States is emerging in their Compass/BeiDou-2 navigation satellite system. This satnav system has achieved regional coverage and is building toward global coverage. The U.S. GPS system is the benchmark against which all other potential competitors are measured. The Russian GLONASS and European Galileo systems were both constructed as alternatives to the U.S. system, the latter as a direct commercial competitor while the Russian system is a carry forward from the Cold War. Both have encountered some turbulence but are both either on line (GLONASS) or coming into service (Galileo). Regardless, the Chinese system is rapidly growing in impact. Both Galileo and Compass/BeiDou-2 should be globally operational in 2020. A growing number of Global Navigation Satellite System (GNSS) commercial applications are built in multi-GNSS configurations, meaning presently GPS plus one of the others, GLONASS, Galileo or Compass/BeiDou-2. However, there is mounting evidence that different states involved in supporting a GNSS system are requiring their nationals to use their system. The Europeans are already being challenged on that requirement but the reality is China does not have to officially require its operators to do so since most operate at the sufferance of the government. The alliance between Russia and China (driven in part by the Ukrainian situation) will probably end with GLONASS and Compass/BeiDou-2 being their preferred arrangement especially after the latter becomes global. GNSS applications are a major economic driver in the global market as the uses proliferate well beyond the dreams of the original builders. The major U.S. advantage is that U.S. GPS satellites have proven extraordinarily reliable over the years while the GLONASS has had recurrent gaps in coverage.

>The impact of China's civil space programs and activities on U.S. space programs and industries comes mostly at the level of cooperative projects when China is willing to subsidize participation by economically challenged or neutral states. The U.S. further hampers its international cooperation efforts through the ITAR process but that has been a burden the nation has agreed to bear. China is excluded completely from space relevant exports under ITAR as it is applied. Otherwise, the U.S. relies on private vendors to make sales in other states that can qualify. That means that economic benefits are lost due to technology transfer restrictions tied to national security concerns. Such losses occur across the spectrum of U.S. space technologies and activities

which means solutions will be sector by sector or else sale by sale. That may be a bearable cost but one must insure the review process is both timely and relevant.

> Recommendations are few given the ongoing international situation between China and the United States as rivals:

1. As suggested above, the ban on NASA interacting with China should be addressed so that more nuanced decisions can be made regarding what cooperation with China is deemed possible given security and economic concerns. The reality is that the United States may find itself outside many future civil space programs which will likely be cooperative rather than standalone by the United States. China is actively working to pull others into their orbit, a competition the United States is in effect ignoring or saying that nothing can be done. Also, the United States cooperated with the Soviets earlier, indicating that security concerns can be addressed successfully.
2. A more general but relevant recommendation is that the U.S. needs to decide what it plans on doing regarding our civil space program, the commercial aspect is well underway and moving to the next level of international competitiveness. NASA and other government programs need a stronger sense of direction supported by actual budgets moving forward in time. Understanding that Congress wishes to retain power of the purse, the necessity is that we as a nation generate a path to the future (with the possibility of detours) regarding our space program. Otherwise, we will continually meander forward and waste scarce fiscal resources and professional talent in a continual trip to nowhere. Supposedly, reaching orbit meant the entire solar system and universe was open to us that has not happened.
3. More broadly, the United States must systematically review its ITAR policy in order to maximize trade options while maintaining necessary security restrictions. The major changes involve improving the capacity to review and decide on requests more quickly. The international space marketplace is evolving quickly and the United States must work to remain competitive. Markets once lost are difficult to recover especially given the quickness with which change is occurring globally.

Table 1*[1]

NASA Budget Historical Current Dollars FY 1959-2010

Fiscal Year	NASA Budget (current dollars, millions)	Percent Change	Percentage Federal Government Outlays
1959	145	-	0.1
1960	401	177%	0.5
1961	744	85.5	0.9
1962	1,257	69	1.2
1963	2,552	103	2.3
1964	4,171	63.4	3.5
1965	5,092	22.1	4.3
1966	5,933	16.5	4.4
1967	5,425	-8.6	3.4
1968	4,722	-13.0	2.7
1969	4,251	-10.0	2.3
1970	3,752	-11.7	1.9
1971	3,382	-9.9	1.6
1972	3,423	1.2	1.5
1973	3,312	-3.2	1.3
1974	3,255	-1.7	1.2
1975	3,269	0.4	1.0
1976	3,671	12.3	1.0
1977	4,002	9.0	1.0
1978	4,164	4.0	0.9
1979	4,380	5.2	0.9
1980	4,959	13.2	0.8
1981	5,537	11.7	0.8
1982	6,155	11.1	0.8
1983	6,853	11.3	0.8
1984	7,055	2.9	0.8
1985	7,251	2.8	0.8
1986	7,403	2.1	0.7
1987	7,591	2.5	0.8
1988	9,092	19.8	0.9
1989	11,036	21.4	1.0
1990	12,429	13.6	1.0

1991	13,878	11.7	1.0
1992	13,961	6.0	1.0
1993	14,305	2.5	1.0
1994	13,694	-4.3	0.9
1995	13,378	-2.3	0.9
1996	13,881	3.8	0.9
1997	14,360	3.5	0.9
1998	14,194	-1.2	0.9
1999	13,636	-3.9	0.8
2000	13,428	-1.5	0.8
2001	14,092	4.9	0.8
2002	14,405	2.3	0.7
2003	14,610	1.4	0.7
2004	15,152	3.7	0.7
2005	15,602	3.0	0.6
2006	15,125	-3.1	0.6
2007	15,861	4.9	0.6
2008	17,833	12.4	0.6
2009	19,168	7.5	0.5
2010	18,906	-0.2	0.5
2011	17,618	-6.8	0.5
2012	17,190	-2.4	0.5
2013	16,865	-1.9	0.5
2014	17,646	4.6	0.5
2015	18,010	3.11	0.5

*"Historical Tables, Budget of the U.S. Government, Fiscal Year 2015" (Washington: Office of Management and Budget, White House, 2015), Tables 5.2 and Table 5.3. Fiscal Years 1959-1961 come from Jane Van Nimmen and Leonard C. Bruno with Robert L. Rosholt, "NASA Historical Data Book, 1958-1968, Vol. I, NASA Resources," (Washington: NASA SP-4102, 1976), Table 4.4, page 118. Updated January 30, 2015.

[1] Chart originally reported in Roger Handberg, "Human Spaceflight and Presidential Agendas: Niche Policies and NASA, Opportunity and Failure," *Technology in Society* 39 (2014), 31-43.