

Hearing of the Senate Space, Science, and Competitiveness Subcommittee

“NASA at a Crossroads: Reasserting American Leadership in Space Exploration”

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Thank you Chairman Cruz, Ranking Member Peters, distinguished members of the Subcommittee, as well as the Subcommittee’s dedicated and hardworking staff, for this opportunity to discuss the future of NASA. My name is Mike Gold and I am the Vice President of Washington Operations for Space Systems Loral. Space Systems Loral (“SSL”) is America’s most prolific commercial satellite manufacturer, a global leader in space-based robotics, and an innovator for spacecraft technologies such as solar electric propulsion.

I would like to begin by taking a moment to acknowledge my fellow witnesses, starting with the Atlas of NASA, William Gerstenmaier. Mr. Gerstenmaier’s unparalleled leadership and unflagging devotion to NASA’s human spaceflight program has been the foundation which the Agency, this Congress, and the American people have consistently relied upon. Those of us who care about NASA and space exploration owe a great debt to Mr. Gerstenmaier whose consistent, calm, and steady hand has helped steer the Agency through extraordinary and challenging times.

Similarly, it’s an honor to testify with Mark Sirangelo. Mr. Sirangelo has been doing no less than transforming dreams into reality via the design and development of Sierra Nevada Corporation’s Dream Chaser spacecraft. Like Mr. Gerstenmaier, Mr. Sirangelo has provided vital leadership within the human spaceflight community, both as a Vice President of Sierra Nevada Corporation and as the former Chair of the Commercial Spaceflight Federation. It has been a privilege to work with Mr. Sirangelo over the years and to appear with him at this hearing today.

Mary Lynne Dittmar has also provided critical leadership in the space world throughout her august career, first as an executive with Boeing, and later as an expert advisor to the Center for the Advancement of Science in Space (“CASIS”), the National Academies, and the American Astronautical Society. Now, as the Executive Director of the Coalition for Deep Space Exploration, it has been a pleasure to continue to work with Dr. Dittmar to support NASA’s efforts to push further into the final frontier.

Finally, few people have contributed as much to the future of deep space exploration as Dan Dumbacher. The cornerstones of America’s beyond LEO exploration efforts, the Space Launch System and Orion spacecraft, would not be where they are today without the tireless efforts and leadership of Professor Dumbacher, both at Marshall Spaceflight Center and at NASA Headquarters and, again, it’s a privilege to join him and our fellow witnesses at today’s hearing.

Technology and Policy are important, but ultimately, the success of America's space exploration program is dependent upon people, and my fellow witnesses and our colleagues in government and industry are why I continue to remain optimistic regarding this country's future in space. However, now more than ever we will need every bit of creativity and perseverance that America's space workforce and leadership can muster, since the challenges that this nation faces in space exploration are both numerous and robust, starting in Earth orbit.

I. Maintaining an American Presence in LEO

America's human spaceflight journey began with Alan Shepard's first foray into orbit, and while NASA has and will continue to push far beyond the historic flight of Freedom 7, the environment in and around Earth orbit has never been more important. Specifically, the International Space Station ("ISS") is the crown jewel of not only NASA's but the world's human spaceflight capabilities. I fear that the general public and even those of us in the space industry far too often take the ISS for granted, and fail to acknowledge the titanic accomplishment that the station represents. Per the title of this hearing, we now stand at a crossroads, with Congress and NASA asking what comes next. Although NASA should and must push forward into the final frontier, it's just as vital that the Agency and America not abandon space's first frontier, low Earth orbit ("LEO").

The ISS is aging, and while NASA intends to maintain the station through 2024 the end of the ISS era, particularly in terms of the long lead times required by major aerospace projects, is nearly upon us. Although the ultimate path forward remains uncertain, it's clear that NASA has no desire or intent to build and launch another government sponsored LEO space station. Therefore, the future of LEO remains squarely on the shoulders of the private sector, which presents both an extraordinary challenge and an equally extraordinary opportunity.

Thus far, LEO human spaceflight in general, and the ISS in particular, have been able to depend upon funding from governments to support operations. This will change substantially as LEO is transitioned from government to private sector auspices. The greatest challenge that America will face in maintaining a human presence in LEO is developing the robust private sector demand necessary to fund such space-based activities. NASA, as well as various other organizations and associations, have held numerous discussions regarding 'LEO commercialization' and what the path forward will look like. Microgravity research and development has certainly shown promise, but it's highly unlikely that scientific activities alone can generate sufficient near-term revenue to meet the relatively high costs of orbital crewed operations.

A. Orbital Satellite Manufacturing

A potential solution to this funding challenge can be found just above the ISS in geostationary orbit ("GEO"). Although NASA and the domestic space industry have struggled to identify revenue generating activities in LEO, hundreds of billions of dollars are pouring into GEO annually to manufacture satellites, construct ground stations and related hardware, and pay

for satellite services. The answer to NASA's question of LEO commercialization could be as simple as abiding by the old Washington adage to follow the money.

No one doubts the importance of GEO telecommunications activities or its strong financial underpinning. The potential opportunity that NASA has before it is to merge this robust, existing industry with crewed LEO activities, and this should be explored as expeditiously as possible.

The satellite telecommunications industry is in a constant competition with terrestrial capabilities. Innovation in the satellite world isn't just a luxury, it's a necessity, and it's this dynamic that has resulted in the consistent improvement of telecommunications services even while costs to the consumer are dropping. This ongoing need for innovation may actually drive the next evolution of satellite innovation off of Earth and into LEO.

Currently, telecommunications satellites face numerous constraints. The number and size of a satellite's radio frequency ("RF") reflectors are limited by the dimensions of a launch vehicle's fairing. Moreover, due to high launch costs, satellites are usually designed to last for at least fifteen years, a period of time that is a virtual eternity when compared with the rapidly changing pace of customer demand, evolving population centers, and constant technological innovation. GEO satellite operators need to be able to refresh their technologies with much greater frequency while increasing their RF reflector sizes, and on-orbit satellite manufacturing via a platform such as the ISS presents a potentially attractive solution to address both of these needs.

In any future reauthorization bill, Congress should encourage NASA to work jointly with the private sector to conduct a near-term demonstration of satellite manufacturing and assembly aboard the ISS. Working together, NASA and the private sector could execute a pilot program that would validate orbital satellite manufacturing techniques and demonstrate the value of such operations to private sector satellite manufacturers. Subsequent to demonstrating the real economic value of satellite manufacturing aboard platforms such as the ISS, the private sector could move forward in a robust fashion establishing a long-term and sustainable commercial activity.

Specifically, in cooperation with the private sector, NASA could demonstrate the viability of fabricating large, shaped surfaces capable of reflecting millimeter-wave RF energy, as well as the ability to produce milli-degree level accuracy relative to surfaces as defined by transcendental equations. Additionally, such an initiative should demonstrate the manufacture and/or installation of tight tolerance joints to allow for the reliable installation of large reflectors to in-space assembled truss structures. This demonstration will require NASA, possibly in conjunction with an organization like CASIS, to provide a private sector partner with (1) the transportation of relevant material and/or components for the orbital manufacturing process to the ISS, (2) sufficient crew time to conduct the demonstration, and (3) external robotics support for the assembly of various satellite components that were manufactured inside the ISS.

Again, this demonstration would validate the benefits of orbital satellite manufacturing and assembly, while also refining various techniques and establishing the proper balance between the

contributions of people and robotics. Orbital satellite manufacturing could be the anchor activity that the private sector has been searching for to fund the expense of crewed commercial operations in LEO. Unlike many potential commercial LEO activities that I have explored over the course of nearly two decades, the market for commercial satellites is already mature and robust. Orbital manufacturing of satellites could unite this strong, existing market with crewed operations in LEO, potentially transforming both activities and entire industries, while providing the U.S. with a unique and nontrivial economic advantage over international competition.

B. Microgravity R&D and Space Tourism

While orbital satellite manufacturing has great promise, NASA should also continue and expand efforts to support microgravity research and development aboard the ISS. The Agency and partners such as CASIS should focus on projects and concepts that have the potential to deliver near-term economic value. When I last testified before this Subcommittee in 2012, I noted the potential for breakthroughs in biotechnology that the microgravity environment offers. I still believe this is true and recommend expanding biotech research aboard the ISS to include stem cell production, agricultural engineering, and the development of niche drug treatments. NanoRacks, led by Jeffrey Manber, the only CEO who has actually run a commercial space station, is leading the way in commercial biotech R&D and NanoRacks has already created a business for cubesat deployment from the ISS. SSL and NanoRacks teamed on a recent proposal to NASA under the NextSTEPs program and, if selected, I'm eager to see what America's most prolific commercial satellite manufacturer can do in combination with the country's leader in LEO utilization.

NASA should also take whatever actions it can to enable the orbital tourism market. The Agency initially spurned space tourism forcing Americans to go overseas and fly with the Russians. As we have seen all too often in the space world, despite its history as a former communist regime, Russia has been far more successful at commercializing its human spaceflight program than America. Working in cooperation with companies such as Space Adventures, it's my hope that NASA will continue the recent trend of being more supportive of space tourism, since tourism, as well as flying professional astronauts from foreign nations, could play an important role in the ability of the private sector to maintain an American presence in LEO.

C. Benefits to Beyond LEO Activities

NASA support for these commercial activities is critical, since in the very near future, responsibility for maintaining an American human presence in LEO will be left to the private sector. Our great nation must not and cannot abandon its presence in LEO. Active and robust public and private sector operations in LEO is the foundation that all future human exploration missions, including beyond LEO exploration, will be built upon. Traveling to LEO is the terrestrial equivalent of going to the airport, once you're there, you can easily be transported to a wide variety of destinations both near and far. Countries that have a strong LEO infrastructure will be able to move crew and cargo quickly, safely, and affordably to orbit, where large spacecraft and supplies can be assembled and staged for future missions to the Moon, Mars, and beyond. In drafting a future NASA reauthorization bill or any other legislation related to NASA,

I urge the members of this Subcommittee to recognize that LEO and beyond LEO activities are not in conflict, and are both required for either endeavor to be successful.

However, I am not blind to the funding shortfall that NASA faces. NASA has been given numerous missions, and not nearly enough funding to execute them all. Unfortunately, this is an inevitable product of the fiscally constrained environment that the U.S. finds itself in, and far from blaming Congress, I'm grateful to the members of this Subcommittee as well as your colleagues on the Commerce, Justice, Science, and Related Agencies Appropriations Subcommittee for their generosity towards NASA despite an overall paucity of available federal funds. Since NASA cannot and should not count on anything more than stable funding in the future, and perhaps not even that, the Agency must find creative ways to leverage private sector investment in conjunction with its own funding to ensure that America does not abandon its presence in LEO.

D. AES's NextSTEPs Habitat Initiative

An excellent example of how NASA can husband its resources with private sector financing and capabilities is the habitat initiative under the Next Space Technologies for Exploration Partnerships ("NextSTEPs") program. NextSTEPs, which falls under the auspices of NASA's Human Exploration and Operations Advanced Exploration Systems ("AES") division, is run by Jason Crusan, one of Mr. Gerstenmaier's best and brightest executive managers. Mr. Crusan has a longstanding reputation for innovation and leveraging private sector resources to vastly multiply the impact of a relatively meager amount of federal investment. For example, the current NextSTEPs habitat procurement is crafted to identify and support the intersection between NASA's needs for beyond LEO human exploration missions, and the private sector's plans for LEO commercialization. Specifically, the NextSTEPs solicitation envisions the possibility of a private sector habitat being developed, launched, and attached to the ISS. Such a habitat would serve as a critical testbed for the discrete validation of systems and technologies that NASA needs for ambitious beyond LEO human exploration missions. Moreover, such a habitat would not only demonstrate new technologies but, just as importantly, the habitat could serve as a hub for demonstrating the business case for private sector LEO operations including satellite manufacturing and deployment, microgravity research and development, and space tourism. A NextSTEPs habitat attached to the ISS could be a laboratory for commercial development, identifying and maturing the most promising activities that can later be transitioned to a future private sector space station.

The brilliance of NextSTEPs is that by leveraging the intersection of public and private sector interests, AES will be able to gain commercial support for a key piece of human exploration hardware that the Agency would otherwise bear the costs for on its own. However, even under NextSTEPs, some government support will be required. For example, at a minimum, NASA should commit to launching the habitat and paying the private sector partner for the right to utilize some its volume and resources. For its part, a private sector partner should also be responsible for contributing a nontrivial percentage of the financing for the habitat's development, and the private sector partner must also fund the vast majority of the habitat's ongoing operation expenses via commercial activities. Leveraging and combining public and private sector interests in this manner is the future of NASA, and a NASA reauthorization bill or

other relevant forms of legislation should embrace this ideology, bolster the NextSTEPS program, and encourage similar activities throughout the Agency.

Moreover, as stated previously, LEO and beyond LEO activities are not in conflict. An important reason to turn LEO over to the private sector is to ensure that NASA has the funding that it needs to conduct ambitious beyond LEO missions. NASA cannot sustain the existing costs of the ISS while supporting robust beyond LEO human exploration. However, NASA cannot and should not abandon LEO. Therefore, the only option available to the Agency is to lower its costs by leveraging commercial support whenever and wherever there is an intersection between public and private sector interests. Again, I implore the members of this Subcommittee to recognize the necessity for NASA to collaborate with the private sector via partnerships such as NextSTEPS, and to weave this concept into the fabric of a future reauthorization bill.

II. Emulating DARPA's Use of BAAs

Government agencies leveraging private sector funding and capabilities is not a new concept, and instead of reinventing the wheel, NASA would do well to learn from and even imitate the methodologies of the Defense Advanced Research Projects Agency ("DARPA"). DARPA has a longstanding tradition of working closely with the private sector to develop new technologies and capabilities that are equally important to the government and the private sector. For example, via the Robotic Servicing of Geosynchronous Satellites ("RSGS") program, DARPA is seeking to service defense and intelligence satellites by establishing a private sector capability that will meet government needs without requiring as large a government investment as would otherwise be necessary since the system will be sustained primarily by commercial missions.

DARPA's robust partnerships with the private sector can be attributed in large part to the Agency's unique contractual strategies. There has been a great deal of discussion of Space Act Agreements ("SAAs") by NASA officials and policymakers, and DARPA does indeed use a form of 'Other Transactional Authority' to execute many if not most of its programs. However, what has largely been ignored due to the prominence of the SAA debate is the importance of the contractual vehicle that is used to solicit proposals, and this is an area where DARPA excels. Specifically, DARPA uses standing Broad Agency Announcements ("BAAs") as its primary means of outreach to the private sector community. At NASA, the private sector has to wait for specific procurement opportunities to be announced, such as the Commercial Orbital Transportation Services program, or the Space Technology Mission Directorate's ("STMD's") Tipping Point program. Conversely, DARPA uses standing BAAs which are so broad that the private sector is able to submit any relevant idea to DARPA at any time. Moreover, instead of being forced to immediately submit lengthy proposals for Agency consideration, the DARPA BAA process begins with the submission of a short executive summary, and then moves on to a white paper and eventually a full proposal if DARPA is sufficiently interested in the activity. This saves the contracting community a great deal of time and effort since the private sector can quickly bring a concept to DARPA's attention and does not need to commit a great deal of resources to proposal writing unless there is already a nontrivial interest by DARPA to support the project. DARPA's use of BAAs has encouraged creativity, broadened the amount and type

of companies that can work with the Agency, and increased the flexibility and pace of the government procurement process.

NASA AES has already been using BAAs to great effect, for example, both phases of the NextSTEPS habitat initiative used BAAs. NASA should increase the utilization of BAAs throughout the Agency, and STMD in particular should establish a DARPA-like BAA system as NASA's primary means of engaging with the private sector. As a member of the National Academies Space Technology Industry-Government-University Roundtable, I have recommended this concept to STMD leadership, and they have been receptive to the idea.

III. American Competitiveness

A. Satellite Servicing

This Subcommittee's purview includes not just space and science, but American competitiveness, and this is an arena where NASA has a critical role to play. Last month, I testified in the House regarding 'Satellite 2.0'. I described a new era wherein satellites are no longer built on the ground, launched, and then thrown away at the end of their lifetimes, but will instead be refueled, refurbished, and enhanced while in orbit. Currently, only about 20 percent of a satellite's mass generates revenue. This equation can and inevitably will change dramatically when satellite servicing becomes a reality. The companies and countries that develop this critical capability will not only become leaders in space exploration, but since satellite technology impacts nearly every aspect of our daily lives, the first nation to perfect and implement these systems will enjoy substantial economic and military advantages over its global competition. I implore this Subcommittee and this Congress not to sit idly by and let other nations surpass America in this vital technological capability.

I have already described DARPA's RSGS program, and NASA also has its own satellite servicing activity, Restore-L, which is being developed to refuel and relocate the Landsat 7 satellite. However, NASA, and the U.S. government in general, need to do much more than sponsor two relatively limited programs to bolster this critical capability. America cannot afford to lose the satellite servicing race, and we are already falling behind.

China's National University of Defense Technology recently announced the successful orbital refueling of a satellite, enhancing both its maneuvering capabilities and functional lifetime. This was accomplished using the Tianyuan-1 refueling system which was deployed on July 2nd by a Long March 7 rocket. During this mission, China tested various processes and validated Tianyuan-1's operations via telemetry and video. China is now a leader in satellite servicing providing the nation with a substantial advantage over the U.S. for both commercial and national security operations.

If the U.S. is to match and hopefully surpass Chinese capabilities, new programs, opportunities, and additional funding should be directed toward satellite servicing and, most important of all, NASA should use its power as a customer to inspire the development of private sector systems. The private sector is willing to make substantial investments in next-generation

satellite servicing but, like in any new business endeavor, potential customers remain somewhat wary of unproven concepts. NASA could help the private sector overcome such challenges by acting as a catalyst via the execution of contingent contracts with domestic companies to service its own fleet of satellites. NASA would thereby support the demonstration of private sector satellite servicing systems, providing the assurances and predictability that commercial satellite operators need to become customers for these services, leading to the development of a firm and large private and public sector market. By acting as a customer for commercial satellite servicing capabilities, NASA would also benefit by saving vital funding at a time when its budget is being stretched thin, all while simultaneously creating new private sector jobs and bolstering American competitiveness. Therefore, I strongly recommend that in any future NASA reauthorization bill or related legislation, the Senate should commend NASA for its existing satellite servicing activities, while also encouraging the Agency to do more and, in particular, to act as a robust customer for domestic commercial satellite servicing capabilities.

B. Solar Electric Propulsion

Another technology that is vital to NASA's future is solar electric propulsion ("SEP"). SEP and electric propulsion ("EP") systems in general, are a critical capability for commercial satellites, NASA robotic spacecraft, and such systems even have an important role to play in LEO and beyond LEO crewed spacecraft. America can ill afford to fall behind in SEP, and I applaud NASA for moving forward with programs such as Psyche (a Discovery Mission currently in Phase A) which will test and demonstrate SEP capabilities. Other space agencies are already funding their private sector contractors to develop new and better EP systems for commercial satellites. SSL finds itself competing against these entities and we need NASA to do more to level the playing field and ensure that American companies are not shut out of the global marketplace by subsidized international competition. Similar to the NextSTEPs habitat initiative, SEP represents an intersection between government and private sector interests, and in future legislation, I hope this Subcommittee will encourage NASA to identify and develop new means to bolster domestic SEP capabilities while supporting ambitious NASA missions to exciting beyond LEO destinations such as the moons of Mars, Europa, and Titan.

Whether it's utilizing EP, executing contracts for commercial satellite servicing, or releasing BAAs to support broader and more efficient STMD outreach, NASA must find new and better ways to work with the private sector. Again, per the title of this hearing, we are indeed at a crossroads, and clearly every road leads toward more private sector engagement. In today's competitive global economy, America is not only in a race to destinations such as the Moon or Mars, but we're in a race for the economic and national security advantages that new space technologies will engender. Therefore, NASA must remain vigilant in every one of its activities to find ways not only to achieve its own goals, but to bolster American domestic private sector capabilities in the process. Moreover, NASA can actually save money while doing this without sacrificing safety or quality. For example, SSL recently submitted a bid for Landsat 9 which leveraged our company's low-cost, heritage capabilities to achieve an extraordinarily affordable price point. By taking advantage of private sector products that are already being sold commercially, NASA can bolster domestic businesses and job creation while reducing its own expenses.

IV. American Leadership

America must lead. Nowhere is this more true than in the global space community where nations across Europe and Asia are clamoring for America to join with them in executing a clearly articulated space strategy. NASA's future in LEO after ISS retirement remains uncertain both domestically and abroad. Since no future government station will be built, NASA should fully commit to an ISS transition and redouble its efforts via NextSTEPS and similar programs, while reaching out to the private sector to bolster customer demand via collaborative projects such as the demonstration of orbital satellite manufacturing, assembly, and deployment.

At a time when policymakers are decrying American dependence on Russia for crew transportation to the ISS, we are already in the process of creating another capability gap for the space station itself. Far too soon after American human spaceflight systems begin delivering crews to LEO the ISS will be retired. As Mr. Gerstenmaier and his colleagues at NASA can tell you, deploying a space station, even one that is smaller than the ISS, will take time, and it will already be difficult to develop, build, deploy, and test an operational station before ISS retirement. If America fails to field a new space station U.S. leadership in this arena will quickly be subsumed by China, which has plans to deploy its own space station using a new heavy-lift rocket capability. The Chinese station will likely become operational in the early 2020s, nearly matching the anticipated timeframe for ISS retirement. China has made overtures bilaterally and in the United Nations for the world to join its space station effort while, again, the U.S.'s future in LEO remains uncertain. America should embrace international cooperation and even a collaboration with China could be beneficial under the right circumstances. However, while cooperating with another country is commendable, being dependent upon another country is deplorable, and NASA must avoid abandoning LEO to China, Russia, or other nations.

The greatest success of the ISS has nothing to do with technology. The station's most important achievement was demonstrating that over a dozen nations, representing a diverse array of cultures and ideologies, could come together as one to deploy and operate the most complex spacecraft in the history of humanity. The ISS partnership was hard earned over several decades and must be preserved. NASA and this nation should provide a clear vision to its international partners for what will come after the ISS, and if the path forward is a private sector station, or stations, then we must move forward with alacrity to build the necessary commercial demand for such space platforms to become a reality.

Moreover, NASA should reach out to new entrants into the space arena. For example, the Senate should commend the recent execution of a Memorandum of Understanding between the United Arab Emirates Space Agency and NASA as an example of NASA showing leadership abroad by engaging with a new, ambitious, and capable space agency. NASA should deepen relations with the UAE and reach out to other new national players in space, demonstrating that America is a ready and willing partner, and is fully prepared to lead the world into the final frontier.

Whether in LEO or beyond, it's vital that America show both consistency and clarity of purpose. The rewards of America reasserting its leadership in space exploration are only exceeded by the financial and political challenges we will face along the way. Achieving

success will demand the contributions, creativity, and perseverance of every one of us in the space sector, public and private institutions, large established companies, and entrepreneurial newcomers alike. America has never faced more competition in space than it does today and the stakes have never been higher. The domestic space sector, both public and private, can ill afford divisiveness and discord at this critical juncture. I urge this Subcommittee to use any future legislation to bring us all together, as an industry and as a people. We must follow the advice of the great American entrepreneur and statesman Benjamin Franklin, that if we in the domestic space sector do not hang together, we will assuredly all hang separately.