FEDERAL AVIATION ADMINISTRATION OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION

(114–46)

HEARING

BEFORE THE

SUBCOMMITTEE ON
AVIATION

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

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June 17, 2016

SUMMARY OF SUBJECT MATTER

TO: Members, Subcommittee on Aviation
FROM: Staff, Subcommittee on Aviation
RE: Subcommittee Hearing on "FAA Oversight of Commercial Space Transportation"

PURPOSE

The Subcommittee on Aviation will meet on Wednesday, June 22, 2016, at 10:00 a.m. in 2167 Rayburn House Office Building to explore issues related to the Federal Aviation Administration's oversight of the commercial space transportation industry. The Subcommittee will receive testimony from the Federal Aviation Administration (FAA), members of the Commercial Space Transportation Advisory Committee, and representatives of the commercial space transportation industry.

BACKGROUND

This decade has been one of tremendous change for the commercial space transportation industry, and the U.S. space industry in general. With the retirement of the Space Shuttle in 2011, the United States has been left without a domestic option to transport humans into space, requiring the National Aeronautics and Space Administration (NASA) to pay millions of dollars per seat on Russian spacecraft for astronauts to reach the International Space Station. Private industry, with the support of NASA and the FAA, has worked to fill this transportation gap while developing new and innovative methods to transport passengers and cargo safely and efficiently into space. As these public and private efforts progress, ensuring that FAA's oversight and regulation of the industry creates the conditions for continued U.S. leadership in the field of commercial space transportation is of great interest to the Subcommittee.

Office of Commercial Space Transportation

Under the 1984 Commercial Space Launch Act and subsequent amendments, the Secretary of Transportation has the responsibility and authority to facilitate, regulate, and

promote the commercial space launch industry.[1] In 1984,this function was assigned to the newly established Office of Commercial Space Transportation (AST) as part of the Office of the Secretary of Transportation (OST).[2] In November 1995, AST was transferred to the Federal Aviation Administration (FAA). AST is led by the Associate Administrator for Commercial Space Transportation who reports directly to the FAA Administrator.[3]

According to the FAA, the AST's mission "is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation."[4] AST issues launch and reentry licenses for commercial space launches and permits for experimental launches. Each process includes opportunities for pre-application consultation. The consultations allow AST and industry to work collaboratively to ensure regulatory compliance and facilitate the timely approval of commercial space launch applications. Since 1989, FAA has licensed 246 commercial space launches and permitted 42 launches.[5]

Since fiscal year 2009, AST's budget has grown from $14.094 million to $17.8 million while its staffing has increased from 71 full time positions (FTPs) to 106 FTPs.[6] AST began systematically measuring its workload metrics in August 2014. Since that time, the number of companies seeking at least one new or modified authorization has increased from 14 to 44 while the total number of authorization projects in all phases prior to the issuance of a license or permit increased from 26 to 66.[7] FAA has requested a fiscal year 2017 budget of $19.826 and a staffing increase of 13 FTPs for AST.[8]

Safety

The human commercial space transportation industry continues to mature within a regulatory "learning period" first established under the 2004 Commercial Space Launch Amendments Act.[9] Currently, the FAA may not implement regulations regarding spacecraft design or operation. The industry currently operates under an informed consent model, in which participants must acknowledge the inherent risks of spaceflight and the absence of government safety regulations. Notwithstanding this moratorium, the FAA may "issue requirements or

[1] *See* the 1984 Commercial Space Launch Act (P.L. 98-575), the 1988 Commercial Space Launch Act Amendments (P.L. 100-657), the 1998 Commercial Space Act (P.L. 105-303), the 2004 Commercial Space Launch Amendments Act (P.L. 108-492), and the 2015 US Commercial Space Launch Competitiveness Act (P.L. 114-90).
[2] AST is the acronym assigned to the FAA's Office of Commercial Space and was not the office's designation when it was part of the Department of Transportation
[3] FAA, "About the Office: Office of Commercial Space Transportation," available at https://www.faa.gov/about/office_org/headquarters_offices/ast/about/
[4] Ibid.
[5] Permitting statistics are measured from 2006, available at http://www.faa.gov/data_research/commercial_space_data/
[6] FAA Budget Estimates for Fiscal Year 2010 and 2017.
[7] FAA Briefing to Aviation Subcommittee Staff (May 16, 2016).
[8] FAA Budget Estimates for Fiscal Year 2017.
[9] 51 U.S.C. § 50905(c)(9).

regulations to protect the public health and safety, safety of property, national security interests, and foreign policy interests of the United States."[10]

The learning period was most recently extended by the 2015 U.S. Commercial Launch Competitiveness Act (CLCA) through fiscal year 2023. The CLCA also structured a process by which the commercial space transportation industry and the FAA would jointly create interim voluntary industry consensus standards that will ultimately form the basis of future regulations. Furthermore, the law contains several reporting requirements that will serve as benchmarks for measuring industry maturity and the scope of future regulations.

While the commercial space industry has heeded Congress' calls to work toward consensus safety standards, two incidents in 2014 highlight the safety challenges inherent to commercial space transportation. On October 28, 2014, an Antares 130 rocket operated by Orbital Sciences under an FAA license exploded fifteen seconds after launch from the Mid-Atlantic Spaceport at the Wallops Flight Facility in Wallops Island, Virginia. The explosion destroyed a Cygnus spacecraft scheduled to resupply the International Space Station and caused substantial damage to the launch pad.

Three days later, on October 31, 2014, a test flight of SpaceShipTwo operated by Scaled Composites under an FAA commercial space experimental permit crashed in New Mexico, killing co-pilot Michael Alsbury and severely injuring pilot Peter Siebold. This was the first in-flight fatality as a result of a crash of a spacecraft operated under an FAA commercial space license or permit.

Both incidents demonstrate the nascence of the commercial space transportation industry and also the continued necessity of public-private cooperation to lay the foundation for a future regulatory framework. The FAA can both maximize safety and foster a vibrant and competitive industry by working with the private sector in fora such as the Commercial Space Transportation Advisory Committee (COMSTAC). The COMSTAC has served to instill a robust safety culture within the commercial space transportation industry in the absence of formal regulation.

Integration into the National Airspace System

As the number of commercial space launches and reentries become more routine, safer and more efficient methods of integrating their operations into the National Airspace System (NAS) will be needed. Currently, commercial space transportation is "accommodated" within the NAS rather than integrated into it, requiring the blocking of massive amounts of airspace over several hours and disruption of commercial aviation traffic. This process is not automated, requiring FAA employees, including air traffic controllers, to call each other on the telephone to read out spacecraft trajectories.

The FAA is creating a Space Data Integrator that will feed commercial spacecraft data into FAA systems, including the Traffic Flow Management System Traffic Situational Display.[11]

[10] 51 U.S.C. § 50905(c)(10).
[11] FAA Briefing to Aviation Subcommittee Staff (May 16, 2016).

The FAA is also developing a Commercial Space Integration Roadmap to better define its "policies, regulations, procedures, and automation capabilities moving forward."[12]

Spaceports

There are 22 active launch and reentry sites in the United States.[13] AST is responsible for licensing 10 commercial launch and reentry sites, also known as spaceports.[14] However, AST does not license or oversee the eight Federal launch sites or the non-profit launch site operated by the University of Alaska. There are three additional launch sites from which AST licensed and permitted launches occur, but because the three are owned, operated, and exclusively used by a single private company each, they do not require an AST spaceport license. Of the ten licensed spaceports, the most active is located at the Cape Canaveral Complex in Florida, from which eight licensed launches have occurred in fiscal year 2016.

Indemnification

The current commercial space launch insurance regime relies on a risk-sharing system to limit the exposure of commercial space companies using FAA licenses and protect the industry against catastrophic loss. Licensees are required to obtain $500 million in liability insurance covering private third party claims and $100 million in liability insurance covering claims by the government for property destruction.[15] In the event private third party claims exceed the $500 million requirement, the government (subject to appropriations) will cover the additional claims up to $1.5 billion in 1989 dollars.[16]

This indemnification regime has been in place since the passage of the 1988 Commercial Space Launch Act Amendments. To date, the risk-sharing indemnification regime has not been invoked. The indemnification regime has been extended eight times since its original enactment, most recently by the CLCA through the end of fiscal year 2025.[17] The CLCA also requires the Government Accountability Office to report on the potential inclusion of State and municipal property in the existing indemnification regime.[18]

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[12] Michael Whittaker, "As Commercial Space Takes Off, FAA Moves from Accommodation to Integration," Department of Transportation, February 11, 2016, available at https://www.transportation.gov/fastlane/faa-moves-to-integrate-commercial-space.

[13] "The Annual Compendium of Commercial Space Transportation: 2016," FAA, January 2016, available at https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2016_Compendium.pdf; One of these 19 sites is the Ronald Reagan Ballistic Missile Defense Test Site, located in the Marshall Islands. The Marshall Islands are a sovereign country that has entered into a Compact of Free Association with the United States.

[14] One of these 19 sites is the Ronald Reagan Ballistic Missile Defense Test Site located in the Marshall Islands, a now sovereign country that has entered into a Compact of Free Association with the United States.

[15] 51 U.S.C. § 50914(a).

[16] 51 U.S.C. § 50915(a).

[17] S. Rept. 114-88; P.L. 114-90, § 102(d)

[18] P.L. 114-90, § 115

WITNESS LIST

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FEDERAL AVIATION ADMINISTRATION OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION

Wednesday, June 22, 2016

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON AVIATION,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
Washington, DC.

The subcommittee met, pursuant to call, at 10:05 a.m., in room 2167, Rayburn House Office Building, Hon. Frank A. LoBiondo (Chairman of the subcommittee) presiding.

Mr. LOBIONDO. Good morning. The subcommittee will come to order. Before actually getting started, I ask unanimous consent that Members not on the subcommittee be permitted to sit with the subcommittee at today's hearing, offer testimony and ask questions. And without objection, so ordered.

Good morning, and thank you all for being here. Today we will be examining the Federal Aviation Administration's oversight of commercial space transportation. We are at an exciting time in the aviation world. In the past few years, this committee has met regularly to discuss the advent of drones into the National Airspace System, and we are here this morning to talk about the burgeoning industry of commercial space transportation.

Before we begin, I would like to note that yesterday the FAA released its long overdue final rule on small drones, and although we are continuing to review it in detail, I am very pleased that the rule focuses on safely integrating drones in operation today while providing flexibility to permit more advanced types of operations as technology improves. It is a very good step forward, I think.

It has been 7 years since this subcommittee last held a hearing dedicated to this topic. Since that time, the space shuttle has been retired, leaving the United States without a domestic option to transport humans into space, and requiring NASA to pay millions of dollars per seat on Russian spacecraft.

Private industry, with the support of the FAA and NASA, is working to fill this transportation gap, while developing new and innovative methods to transport passengers and cargo safely and efficiently into space. The result has been the domination of these commercial space industries by the United States in virtually all areas. United Launch Alliance, a joint venture of Lockheed Martin and Boeing, provides valuable and highly reliable launch services to the U.S. Government.

Orbital ATK has operated five successful unmanned supply missions to the International Space Station, and we wish them well on their launch 2 weeks from today.

SpaceX and Blue Origin are leading pioneers in the effort to bring down the cost of commercial space launches by reusing launch vehicles. Virgin Galactic, World View Enterprises, and XCOR seek to offer new and exciting experiences and bring space travel and tourism to the general public. These companies and many others contribute to a highly innovative industry advancing U.S. leadership in the field.

I believe we are witnessing a major change in transportation, one that will match the energy and enthusiasm of the early days of barnstorming. These advances require the close cooperation and oversight of FAA's Office of Commercial Space Transportation, or AST. AST's mission is to protect the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.

Commercial space transportation is still an inherently risk-filled endeavor. Our hearing summary outlines two specific accidents, but there have been others. We want to ensure that AST and industry learn from these incidents in order to lay the foundation for a future commercial space transportation safety regulatory framework.

In November 2015, Congress passed the U.S. Commercial Space Launch Competitiveness Act, which has helped position the industry in the United States to further expand and capitalize on our Nation's leadership in this field. We have invited you all here today to get a better sense of the state of the industry following enactment of this law and to learn about opportunities and challenges related to commercial space transportation.

Though this is a newer topic to me and many on the subcommittee, much of the FAA's work in this area is performed in my district at the FAA's premier flagship technical facility in Egg Harbor Township, New Jersey. There, private companies are working with the FAA on a number of projects, including modeling of debris fields, simulating launches and reentries, utilizing the expertise of air traffic controllers, and testing communications systems between spacecraft and air traffic control.

We appreciate all of the work that industry and FAA are doing at the FAA Tech Center in order to continue advancing safe commercial space transportation. As this subcommittee continues to assess the current state of the commercial space transportation industry, it is important that industry engage with members of this panel. I would also encourage all Members to reach out to our distinguished witnesses and others in the commercial space transportation field to learn more about how this transportation sector impacts each and every congressional district.

I am sure this will be an interesting hearing, and I very much look forward to hearing from our distinguished panel of witnesses. Now I would like to yield to Mr. Larsen for any statements he may make.

Mr. LARSEN. Thank you, Mr. Chairman, and thanks for calling this hearing to take a closer look at the FAA's oversight of commercial space transportation.

This committee has not convened a hearing on commercial space transportation since 2009, and I think we can all agree that there have been many exciting advancements in the industry that have occurred over the last 7 years, so I think it is really ripe for us to take a look.

And as we have seen recently, there is a great deal of promise with the expansion of the commercial space industry. Take, for instance, Blue Origin's success this weekend in landing the New Shepard rocket for the fourth time. This reusable capsule could be used in the future for human spaceflight, or SpaceX, which has been able to land its Falcon 9 rocket on an unmanned ship after successful missions and deliver communication satellites into orbit.

But the promise of commercial space does not end there. Several other companies, including many in my home State, are venturing into unchartered territory when it comes to mining asteroids, developing reusable vehicles, repairing satellites in orbit and other research that we once thought was impossible. In fact, this week, in Seattle, there is a conference on space where many of the leading companies in the industry are showcasing the latest in commercial space, including commercial space transportation.

But with that immense promise comes the need to make sure that we have a robust safety framework in place, and it is not an easy thing to achieve particularly as Congress is cautious to not overregulate this nascent industry. The commercial space industry reminds me a lot of what we are currently confronting with unmanned aircraft systems. Both industries are users of the national airspace, experiencing fast-paced growth, and both in their relative infancy.

As technology rapidly evolves, the regulatory side is continually playing catchup. The small UAS rule, the FAA announced yesterday, is representative of this challenge. The FAA had to balance the interest of the public and of the uses of the national airspace while at the same time being careful not to stifle the industry.

As the commercial space industry continues to evolve, we are going to face similar challenges, so I am very curious to hear what our witnesses' perspectives are on how the Government and industry can work together to build consensus around the regulatory framework that fosters innovation while achieving the highest possible level of safety. I am also interested to hear some perspectives on how we can safely and efficiently integrate commercial space launches into our air traffic control system.

Since 1989, the FAA has licensed or permitted over 280 commercial space launches. Those numbers are forecasted certainly to significantly increase in the coming years. What that means is that FAA's air traffic controllers will need to coordinate existing operations with those of the commercial space industry, and of course, throw into that, UAS. It will not be an easy undertaking.

So to me, it seems the most prudent way to accomplish that is by having all of our air traffic control operations reside with the FAA, the agency which is also responsible for licensing these commercial space launches. And while it does not fall under the juris-

diction of this committee, I would be remiss if I did not mention my interest in commercial space exploration and its impacts on national security.

As a member of the Armed Services Committee, I urge all of us to pay close attention to how the DOD leverages the private sector for national security missions, including launches. And as commercial capabilities and satellite imaging and communications continue to improve, the DOD's use of those services will also grow.

Thus, I consider it vital that the DOD be given a seat at the table when the FAA exercises oversight of commercial space transportation, given that national security interest is at stake as well. So it is a very exciting time for commercial space and commercial space transportation, and I look forward to learning more this morning. And with that, I want to again thank the chairman for holding this hearing, and yield back.

Mr. LOBIONDO. Thank you, Mr. Larsen. I would now like to recognize Mr. DeFazio if you have any remarks you would like to make.

Mr. DEFAZIO. Well, thanks, Mr. Chairman. I will be brief. You know, I am hoping the panel will—I haven't had a chance to read testimony, but will discuss what our role should be after 2023, when the moratorium on FAA regulating safety expires, if we are looking at a robust, civilian basically tourist- or science-based, commercially launched vehicles into space.

And then secondly, you know, I have a concern, and some will remember this, for many, many, many years there was a mandate that the FAA both promote and regulate the aviation industry. For years I tried to change that, and in fact, during one reauthorization, my amendment had been defeated, and people said there is no conflict and there was no problem.

Unfortunately, the ValuJet crash happened. We were in conference, and I get a call saying: How would we put your provisions in the bill? I didn't get everything I wanted, but I got most of it. There is an inherent conflict between promotion and regulation and oversight of safety, and I think that we need to look very carefully at that, and I hope that some of the witnesses can address that.

I mean, it would be more appropriate to say commerce will promote, FAA will regulate, in my opinion, but I would be interested in the opinion of those who are going to testify.

So thank you really for holding this hearing today, Mr. Chairman. I think it is a very important topic.

Mr. LOBIONDO. Thank you, Mr. DeFazio. Now we will turn to our distinguished panel of witnesses today.

We have Dr. George Nield, Associate Administrator of Commercial Space Transportation, Federal Aviation Administration; Dr. Gerald Dillingham, Director of Physical Infrastructure Issues for the United States Government Accountability Office; Mr. Michael Gold, Chairman of Commercial Space Transportation Advisory Committee; Mr. Michael Lopez-Alegria, Vice Chairman of Commercial Space Transportation Advisory Committee; and Taber MacCallum, chief technology officer of World View Enterprises.

I thank you all for being here today. I would also like to ask unanimous consent that our witnesses' full statements be included in the record. Without objection, so ordered.

And to the witnesses, since your written testimony is in the record, if you can try to come close to the 5 minutes, that would be helpful. But Dr. Nield, you are recognized.

TESTIMONY OF GEORGE C. NIELD, PH.D., ASSOCIATE ADMINISTRATOR FOR COMMERCIAL SPACE TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION; GERALD L. DILLINGHAM, PH.D., DIRECTOR, PHYSICAL INFRASTRUCTURE ISSUES, U.S. GOVERNMENT ACCOUNTABILITY OFFICE; MICHAEL GOLD, CHAIR, COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE; MICHAEL LOPEZ-ALEGRIA, VICE CHAIR, COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE; AND TABER MACCALLUM, CHIEF TECHNOLOGY OFFICER, WORLD VIEW ENTERPRISES

Dr. NIELD. Chairman LoBiondo, Ranking Member Larsen——

Mr. LOBIONDO. Can you—I think your mic needs to be flipped on.

Dr. NIELD. Chairman LoBiondo, Ranking Member Larsen, and distinguished members of the subcommittee——

Mr. LOBIONDO. I am sorry. Could you pull a little closer?

Dr. NIELD. Thank you. Chairman LoBiondo——

Mr. LOBIONDO. Thank you.

Dr. NIELD [continuing]. Ranking Member Larsen, and distinguished members of the subcommittee, I appreciate the opportunity to speak with you this morning about the FAA's oversight of commercial space transportation. In my testimony today, I will briefly describe the FAA's responsibilities, discuss recent developments in commercial space transportation, and identify some of our key challenges.

The FAA has exercised oversight of commercial space transportation since 1995 when the Office of Commercial Space Transportation was established as one of the FAA's lines of business. Our mission is to protect the public safety, safety of property, and national security and foreign policy interests of the United States during commercial launch and reentry activities and to encourage, facilitate, and promote U.S. commercial space transportation.

This dual mission is an important part of our culture. Although the FAA has licensed or permitted 290 launches to date, there have never been any fatalities, serious injuries, or significant property damage to the general public.

This is an exciting time for commercial space. Following the retirement of the space shuttle, SpaceX and Orbital ATK have been delivering food, clothes, and scientific equipment to our astronauts on board the International Space Station as part of the commercial cargo program. Separately, Boeing and SpaceX have been awarded contracts under the commercial crew program to take American astronauts to the ISS beginning as early as 2017. Although these are NASA contracts, the FAA is a critical partner in both programs.

We are also starting to see some very impressive advances in technology. Blue Origin has demonstrated that it can launch and land the same rocket numerous times on suborbital flights. SpaceX has shown that it can deliver satellites to orbit and then successfully recover the first stages of its rockets, touching down either on land or on a drone ship in the Atlantic Ocean. These are incredible achievements that demonstrate both the engineering prowess and

the capability for innovation that are hallmarks of American industry.

One of the key challenges that we are facing today involves new and nontraditional space operations. Currently, the FAA licenses commercial launches and reentries, but does not regulate activities in orbit or beyond. For example, if a company wanted to launch a payload to the moon, the FAA would license the launch but not what happens on the lunar surface. However, article VI of the Outer Space Treaty requires the Government to authorize and continuously supervise all nongovernmental activities in space.

Last fall, Congress directed the Office of Science and Technology Policy to develop a process to address this issue.

After extensive discussions, both within the interagency community and with industry, a plan was developed and has now been forwarded to Congress. Under the recommended legislative proposal, the FAA would be able to grant mission authorizations, consistent with the international obligations, foreign policy, and national security interests of the United States.

A second challenge concerns how best to deal with the growing problem of orbital debris. To operate safely in space, operators must know where their systems are and when they have a possibility of colliding with other objects. Currently, the Department of Defense collects space surveillance data and sends out collision warnings when needed. Congress directed the Secretary of Transportation, in concurrence with the Department of Defense, to provide a report on the feasibility of a civil agency taking on this responsibility. We hope to provide this report to Congress soon.

Finally, as the commercial space transportation industry continues to grow, we must ensure that we maintain our ability to keep pace. The FAA appreciates that the Appropriations Committees have so far provided the full fiscal year 2017 appropriations request for our office. This funding is critical to the work that we are doing, and we are grateful for your continuing guidance and support.

In closing, I would like to recognize my predecessor, the late Patti Grace Smith who passed away just a few weeks ago. A true visionary, Patti once observed, "Space is an attitude. It is a set of capabilities, an acceptance of risk-taking activities to uncover potential breakthroughs and endless possibilities. That is precisely why we love it."

Mr. Chairman, this concludes my prepared remarks. I would be pleased to answer any questions that you may have.

Mr. LOBIONDO. Thank you very much.

Dr. Dillingham, you are recognized.

Dr. DILLINGHAM. Good morning, Mr. Chairman, Ranking Member Larsen, Ranking Member DeFazio, Mr. Duncan, and other members of the subcommittee.

My testimony this morning focuses on two areas. First, the developments in the industry, and second, the related challenges FAA faces in overseeing and promoting the industry.

Regarding the developments in the industry. As Dr. Nield has testified, one of the important developments in the industry in recent years is that FAA has been licensing and permitting increasing numbers and types of launches. The expansion includes moving

from exclusively single-use launch vehicles to suborbital reusable vehicles. This expansion includes changes in the launch industry that are bringing significant changes to FAA's oversight, including determining whether and when to regulate the safety of crew and spaceflight participants and issues related to the increased workload for licensing and permitting launches.

Regarding the regulation of safety. In 2014, FAA released a set of recommended practices on human spaceflight occupant safety. Currently, FAA is working with the industry to develop voluntary consensus standards that are needed to implement the agency's recommended practices.

Regarding the second challenge, which focuses on increasing workload for FAA, the challenge includes licensing new and more complex types of vehicles and technologies, such as where companies are developing hybrid launch systems, which have both aircraft and rocket powered components. This challenge also includes licensing more complex launch sites. Launch sites traditionally have been located in coastal areas at Federal launch facilities. FAA is licensing more non-Federal launch sites, and in 2014, FAA licensed an inland launch site that is collocated at a commercial airport in Midland, Texas.

The potential impact of the challenges could have far reaching implications. For example, the expansion could affect the Federal Government's overall liability exposure and indemnification for launches. In general, by increasing the volume of launches and reentries and with the introduction of new types of launch vehicles, the probability of an accident occurring also increases.

A catastrophic accident could result in third-party losses over the maximum probable loss, or MPL, which is now capped at $500 million per launch and could in turn invoke Federal indemnification. In our July 2012 report, we found that FAA's MPL methodology, which was established in the 1980s, should be reviewed and updated. Given the advances that have taken place in catastrophic modeling, we recommended that FAA undertake such a review.

Congress subsequently mandated the FAA to review its MPL methodology and report back to it by April 2016. To date, FAA has not submitted the required report. Another concern related to the expanding commercial launch industry is FAA's budget request and resource needs. In 2015, we found that FAA generally based its budget submission on the number of launches that it was projecting for the following year. But during 6 of the 10 years from fiscal year 2005 to 2014, the actual number of licensed and permitted launches was much lower than projected. For 2016, FAA projected over 30 launches and reentries. To date, there have been 13 launches in fiscal year 2016.

We recommended that FAA provide more detailed information in its budget submission about the various launch related activities and overall workload. In our review of FAA's 2017 budget submission, we found that FAA had provided more detailed information. We plan to continue to work with FAA to assess what other steps they are taking to measure their commercial space launch workload and to provide that critical information to Congress to assist it in its oversight.

Mr. Chairman, Ranking Member Larsen, and members of the committee, that concludes my prepared statement.

Mr. LOBIONDO. Thank you, Dr. Dillingham.

We will now turn to Mr. Gold. You are recognized.

Mr. GOLD. Thank you, Chairman LoBiondo, Ranking Member Larsen, distinguished members of the subcommittee, and excellent subcommittee staff for this opportunity to discuss critical issues facing the FAA AST and the commercial space industry.

My name is Mike Gold, and I am the Chairman of the Commercial Space Transportation Advisory Committee, or COMSTAC, a Federal advisory committee comprised of executives from a wide variety of aerospace corporations.

Before I delve into the challenges and opportunities that the commercial space transportation industry faces, I would like to take a moment, like Dr. Nield, to acknowledge the passing of his predecessor, Patti Grace Smith. Ms. Smith initially appointed me to the COMSTAC and served as the Associate Administrator of Commercial Space Transportation for an unprecedented 11 years. Ms. Smith was a beloved and well respected leader in the commercial space world who fostered an environment of growth, innovation, and cooperation between industry and Government that we are still enjoying today.

It is actually appropriate that I begin my testimony with a reference to Ms. Smith because I first met her at a meeting during which we were attempting to address the issue of private sector operations in low Earth orbit, or LEO. At that meeting, I was told the AST has authority for commercial space transportation launches to orbit as well as reentries from orbit but that no Government agency has authority over private sector operations in or beyond LEO.

Sixteen years later, we have still failed to answer this basic question, and I come before you today begging for a resolution. This problem stems from article VI of the Outer Space Treaty, ratified by the U.S. in 1967, which requires countries to provide authorization and continuing supervision of their private sector space activities. The U.S. signed the Outer Space Treaty, creating an obligation for the continuing supervision of nongovernmental entities, but we failed to craft a mechanism for such supervision to take place.

This created a potential regulatory quagmire that domestic companies are already suffering from. Fortunately, a simple effective solution is available. Congress should, as soon as possible, direct the AST to update its regulations to support a mission licensing process. The mission licensing approach, or some iteration thereof, could mirror the AST's existing payload review procedures and would be limited to requiring only basic information, such as if the payload or planned activity will conform to international treaty obligations or interfere with national security interests.

The requirement for continuing supervision would be explicitly met by inserting a proviso into every mission license for the company to inform the AST if they experience a material change to their activity. This concept would fully address the continuing supervision requirement, via a benign registration-based regime. Even if there were no Outer Space Treaty, establishing a simple, efficient means of registering domestic commercial space activities

in and beyond LEO would make sense to prevent potential conjunctions and other forms of harmful interference between domestic and foreign outer space activities. This issue must be resolved, and it must be resolved with alacrity.

In addition to chairing the COMSTAC, I am also a vice president of Washington operations for Space Systems Loral, the world's most prolific commercial satellite manufacturer. As you have seen in the videos, which have been playing in the background, we are about to enter a new era of robotic satellite servicing, wherein satellites are no longer built on Earth and then disposed of, but instead are refueled, refurbished, and enhanced while still in orbit.

This new world of satellite 2.0 will create a revolution in capabilities, impacting every aspect of our daily lives in ways that we cannot now even begin to imagine. However, what I can predict with utter certainty is that the companies and countries that are leaders in satellite servicing and orbital assembly will enjoy an overwhelming competitive edge over nations that have fallen behind.

The Defense Advanced Research Projects Agency, or DARPA, and NASA each have their own pilot programs to demonstrate satellite servicing. But in order to transition such capabilities to the private sector and to make the U.S. a global leader, more support, programs, and funding are needed, and the Government must not immediately throw up a regulatory roadblock by failing to address article VI's continuing supervision requirement.

Moreover, I would be remiss if I didn't use this opportunity to also raise the COMSTAC's concern over funding shortfalls at the AST. The workload at the AST continues to increase rapidly, far exceeding the relatively meager growth in the AST's budget. Without proper funding, I fear the AST will soon simply run out of bodies to handle their ever increasing workload, resulting in licensing and other administrative delays that could substantially hamper commercial space transportation development and encourage companies to move their operations overseas.

At nearly every COMSTAC meeting, the committee has recommended support for increased AST funding. I cannot think of another example where industry has uniformly and consistently called for increasing funding for a regulatory agency, and this situation is both a tribute to Dr. Nield's leadership as well as a warning sign regarding the dire need for additional resources.

Again, I appreciate this opportunity to testify. I look forward to answering your questions, and I urge the subcommittee to take expeditious action to ensure that in the future, commercial space companies can focus more on launches and less on lawyers.

Mr. LOBIONDO. Thank you, Mr. Gold.

Mr. Lopez-Alegria, you are recognized.

Mr. LOPEZ-ALEGRIA. Thank you, Chairman LoBiondo, Ranking Member Larsen, and Ranking Member DeFazio, and members of the subcommittee. Thank you for organizing the hearing and allowing me to offer some thoughts as the Vice Chair of the COMSTAC. Compared to the esteemed Chair of the COMSTAC——

Mr. LOBIONDO. Excuse me, could you pull your microphone a little closer.

Mr. LOPEZ-ALEGRIA. Hello, test. Is this better?

Mr. LOBIONDO. Much better.

Mr. LOPEZ-ALEGRIA. OK.

Mr. LOBIONDO. Thank you.

Mr. LOPEZ-ALEGRIA. Compared to Mr. Gold, I am a latecomer and a rather reluctant recruit to commercial space. In the summer of 2006, I was a NASA astronaut in Baikonur, Kazakhstan, waiting to launch to the International Space Station on a Russian Soyuz rocket. Not 2 years earlier, a commercially built hybrid launch system consisting of a strange mothership airplane and a rocket-powered glider attached to its belly took off from the Mojave Air and Space Port. After detaching from the mother ship, the rocket blasted its way to an altitude of 100 kilometers, recognized the boundary of space, and then its pilot made a glided landing on the same runway from which it had departed. Five days later it happened again, clinching the Ansari X Prize and signaling the dawn of the commercial space age.

Back in Baikonur, I was scheduled to ride share the Soyuz with someone bearing the same name, Anousheh Ansari. I was honestly none too happy about it. Space was the realm of professionals, and I didn't spend all that time training to babysit a tourist.

But in the 10 or so days that I spent in space with Anousheh, my views on space tourism were forever altered. As the first person to blog from orbit, she reached tens of thousands of people who otherwise wouldn't have cared about ISS, about NASA, or about space. She sparked imagination in adults and inspired kids. She made people look up instead of looking down. She represented a wonderful idea: the democratization of access to space.

I am mindful that we are a long way from being able to hop on a rocket like we take Uber or Southwest, but we are starting. It is an oft used but nonetheless valid analogy. Commercial human spaceflight today is where commercial aviation was in the 1920s. As of today, something like 550 people in the history of humanity have been above 100 kilometers. In the next several years, that number will double, and growth in the following decades will be exponential.

Make no mistake, space is a tricky business. Massive amounts of energy are focused to propel a spacecraft in its intended direction during launch and insertion, and the same energy must later be carefully and precisely shed for deorbit and landing. But what was once the domain of only nation-states is now a small but dynamic industry where entrepreneurship, innovation, and efficiency are leveraging the advantages brought about by computer-aided technologies to make business cases close and unleash the competitive forces of free markets to start a new kind of space race.

A threat to any nascent industry is overregulation that might stifle innovation and cut off potential solutions to difficult technical problems. Per the provisions of the Commercial Space Launch Amendments Act of 2004, and subsequent extensions, while Dr. Nield's office effectively protects health and safety of uninvolved public and the safety of property, it is not currently allowed to issue regulations on occupant safety in commercial human spaceflight.

As a pilot and an astronaut, I can assure you that a robust safety culture is an important part of any flight operation, and commer-

cial space is no different. While Congress has wisely directed the FAA to step aside and let industry take its first baby steps, it is incumbent upon that industry to demonstrate their willingness and ability to self-regulate. The development of voluntary industry consensus standards serves just such a purpose, and these standards can later serve as the building blocks of regulation once an appropriate amount of experience is gained and data collected, and rulemaking is therefore allowed.

I would admit that it has been a bit of a struggle to convince a disparate group of companies whose vehicle designs vary greatly in size, shape, and even destination to come to the table to work on something that doesn't immediately positively impact their bottom line. But I can honestly say that we are converged and heading in the right direction.

An important element of NASA's safety culture is effective training. For over 40 years, a key tool in preparing members of an astronaut corps with backgrounds that include not only pilots but also scientists, engineers, and doctors, has been flight in high-performance military aircraft. Exposure to physiological stressors, wearing unfamiliar gear such as a helmet, oxygen mask, and other equipment, and using the concept of cockpit resource management to work as a team to make quick decisions with real consequences, all combine to make this type of training an excellent means to prepare nonaviators for space missions.

As applied to commercial spaceflight, such an experience would reduce the risk of a potentially safety compromising outcome from a first-time flier, and might also be used as an entry level and affordable trial to help inform a potential spaceflight participant's decision on pursuing a suborbital flight.

There are several companies that are interested in providing such training, but since these military aircraft fall in the experimental category, they are prohibited from being used for compensation or hire. If stringent criteria that establish relevance to commercial spaceflight and that demonstrate superior levels of instructor pilot proficiency and aircraft maintenance history are met, it is well within the Secretary's purview, under the obligation to encourage, facilitate, and promote commercial spaceflight, to support legislation or rulemaking that would allow such operations.

I firmly believe this is an important addition to the commercial spaceflight industry, and I thank you for this opportunity to testify and look forward to hearing questions from the subcommittee.

Mr. LOBIONDO. All right. Thank you very much.

Mr. MacCallum, you are recognized.

Mr. MACCALLUM. Thank you, Chairman LoBiondo, Ranking Member Larsen, Ranking Member DeFazio, members of the subcommittee.

FAA's oversight, regulation, and promotion of commercial space transportation has fostered a strong and growing American industry. The human spaceflight regulations that govern large segments of our industry are currently temporary and I believe should be made permanent.

This impermanence and subsequent uncertainty is one of the largest factors influencing the future success of our industry. Additionally, the industry's growth will require the FAA to seamlessly

incorporate routine commercial space operations into the National Airspace System, without which we run the risk of a conflict between airports, airlines, and the commercial space industry.

I will explain three actions that Congress can take to continue to foster the commercial space industry and protect the public's interest.

First, some background. I am a founder and the CTO of World View Enterprises. Our Arizona-based company is the operator of Spaceport Tucson and is developing and operating balloon-based vehicles working at the edge of space. Like an ice cube floating on water, our vehicles float on top of the Earth's atmosphere. Our vehicles have made numerous flights to high altitudes for research, and we are the world's record holders for human flight under a balloon, flying to 136,000 feet.

Here is Virgin Galactic's SpaceShipOne aircraft plus rocket system designed to take spaceflight participants to the edge of space in a suborbital rocket ride. Blue Origin's New Shepard rocket uses a vertical take-off approach to provide participants with a spaceflight experience. The World View Voyager capsule, will ascend to the edge of space under a large balloon shown here. All three of these companies' human spaceflight operations are regulated by the FAA Office of Commercial Space Transportation with whom we have worked for many years. I am happy to say that the FAA Associate Administrator responsible for this office, Dr. Nield, runs a truly great organization.

Thank you for the opportunity to convey an industry's perspective on FAA oversight of commercial spaceflight. Spaceflight operations involving humans, called spaceflight participants, are regulated under a regime based on the participants being informed of the risks and formally consenting to them. The regulations provide extensive protection of the uninvolved public, protection of property, and safe integration into the National Airspace System.

This informed consent regime ingeniously fosters innovation, technology development, and investment by creating a market for tourists, researchers, and astronauts to fly in space. This, like other tourism or sporting activities, such as skydiving, paragliding, and scuba diving, that involve informed consent, waivers, and releases. Members of the public have the right and freedom to voluntarily engage in activities where they believe the benefits outweigh the informed risks.

However, unlike skydiving, the regime for human spaceflight operation is temporary, called the learning period. It is subject to extension by Congress, and under certain conditions, all or part of this informed consent regime can be ended by the FAA.

The idea behind the learning period was that a time will come when the entire human commercial spaceflight industry should be transitioned to a regime in which the safety of a spaceflight participant is regulated. The informed consent regime is creating an industry and should not be subject to termination. At the same time, there is a desire and longstanding vision, as we have heard, to see the commercial space industry evolve into routine operations with the success and safety of the commercial airline industry.

I believe that the best solution is for two regulatory regimes to permanently exist in parallel. The existing informed consent regu-

latory regime or license and a new extended license, a regulatory regime that includes spaceflight participant safety. An extended license would be required for operations that constitute common carriage under Federal aviation regulations.

For example, Virgin Galactic could offer regular 1-hour service from New York to Sydney under an extended license. For services whose destination is space itself, common carriage does not apply, and the current license protecting the public property and national airspace is appropriate. Voluntarily garnering an extended license for such activities would confer, I believe, a great competitive advantage to operators.

It is in the Government's interest to maintain our country's leadership in aerospace by creating a stable yet flexible regulatory regime. I encourage Congress to take the lead in this area with three actions.

First, make the informed consent license permanent; second, direct the FAA to develop an extended license to include participant safety; and third, make it a high priority for the FAA to seamlessly incorporate routine commercial space operations into the National Airspace System.

Thank you very much. I look forward to your questions.

Mr. LOBIONDO. All right. Thank you very much. I will now turn to Mr. Larsen for questions.

Mr. LARSEN. Thanks. Mr. MacCallum, thanks for ending on those notes about actions to take. Is it your opinion that FAA could do these—take these actions with the current learning period or moratorium that Congress has in place through 2023?

Mr. MACCALLUM. I believe that the FAA could develop an extended license, one that involved the safety of human spaceflight participants in parallel right now. And one of the benefits of that is it allows the voluntary industry standards to move from a voluntary basis within the current license regime into being part of that extended license.

I do believe, for the sake of industry stability and investment, that ending the impermanence of the current license regime would be beneficial, especially in the context of developing a permanent license that does involve the safety of participants.

Mr. LARSEN. Dr. Nield, would you agree? What would be your answer to my question? Would the FAA be able to move forward on these kinds of recommendations without lifting the moratorium?

Dr. NIELD. Our understanding of the current law is that there is a moratorium in place, the learning period which lasts until 2023, and that specifically is intended to prevent the FAA from issuing regulations that are designed to ensure the safety of the flight crew or spaceflight participants. So we believe that would preclude us from issuing new regulations.

Now, we certainly can work with industry on voluntary consensus standards, and that is what we are planning to do.

Mr. LARSEN. From an industry perspective, are voluntary consensus standards enough? Mr. MacCallum.

Mr. MACCALLUM. I believe all active industries will self-regulate, and putting together consensus standards helps create a unified baseline. However, we see so many different technologies that these standards must, by necessity, end up being performance

standards rather than trying to regulate technology. Because of that and this situation that we are in, that is why I think both regimes are beneficial, allowing industry to graduate into a more regulated environment where they can.

I cannot speculate on the exact points of the law. I would hope that the FAA would be able to begin creating a parallel regulatory regime that the industry can voluntarily move into, but that would be a point of law I am not an expert on.

Mr. LARSEN. Dr. Dillingham, can you discuss a little bit more the issues brought up about the liability exposure the FAA would have with regards to the issues that you brought up in your report? You talked to them a little bit in your testimony. Can you provide a little more detail about it?

Dr. DILLINGHAM. Yes, sir. There is a three-tier insurance scheme for commercial space. At the first level is the maximum probable loss insurance that is required of the launch, and that is set on an individual basis by the characteristics of the launch by FAA. If that probable loss, if that loss exceeds the MPL that is capped at $500 million now, then the Federal indemnification comes into play, which is a little bit more than $3 billion, and if the loss or the damage exceeds that, the third level goes to the launch company itself.

The problem with that, from our perspective, is that the calculation, the methodology that FAA uses to establish where that maximum probable loss is, is certainly dated by a few decades, and we have asked them to update that because that determines when the Feds become liable for the loss.

Mr. LARSEN. When the taxpayers become liable for the loss?

Dr. DILLINGHAM. Yes. The taxpayers, subject to appropriations from the Congress. So it is very important that that maximum probable loss insurance segment that is required of the launch company be accurate and not pull the taxpayer in before the taxpayer should be pulled in or is legislated to be pulled in.

Mr. LARSEN. OK. Did the GAO find that there are enough folks then, in the FAA, to do inspections, to process licenses, to do the basic work that they would be required to do?

Dr. DILLINGHAM. Mr. Larsen, that is hard to say, but what the evidence has shown us, and we have talked to FAA about this, that in some cases they were unable to do some 10 percent of their required inspections for launches. We talked to FAA about that, and you know, what are the implications of this? What are the safety implications of this?

The response that we got was that there were no safety implications, that the agency prioritized its inspections. I could not understand how a critical mission guaranteeing safety, and not able to do those inspections, was not, you know, something that needed to be dealt with. We told FAA or—and recommended to FAA, and they are following through on that to if they need more resources, that in order to make that case to Congress, they had to present better information so Congress could evaluate the need, and that had to be based on a more detailed explanation of what are the actual duties and responsibilities that the agency has and how does it match up with the resources they have.

And as we have seen, and everyone has testified to this morning, there is expanding responsibilities, increasing launches, but at the

same time, the relative size of the FTEs is pretty much been level across the board, not matching.

So a lot of this is on FAA in terms of making that presentation to Congress to justify the resources that they will need.

Mr. LARSEN. Thank you. I have just one more question.

Mr. Gold, did you want to weigh in on that question? You seem——

Mr. GOLD. I would love to.

Mr. LARSEN. Yeah.

Mr. GOLD. And I really appreciate——

Mr. LARSEN. Sure.

Mr. GOLD [continuing]. The question, Congressman. I believe the funding situation is just critical. Congressman DeFazio mentioned safety. It is only a matter of time until safety suffers due to a lack of funding.

I would like to compliment your colleagues, Congressman Bridenstine and Congressman Kilmer, who have fought to at least get the Presidential budget request for the FAA AST this year and match what is in the Senate, but as you have heard from everyone on this panel, the field is expanding, and to just look at launches is a very poor way of judging what the AST needs in terms of resources.

As I said in my testimony, the COMSTAC at every meeting has endorsed the need for more funding. When have you seen companies asking for more funding for their regulators before? If we don't deal with this, I believe the repercussions will be dire not just to safety, but maybe a little less important than safety but still important, is the health of the industry. The AST will be caught in a triage situation where they will probably have to look at activities that involve the Government first and only then look at the private sector funded activities.

This is the exact opposite message that we want to send to entrepreneurs, to innovators who are putting their own money into these projects. So not only for safety but for the competitiveness of America, we must deal with this issue.

Mr. LARSEN. Thank you. Thank you, Mr. Chairman.

Mr. LOBIONDO. Mr. Young.

Mr. YOUNG. Thank you, Mr. Chairman, and you may wonder why I am here, but we have a lot of space activity in Alaska, more primary launches. But you know, I was just sitting here thinking, you know, in 1492, Columbus sailed the ocean blue without any regulations, and I am a little concerned in this new vision that you have, and thank you, all of you, for this, that what we have watched over the years is regulations stifle the imagination, the entrepreneurship, and this is a fledgling industry. It really is something that is down the road. I will never see the final of it, I know that, but it is something I believe this Nation is going to be faced with, and it will be exciting. It will be something that we can all look upon with great pride.

What I don't want is the baby to be suffocated with too many blankets. And all due respect to you, Dr. Nield, the FAA doesn't have the greatest reputation in the world right now, and we are working on a renewal of that bill, as you know. And I just wondered, Dr. Nield, do you think that you should be the agency or

should we have another group of people that would write regulations with the cooperation of the industry itself?

I am afraid you are going the get some college graduate, or some noncollege graduate, involved writing regulation not knowing the effect upon industry, which has happened in a lot of other agencies. Do you think you are—you are the only one in the street now. Do you think you are the appropriate one, or should there be another agency to work with the industry to make sure it is safe?

Dr. NIELD. We very much believe that we are the right people to do this. Although I respect the fact that different people have different opinions, I believe that the dual mandate to ensure public safety and to encourage, facilitate, and promote the industry, and—based on the instructions in the law—to regulate only to the extent necessary to meet international obligations, public safety, foreign policy, and national security interests of the U.S., is the right calibration for us. We are strongly interested in seeing not only safe, but also successful operations by the industry.

We believe we are doing a good job of that and certainly encourage you to continue to interact with industry to see if they agree with that assessment. We believe we can meet that dual mandate, ensuring public safety and continuing to support the great innovation.

Mr. YOUNG. Again, my concern is, Mr. Chairman, maybe there ought to be some type of direction so that that cooperation continues because the agency itself changes personnel and they change attitudes—not just you. I am talking about every agency—about how the industry should interface with one another. The biggest complaint we are having after my years in Congress is the people directly affected are never consulted when the regulations are being written.

Does anybody want to comment on that? Mr. Gold?

Mr. GOLD. Thank you, Congressman. And again, I appreciate the point you are making. A good example of what you are referring to is export control regulations. Had export control and ITAR existed for Columbus, he would still be in Europe today.

Mr. YOUNG. Yeah. That is right.

Mr. GOLD. The overbroad and often irrational way that export controls were implemented took America from being the only country that would conduct commercial space launches to often having only one launch per year. Companies would pay millions of dollars to meet burdensome Government requirements that often had almost no relation to reality, protecting parts and components that you could purchase at a Radio Shack instead of actually protecting technologies that warrant it.

So I am very concerned with this topic, but I can assure you that there is no better relationship between industry and a regulator than what we have with the FAA.

I think the group that you are almost referring to is actually the COMSTAC, that we are the backbone with industry that remains, regardless of who is in charge at the FAA AST. I have served with COMSTAC under George's predecessor and George, and the way that Dr. Nield interacts with us, the way that the AST works cooperatively with industry has been tremendous and necessary. As

Taber points out, there is great diversity in technologies, and this is not a well understood field, frankly, by Government.

No one knows more about private sector systems than the private sector.

Mr. YOUNG. That is right.

Mr. GOLD. And I assure you, Dr. Nield has reached out, as well as his people, to work hand-in-glove with us. If they had not, we would not be here asking for more funding for Dr. Nield, I assure you.

Mr. YOUNG. Well, again, I hope, Dr. Nield, you understand, if you get more funding, it is going to go directly to the program that has space exploration, not being spread around looking at my tail numbers on my airplane, if you follow what I am saying.

So that is just—my time is up, and I thank you, Mr. Chairman, for allowing me to participate.

Mr. LOBIONDO. Mr. DeFazio.

Mr. DEFAZIO. Thank you, Mr. Chairman. Don't worry. The tail numbers are available commercially on a realtime basis, so you don't have to worry about the Government there looking at you, Don.

I just want to return to the question. I understand that we want to promote this industry, and we do. You know, this is great for the U.S. to maintain our leadership in space, but the question is, why would we have the same agency promote and oversee safety? Why wouldn't it be the Department of Commerce or some other part of the Government that would do that?

Again, I mean, no offense, Dr. Nield, but I heard exactly those same things a couple of months before ValuJet when my amendment was defeated, and then my colleague said: Oops, that doesn't look too good, does it?

And so why wouldn't it be appropriate to have another agency of the Federal Government like the Department of Commerce, promote?

Dr. NIELD. Thank you for that question. I think an important part of that is exactly what do we mean by the terminology, and so let me explain how we interpret that phrase, "encourage, facilitate, and promote," by saying what it is not. It is not favoring one company over another. It is not cutting corners. It is not compromising when it comes to public safety. In fact, we do have that perfect safety record with 290 licensed or permitted activities.

Mr. DEFAZIO. The qualification being no member of the public has been killed.

Dr. NIELD. Which is the job that Congress has given to us.

Mr. DEFAZIO. There is some criticism of the NTSB regarding the process that went forward, you know, the construction of the vehicle before there was any review by FAA AST, and the whole human factors interaction issue in which some FAA AST technical staff member reported their questions did not directly relate to public safety, were filtered by FAA AST management to reduce the burden on scale. Well, unfortunately, someone died.

So, that leads me exactly to the point I am making. That pressure was exerted and they complied because of your promotional mandate.

Dr. Dillingham, do you have anything to comment on this? Is there another agency of Government that could do the promotion while the FAA could just focus on safety and maybe they wouldn't need to hire a bunch more people if they just focused on that part.

Dr. DILLINGHAM. Thank you, Mr. DeFazio. In one of our earlier reports, we made that exact point, that there is either inherent or potential conflict with the dual mandate of promotion and safety oversight. We also made the recommendation that FAA work with the Department of Commerce to come up with a memorandum of understanding that would in fact delineate which of the agencies would be responsible for what part of promotion in line with their statutory—their statutory situation, as well as their mission.

So bottom line, we still think that that is something that needs to be looked at. It is hard to know where that line is drawn, but the more the industry expands with all the different kinds of vehicles and technologies, it is becoming—it is still a risk and will become even more of a risk.

Mr. DEFAZIO. OK. Thank you.

Now, back to this, the insurance. I am struggling with this a little bit. When did FAA set the $500 million cap on acquired insurance?

Dr. DILLINGHAM. FAA developed the methodology to set the level of insurance in the mid-1980s, I think.

Mr. DEFAZIO. OK. And they also have this nub then where you have the Federal Government indemnification, which back then I think was estimated to be $1.5 billion, but now we are adjusting that part for inflation and saying the potential Government indemnification, subject to appropriation—might be a problem there—is $3.06 billion but we haven't talked about the $500 million and indexing that to inflation.

So why are we indexing the Government, the taxpayer's liability to inflation but not the required acquisition of insurance?

Dr. DILLINGHAM. Dr. Nield.

Dr. NIELD. My understanding is both of those numbers are inflation adjusted. I could be incorrect about that but——

Mr. DEFAZIO. I don't know. My understanding is from the GAO documents that it was set at $500 million and that it hasn't been indexed.

Mr. LOPEZ-ALEGRIA. Congressman, if I could just comment. I think the reason that we really don't know the answer to that question is because that number practically has never been approached. It is actually set by the MPL with a cap of $500 million, and if the maximum probable loss is calculated to be less that, then the question has never been asked, and as I understand it, that has been the case.

Mr. DEFAZIO. OK. So I mean, wouldn't this vary per operation, depending upon whether you are launching out of a heavily populated area, whether you are launching in a very remote area, the trajectory that you are going to use, et cetera, shouldn't it vary on each one?

Dr. NIELD. Yes, it does. We calculate a separate maximum probable loss for each vehicle, each location, and as long as it is less than that cap of $500 million, then that is the number in terms of how much insurance needs to be purchased.

Mr. DEFAZIO. OK. But if someone were doing something that you thought was going to exceed $500 million, you would just say: Well, you buy $500 million and the Government will take care of the rest?

Dr. NIELD. That is the general principle, although I think it is important to recognize that it is a conditional payment of excess third-party claims. It is not a guarantee. Congress would need to be persuaded that payment is the appropriate thing to do to reimburse the third parties that have suffered under that condition.

Mr. DEFAZIO. OK. All right. Thank you, Mr. Chairman.

Mr. LOBIONDO. Mr. Duncan.

Mr. DUNCAN. Well, thank you, Mr. Chairman. Where are we in relation to other countries, Dr. Nield? Are any other countries further along in this area than we are?

Dr. NIELD. There is a bit of a dichotomy. It was mentioned previously that we are currently relying on the Russians to take our astronauts to the International Space Station, although industry is working hard to bring that capability back to the U.S.

But in terms of commercial space transportation specifically, including suborbital spaceflight, the U.S. is far and away in the lead right now. That is because of the creativity and innovation of our American industry, and also, frankly, I believe because of the proactive way that we have set up a regulatory framework that lets everyone know what is expected, what the rules are going to be. You can factor that into your planning, and you can proceed under an informed consent regime as opposed to insisting upon zero risk. That is a different environment than any other country has put into place.

Mr. DUNCAN. Well, I would have assumed that we were ahead, particularly you talked about the Russians. Their economy is in tatters, so I wouldn't expect that there would be a lot of commercial space programs over there, but I am like Mr. DeFazio, I was going to ask some questions about this indemnification procedure.

According to the information we have, it has been in effect since 1988, 28 years now, and it has not been invoked, yet it is still in the law till 2025.

I know there are some businesses and industries that the Federal Government insures but not many. Most businesses that we would—that I could go into or that anyone could go into are not insured. They are not backed up by the Federal Government.

Why is it still necessary that we place this potential liability on the taxpayers? I mean, this is—maybe it was done at the first to encourage a new industry, but when it has gone on this long——

Dr. NIELD. Thank you for that question. My understanding is that indemnification is something that is very important to industry in terms of being internationally competitive. Most other nations have a much more supportive environment in terms of an indemnification regime. The other thing to remember is that in that period of time, the 28 years, the U.S. regime has never resulted in the cost of a single dime to the taxpayers because of the safety culture and the structure that we have set up. So, it is working well, in our opinion.

Mr. DUNCAN. Yes.

Dr. Dillingham.

Dr. DILLINGHAM. Mr. Duncan, you spoke about Russia. And I think it is important to note that in terms of indemnification, where we have a cap of $3.06 billion, there is no cap in Russia so they have a two-tier system. Once the launch company reaches its goal, then the Government will support any amount of damage that occurs. And it is one of the concerns that the U.S. has in terms of competitiveness of launches, that if they have a better regime of indemnification and insurance, that companies may move towards offshore rather than U.S. launching them. So indemnification is really important.

Mr. DUNCAN. All right. Thank you very much.

Mr. LOBIONDO. Mr. Carson.

Mr. CARSON. Thank you, Chairman LoBiondo and Ranking Member Larsen. This is for all the witnesses. Congress previously imposed a moratorium to prevent the FAA from issuing more robust regulations on the operational safety of commercial spaceflight until 2023. And the rationale was, essentially, to avoid overregulating an emerging industry in its infancy.

Do you think that this moratorium needs to be revisited? And should it end earlier or be extended? Based on what is actually happening in the industry today, what do you all think about updating the operational safely rules currently in place?

Mr. MACCALLUM. I think it is important to make the system that we are in right now permanent.

I want to address a point that Ranking Member DeFazio brought up, which I think elucidates this. AST regulates the safety of uninvolved public property, national airspace. So these activities, these launches, are very heavily regulated. We have chosen not to regulate the safety of the passenger because it is, frankly, an experience. It is not common carriage. We are not taking a person from one place to another.

As an experience, I believe it is not in the public's interest to have the safety of the participant regulated. Furthermore, it is not in the public's interest to regulate the safety of a test pilot developing new technologies. These are risks we want our industry to take.

And so what happened with Virgin Galactic is tragic. But it is the kind of thing that happens as we develop new technologies. And it is not in any way the fault of AST or Dr. Nield's leadership that that happened. Dr. Nield was regulating to the letter of the law and, I believe, has no fault. And we should not be—you know, it is Monday morning quarterbacking both looking at the report from—after the accident or the work that was done at AST. I believe they have done a great job, and we should maintain this regulatory regime because it is building a great industry. And giving it more stability is appropriate.

When it goes to common carriage, selling a ticket from one point to another, New York to Sydney, then I believe we are and appropriately, in accordance with the regulations, in a place where we should regulate the safety of the passenger. But only then.

Mr. GOLD. And if I could just chime in as well, Congressman. To echo Taber's sentiments, no new frontier has ever been settled without loss of life. It is unfortunate. It is tragic. It has happened before, and I am afraid it will happen again. Again, what Dr. Nield

and AST did was not driven by their desire to promote the industry. It was the legislative authority that they were given. This is a decision that Congress has made, the administration has made, and unless that changes, there is nothing more that Dr. Nield can or should do in that arena.

And I believe that we have struck a good balance in this area. The COMSTAC has set up the Standards Working Group, and I would welcome our Vice Chair to say more about what we in industry are doing here. But what remains undone and what I would like to say in response to a previous question about are we behind foreign countries, you have heard many of us talk about this article VI concern of authorization and continuing supervision. Other countries have already dealt with that issue and dealt with it well.

I just recently spoke to some colleagues and friends from the United Arab Emirates who are busy setting up a regime that does bolster and support safety but also creates an environment that is conducive to innovation, to growth. And if the United States can't even deal with this simple fundamental issue of addressing an existing international obligation, well, then where are we as a country?

So rather than looking at the moratorium, which I think we can have a discussion about, this is a near-term question that has to be dealt with with alacrity, and then I think we can continue to investigate a moratorium and look at what the COMSTAC and Commercial Spaceflight Federation and industry as a whole are doing relative to developing industry standards.

Dr. DILLINGHAM. As you know, the moratorium was recently extended. But as the U.S. is operating under that moratorium, one of the things that is supposed to happen during the course of that is the collection of operational data and experiences, which would in fact feed into the development of regulations when that time is appropriate and Congress makes that pronouncement. However, from what we can learn, there has been not a lot of coming together of presenting operational information from the various companies for competitive reasons or other kinds of reasons.

So as the moratorium goes forward, it is going to be important that the most safety related operational information is available to FAA so that it can in fact have a basis for regulation when that time comes.

Mr. CARSON. Thank you, Mr. Chairman. I yield back.

Mr. LOBIONDO. Mr. Hanna.

Mr. HANNA. Thank you, Chairman.

Dr. Nield, you have heard the testimony, I know, and it is an interesting dynamic. A moratorium seems to be the antithesis of—and yet at the same time agree with Mr. MacCallum that if you need a moratorium, then you are not capable of doing the job. What would you wait for? And I am thinking of the Next Generation Aviation, which you are familiar with, which is 20 years behind now.

Mr. MacCallum, this industry, there are many different groups in it. It is a great opportunity, depending on who you are and what your level of risk you are able to take. But, I mean, is it possible to do everything everybody wants to do here successfully without having a great deal of latitude in the process? Because there are

multiple ways of doing this and ideas. And we have seen that over the last 5 or 10 years.

Mr. MACCALLUM. I believe the current system that protects the public, national airspace, private property, is actually working very well. The safety record speaks for itself. I believe we should not be regulating where we don't need to regulate. We certainly should regulate where common carriage exists.

Mr. HANNA. But we are not behind yet.

Mr. MACCALLUM. I am sorry?

Mr. HANNA. Internationally, we are not behind yet. But "yet" being the operative word.

Mr. MACCALLUM. Well, I believe one should never underestimate one's competition. And it is quite easy for emerging countries to develop sets of laws that are more favorable than ours. The instability that we have in calling something a temporary moratorium or learning period makes other countries attractive.

Mr. HANNA. It looks like a cheap excuse.

Mr. MACCALLUM. I believe stability and regulation is one of the foundations on which our economy is grown. And we should continue that prerogative.

Mr. HANNA. What do you think, Dr. Nield? Can you manage all that?

Dr. NIELD. Congress has decided to extend this moratorium until 2023. In the ideal world, though, I think we should be working right now to set up what the permanent framework looks like. If that was done appropriately with, for example, a top level regulatory structure where the details of exactly what you have to do is based on industry-developed consensus standards, then I think you would have the best of both worlds. Because you would have the Government oversight, and you would have a permanent regime that everyone can count on. The details of what is required would be developed by the people who know it—who have built, designed, and are operating these systems. So to the extent that we can encourage progress along that approach, I think that would be the best of all worlds.

Mr. HANNA. Mr. Gold.

Mr. GOLD. Congressman, I think it is important to remember just how young this industry is. We don't even know what we don't know, in many instances. There are a great diversity of technologies and approaches. And as Dr. Nield says, and the COMSTAC has been proactive in working with the AST, we need to use this time with the moratorium to figure out what should be done, what can be done. And it is ultimately a balance.

You know, we have international competition here, safety over there, and we have to work together as industry and Government to find that Goldilocks zone where we protect the uninvolved public and protect everyone else, yet don't deter industry. And I think we have had a very collegial and a very productive relationship between AST and Government so far.

Mr. HANNA. Does everyone agree with that?

Mr. MACCALLUM. This is the foundation of my proposal to have two parallel regulatory regimes. Because it takes the heat out of the situation now where industry is looking down the road at the end of the moratorium and regulations are changing, but we are

spending huge amounts of money. Over almost $3 billion was invested just in 2015 in developing vehicles. But we don't know what those new regulations might be, so it is an inherent threat to the industry.

By creating a parallel regime that adopts industry standards and does exactly what Dr. Nield has just recommended, by allowing a voluntary graduation from a license to an extended license, I think we create the environment that both encourages new technologies that may come along in 8 years to work in a regulated environment where there is informed consent and allow the graduation to one where the safety of the participant is regulated.

Mr. HANNA. Thank you. I yield back.

Mr. LOBIONDO. Ms. Titus.

Ms. TITUS. Thank you, Mr. Chairman. And thank the witnesses for being here, especially Mr. Gold. I think you have some familiarity with southern Nevada from your time at Bigelow. A lot of people who come to my district get transported to another dimension, but they don't usually think about it as space travel. So appreciate your knowledge.

I would like to address my question to you, Mr. Gold, and to Dr. Nield. You know, we are just a couple of weeks away from the reauthorization again of the FAA bill. The Senate has passed a version. And we have a version over here on the House side that calls for a privatization of air traffic control system. Part of the problem with that is that it puts the decisionmaking in the hands of a commission or a committee that is dominated by just primarily one special interest and leaves out a lot of the players, including commercial space industry.

So I would ask you, Mr. Gold, if you would be satisfied with a system that where they determine rates and access and every bit of use of airspace where you are not at the table? And I would ask Dr. Nield if he would comment on kind of the relationship between the Office of Commercial Space and air traffic. And I know it is a substantial one, and what kind of challenges would be posed if we moved to this new system that is in the House bill?

Mr. GOLD. First, Congresswoman, let me congratulate you and your constituent Bigelow Aerospace and everyone in southern Nevada who worked to get the Bigelow Expandable Activity Module onto the International Space Station. I used to say that Bigelow Aerospace was the biggest gamble in Las Vegas, but no longer.

Ms. TITUS. That is right.

Mr. GOLD. And it is going in a great direction. And congratulations to you.

Again, we have talked a lot about regulatory risk, you know, choking the child in its crib. And I think what you raise is an excellent example of this. Again, we are dealing with a young industry, one that is just leaving the cradle and beginning to walk. And if we suffocate it with regulations, and particularly regulations where we are not able to interact, to have that seat at the table, to provide the advice, because, again, this is not the aviation industry. These are not mature systems that Government officials have great experience and knowledge of. Most of the experience with commercial spaceflight systems remain only in that company itself because they are so unique and so different and so immature at this time.

And part of the reason that you see myself and others in industry be so supportive of Dr. Nield is not only due to his excellent leadership, but Dr. Nield and his predecessors have always had a seat for us at the table. It is part of why I am here at this hearing with the COMSTAC. And any system that does not allow us that insight, that transparency, and that voice, I would strongly be against.

Ms. TITUS. Thank you.

Doctor.

Dr. NIELD. Yes, I would just point out that the FAA has a strategic initiative that is intended to integrate commercial space activities with other users of the National Airspace System. That includes UAS flights as well as commercial space launch and reentry. We are trying to make sure that you can operate both kinds of systems without negatively impacting others. We have been working very closely with the Air Traffic Organization [ATO] for what is happening today, and with the NextGen office, including the FAA technical center, for what we want to happen tomorrow.

Based on that close collaboration and the research that we are doing right now, I feel pretty confident that we will be able to continue that relationship, regardless of what Congress decides to do on the future of the ATO.

Ms. TITUS. So you think it would work out if you privatize air traffic controllers and they don't have a seat at the table and you are kind of taken out of the picture?

Dr. NIELD. I am confident that we can make it work whichever way Congress decides to proceed.

Ms. TITUS. OK. Thank you.

Mr. LOBIONDO. The gentleman from Georgia.

Mr. WOODALL. Thank you, Mr. Chairman.

I have heard a common theme of a new frontier and emerging industry, young industry. Mr. Lopez-Alegria, help me understand what the tipping point is when it does move to the common carriage that Mr. MacCallum mentioned. When do we stop having the conversation about an immature industry and start having the conversation about safety and a mature industry that is ready for commercial travel?

Mr. LOPEZ-ALEGRIA. Thanks for that question, Congressman. I think what Mr. Gold referred to before, in the COMSTAC's Standards Working Group, is that we have started to lay out this roadmap to regulation. And we have identified some milestones, which clearly don't have dates or anything associated with them.

The first step is to develop consensus industry standards with the participation of FAA, AST, and any stakeholder, Government, private, doesn't matter. At some point, and I will get back to when that point is in just a second, we could use that standard—those standards as a basis of some sort of primitive regulation per se. And at some point when we get to the time of where common carriage, as Mr. MacCallum has pointed out, it might be appropriate to certificate these airplanes, like the FAA does with commercial carriers. That obviously is way out in the future, and we at this table would be extremely excited to be here when that happens. But it is really far away.

Mr. WOODALL. Will it be obvious to me as an outside observer what the difference is between an adventurer and an explorer and someone who is seeking common carriage? How do I tell that transition is happening?

Mr. LOPEZ-ALEGRIA. Well, I think the concept of common carriage means you are going from sort of point A to point B routinely. I mean, how we define that, I think, is sort of in the eyes of the beholder. But I think there will be a mechanism to make that judgment when the time is right.

On the first tipping point, though, between when we do not issue regulations for occupant safety and when we do, right now there is a moratorium that will expire in 2023 unless it is extended again. It was originally supposed to expire in 2012. And it didn't expire because when it was written in 2004, we thought, well, in 8 years we will be there. Well, 8 years came and went and we weren't there. And then 3 more years came and went and we still weren't there. And now we have decided it is going to take another 8 years. And maybe 8 years isn't long enough either.

I think the point is, it isn't a date. It's an accumulation of experience and gathering the data that Dr. Dillingham referred to that we can make—we have the basis on which to make fundamental, sound regulation helped with these standards. So the CSLCA that was referred to by the chairman, asked for a report to identify what are the metrics. What is it? If it is not a date, is it a number of takeoffs and landings? Is it so many hours of flight time? And they are off working on that, and I think that report is due later this year. But that is the kind of answer that we hope to get.

Mr. WOODALL. Mr. MacCallum, I agree with you. I think a stable regulatory foundation is what our economy is built upon. But I have looked at your Web site. I have thought about packing a picnic basket and getting a few friends and coming over. Because I think I understand balloon travel. And I would be regulated for safety today on anybody's balloon but yours.

What was that process for the FAA that distinguished what you are doing as space travel as opposed to just the common balloon experience I would expect?

Mr. MACCALLUM. So we looked at being certified as a hot air balloon is certified. The difficulty is that those regulations are built around a vehicle that goes a few thousand feet in the air under a wicker basket with a cotton envelope. We are going 30 kilometers up into the edge of space in a balloon the size of a football stadium. So it is a whole new technical realm. And there really wasn't a process in the certification side, aviation safety side of the FAA to really encompass what is fundamentally a spacecraft hanging under a very large balloon at the edge of space.

However, the regulatory system that has been set up for commercial space where the public is protected, property, national interests are protected, but we are allowed to develop a new technology under that regulatory regime, is frankly what allowed the investment and our progress to go forward. Without that kind of regulatory regime, we would be unable to move forward because we would have to develop the FAA's understanding of our technology in a certification process that would, frankly, take too long and have too many inherent risks.

I think we know when we have gone from an adventure to travel under common carriage by the very definition of common carriage in the regulations, which is that you are holding out to take a person from a point to a point. An easier way to think of this if I am buying a ticket because my boss told me I had to get to Sydney in an hour, then that is common carriage because I am not taking that flight because of the adventure and the experience. I am taking that flight because my boss told me to. And in that case, it is reasonable to regulate the safety of the occupants.

If I am just going to space or I am a researcher or I am going for the experience, I am doing it because that is either my profession or a more desired experience. And I think we can make that distinction pretty clear, and there will be a market forever for people who want to go experience space. And the existing regulatory regime is perfect for that experience, much like any other sport that we see where the participant's safety is not regulated, but the impacts to the broader community is.

Mr. WOODALL. I thank you all for your expertise.

Mr. Chairman, I yield back.

Mr. LOBIONDO. Thank you.

Dr. Nield, can you describe the current process for alerting air traffic control to a spacecraft that will reenter the atmosphere and pass through the NAS?

Dr. NIELD. Yes. Our current launch and reentry activities require us to work very, very closely with the Air Traffic Organization. We engage them from the very start. When someone comes in and wants a launch license, part of that license is the requirement for a letter of agreement between the operator and the ATO on responsibilities relative to deciding what days, what times, and what conditions those activities can take place. Closer to the launch, the agency is putting out notices to airmen and notices to mariners 48 hours ahead of time. As appropriate, the agency would either implement the flight under restricted areas or have temporary flight restrictions to ensure that the launch or reentry does not negatively impact any of the existing air traffic. So, it is a continuing process and it is working very well.

In the future, we want to try to automate that process so it is not such a manual process with telephone calls and typing in data on the keyboard. Rather, we can take realtime data and have that directly show up on the air traffic controllers' screens.

Mr. LOBIONDO. Thank you.

Dr. Dillingham, according to the August 2015 report your testimony is based on, AST's 2015 business plan contained a plan to determine the feasibility of a voluntary safety reporting system which has been very successful in enhancing commercial aviation safety.

In your view, has the FAA made any progress in establishing such a system for commercial space transportation sector?

Dr. DILLINGHAM. Mr. Chairman, from what we were able to learn, FAA made an effort to establish that voluntary reporting system. However, they did not receive the kind of cooperation that they needed from the launch companies themselves, meaning that they were not really forthcoming with operational data for concerns with competitiveness and proprietary information.

As of the last time we spoke to FAA, that had not changed. It may require some kind of legislative relief in order to protect that kind of information if the companies decide to share it.

Mr. LOBIONDO. Anybody else on the panel want to comment on that?

Mr. Lopez-Alegria, in your testimony, you stated the fact that the occupant safety is not yet regulated in commercial spaceflight does not mean that it is not safe. Can you elaborate on that?

Mr. LOPEZ-ALEGRIA. Well, I think the—you know, regulation doesn't make things safe and not regulating doesn't make them not safe was a sort of simple point of what I was trying to get at. I think we have sort of talked at length here about why we think the current regime is appropriate. In fact, premature regulation could reduce safety by eliminating viable technical solutions to problems that would—what would be more effective than what might be imposed by a Government regulation.

So the—you know, a lot of people point to the unfortunate accident by Scaled Composites and say: Well, there is proof that we are not safe. Again, I think that AST did the job which they were directed to do by Congress. These sorts of accidents are part and parcel of any development program. I don't need to point back to Apollo I or the two space shuttle accidents. You know, this is a tough business, and it is dangerous. My point is that regulating it right now would not make it safer.

Mr. LOBIONDO. OK. Thank you.

Mr. Larsen.

Mr. LARSEN. Yeah, just a closing statement, Mr. Chairman.

It has been 7 years since this particular committee or subcommittee has had a hearing on commercial space. Other committees have, but we haven't really explored our jurisdiction on this in 7 years. And I don't want it to be 7 years before we do this again.

There is a lot to absorb. I think as the industry grows, and we need to, we should put as much attention into this as we are putting into things like UAS in order to stay on top of these issues. So I hope we can have a followup or explore some new issues or other issues in this—certainly perhaps, knocking on wood—early on in the next Congress.

Mr. LOBIONDO. Are you also volunteering for an experience?

Mr. LARSEN. I have enough experiences at this job every day. And this—I think this is about as close as I am going to get to commercial space in my lifetime, right here.

Mr. LOBIONDO. I want to thank the panel very much. It was very enlightening. We appreciate your expertise. We appreciate your service. And we hope to be in touch.

The hearing is adjourned.

[Whereupon, at 11:29 a.m., the subcommittee was adjourned.]

STATEMENT OF
THE HONORABLE PETER A. DEFAZIO
SUBCOMMITTEE ON AVIATION HEARING ON
"FAA OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION"
JUNE 22, 2016

Thank you, Chairman LoBiondo and Ranking Member Larsen, for calling today's hearing on Federal Aviation Administration (FAA) oversight of commercial space transportation. In the seven years that have passed since the Committee last held a hearing on commercial space, a lot has happened.

The National Aeronautics and Space Administration (NASA) has retired the Space Shuttle and started a commercial crew and cargo program. We have seen significant private investment and tremendous innovation that has changed and expanded the nation's global leadership in commercial space. But we have also been challenged – witnessing the first fatality in commercial space in 2014. So this hearing is timely, if not overdue.

Ever since President John F. Kennedy challenged America to land a man on the moon and return him safely to earth within a decade, our space-faring nation has considered America's presence in space to be a given. For national security reasons and others, it is critical that the United States' leadership in space transportation and exploration remain second to none. However, it is equally important that we ensure that U.S. ventures

into space are the safest. And that applies to both the safety of crewmembers and the safety of people and property on the ground.

This might be a nascent industry, but transiting the nation's airspace at high speeds is not an inherently safe business, and strong Federal oversight must ensure that people and property on the ground are safe and that space travel serves our national interests. And some might even point out, there are some elements of the industry that are not so "new" - vehicles have been traveling in low-Earth orbit since the 1960s. But the FAA is demonstrating its ability to think outside the box and accommodate new and novel vehicles.

Just over the past two years, we have seen the FAA ramp up to integrate another nascent technology – unmanned aircraft, or drones – and in fact just yesterday issued a long-awaited set of rules that will integrate small drones into the National Airspace System.

However, Congress, with the agreement of successive presidential administrations and the industry, has actually prohibited the FAA from regulating the safety of people on board space vehicles. We recently extended the moratorium on regulation to 2023 in the Commercial Space Competitive Launch Act of 2015. But of course, that does not mean that federal investment and oversight do not play a critical role.

While the FAA may not be able to fully regulate space travel safety just yet, I think it is worth discussing today what might be ripe in 2023 when the moratorium expires. Are there certain safety rules that the FAA and the industry should begin thinking about and preparing to implement in 2023? Is industry working with FAA as it develops its industry-consensus standards?

A second point I will make is an issue with which I have a long history. The FAA's Office of Commercial Space has a mandate to "facilitate, encourage and promote" the industry – while at the same time it is required to protect people and property on the ground. This seems like an inherent conflict. The FAA used to have a similar dual mandate to "promote" the airline industry, until 1996, when, at my insistence, Congress eliminated the FAA's mandate to "promote" the industry following the disasters of ValuJet flight 592 and TWA flight 800.

Granted, I understand the distinctions between the almost-90-year-old airline industry of 1996 and the commercial space industry of today. But a Federal agency charged with "promoting" an industry— even a new one— can be effective in regulating that industry only to a certain point. I am interested to find out what FAA is doing to ensure that its authority to "promote" the space industry is not interfering with its regulatory functions, and whether the FAA has adequate resources to oversee the

industry. We cannot be blind to the decades of teachings of aviation safety under the guise of "promoting" this new industry. There is simply too much at stake.

In a recent investigation of the first fatality in commercial space, the National Transportation Safety Board (NTSB) criticized the FAA for failing to pay adequate attention to human factors and for failing to fully understand an application before issuing experimental flight permits. I have no doubt that FAA with its limited resources is having trouble keeping up with this rapidly emerging high-tech industry. The pace at which new and novel technologies are being developed is almost unprecedented, and the stakes – and risks – are high.

In the wake of the 2014 crash of SpaceShip Two, the Chairman of the NTSB reported that the safety issues involved in the accident "arose not from the novelty of a space launch test flight, but from human factors that were already known elsewhere in transportation." And he said that "for commercial spaceflight to successfully mature, we must meticulously seek out and mitigate known hazards, as a prerequisite to identifying and mitigating new hazards."

With a "moratorium" on regulations, it seems obvious that one thing that FAA can do to ensure safety is rigorous oversight. However, just last

year, the Government Accountability Office **(GAO) reported that FAA failed to conduct 23 of its safety inspections (or ten percent).** Space travel is inherently risky, but we must ensure that we are not introducing unnecessary risk into our nation's airspace or to those on the ground.

On a final note, I would mention that both launches and reentry operations are inherently disruptive and affect significant areas of airspace, in fact large swaths of airspace from the surface to 60,000 feet above sea level are established as a hazard area prior to a launch. An even greater area would be designated during reentry. This requires substantial coordination between the Office of Commercial Space and the Air Traffic Organization (ATO) during launches of commercial space vehicles. In fact, there is seamless coordination between the two.

If the pace of commercial space transportation increases as some forecast it will, and if commercial tourism becomes a reality, the need for this coordination with air traffic control will become even more crucial. And we will need to ensure that FAA has adequate resources to safely oversee the safe integration of these new and novel technologies into our nation's airspace and that the regulatory and safety mission is never compromised.

Thank you, and I look forward to hearing from the distinguished panelists today.

STATEMENT OF DR. GEORGE C. NIELD, ASSOCIATE ADMINISTRATOR FOR COMMERCIAL SPACE TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE, SUBCOMMITTEE ON AVIATION, ON FEDERAL AVIATION ADMINISTRATION OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION, JUNE 22, 2016.

Chairman LoBiondo, Ranking Member Larsen, Members of the Subcommittee:

I appreciate the opportunity to speak with you this morning about the Federal Aviation Administration's (FAA) oversight of commercial space transportation. In my testimony today, I will provide a brief background on FAA responsibilities, discuss recent developments in the commercial space transportation industry, identify some of the key challenges associated with this dynamic industry, and describe how we work with our stakeholders, including the Congress.

Background

The FAA has exercised oversight responsibility of commercial space transportation activities since 1995, when the Secretary of Transportation delegated authority over the activities to the FAA Administrator, and the Office of Commercial Space Transportation (AST) was established at the FAA. The FAA, through AST, licenses and permits the launch and reentry of commercial space vehicles consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities. The mission AST carries out is unique within the FAA in that it also includes the responsibility to encourage, facilitate, and promote U.S. commercial space transportation. This dual mission is an important part of our culture at FAA AST. These complementary mission objectives together provide an oversight framework that has proven to be very beneficial both to the industry and to the American people. Our track record bears this out; while the FAA

has licensed or permitted over 280 launches, there have never been any fatalities, serious injuries, or significant property damage to members of the public.

FAA policy for commercial space transportation is primarily guided by the Commercial Space Launch Act (CSLA), the National Space Transportation Policy, and the National Space Policy. The CSLA provides the FAA the authority to oversee public safety and to issue regulations. The National Space Transportation Policy offers direction for how the FAA provides safety oversight for non-federal launch and reentry operations and how the FAA interacts with other federal agencies with interests in space. Finally, the National Space Policy directs federal agencies to, among other things, "minimize, as much as possible, the regulatory burden for commercial space activities and ensure that the regulatory environment for licensing space activities is timely and responsive." In exercising authority delegated by the CSLA, the FAA issues launch and reentry licenses, experimental permits, launch site operator licenses, safety approvals, and payload reviews. To date, the FAA has licensed or permitted more than 280 launches and 10 reentries. Additionally, we oversee 10 active launch or reentry sites, or "spaceports," as they are often called, and eight active safety approvals.

Our responsibilities are not limited to protecting the public on the ground or in the air. In 2004 Congress granted the Secretary of Transportation authority to oversee the operations and safety of the emerging commercial human space flight industry. We think this industry segment holds great potential and promise. In order to ensure that the industry has an ample "learning period" to develop, Congress prohibited us from promulgating any regulations governing the design or operation of a launch vehicle intended to protect the health and safety of crew and spaceflight participants until the year 2023, absent death, serious injury, or close call. However, Congress did encourage us to continue to work with industry on ways to improve human space

flight safety. In August of 2014, we released a set of "Recommended Practices for Human Space Flight Occupant Safety." This 62-page document covered three major areas: design, manufacturing, and operations. While the practices are voluntary, and do not constitute regulations, we believe that the document gives industry a great start in understanding the various areas of concern that future safety frameworks may address.

The FAA also funds the Center of Excellence for Commercial Space Transportation, which provides grants to a consortium of universities for the purpose of conducting research important to the continued safety, growth, and expansion of U.S. commercial space transportation. Areas of research include: Space Traffic Management & Operations, Space Transportation Operations, Technologies & Payloads, Human Spaceflight, and Space Transportation Industry Viability.

It is important to note that we are working hard with our colleagues within the FAA in the air traffic organization and in the aviation safety, airports, NextGen, and security and hazardous materials safety offices to ensure commercial space transportation is effectively and efficiently integrated in the National Airspace System (NAS). We are extremely focused on working closely together to protect the safety of the traveling public and persons and property on the ground.

Recent Development in the Industry

Advances in commercial space transportation technology development and investment have been dramatic to say the least. According to a recent report by the Tauri Group, the year 2015 was a record-setting one for space ventures. The investment and debt financing in these enterprises totaled $2.7 billion, with more venture capital invested in space in 2015 than in the

prior 15 years combined. Nearly two-thirds of the investment in space ventures and startups since 2000 has been in the last five years.

These investments have been augmented by recent actions in government contracting and a strategic vision to advance the development of the industry. NASA recently announced an expansion of its commercial resupply services program (CRS) to include three launch providers that are charged to deliver cargo to the International Space Station. Orbital ATK, Sierra Nevada Corporation, and SpaceX were all awarded contracts through this program in January of 2016. Additionally, the Boeing Company and SpaceX have been awarded contracts by NASA to take American astronauts to the International Space Station beginning as early as 2017 under the Commercial Crew program. Although these are NASA contracts, the FAA is a critical partner in the programs. Just as it has been the case for the Commercial Cargo missions to date, every future Commercial Cargo and post-certification Commercial Crew flight will be licensed by the FAA, and we are already working with the companies, NASA, and other stakeholders to ensure smooth processes for conducting these important flights.

As the industry has matured, we have observed significant advances in space transportation technology. This is evident in the recent reusability technology demonstrations from two companies, Blue Origin and SpaceX. Blue Origin has demonstrated that it can launch and land the same rocket multiple times, and SpaceX has demonstrated it can deliver heavy telecommunications satellites to geostationary orbit 22,000 miles above the surface of the Earth and land the first stage of its rocket safely, both on land and on a drone ship in the Atlantic Ocean. If the ability to reuse rockets becomes more common across launch service providers, and the companies with this capability can successfully and regularly reuse rockets on missions with customer payloads, the price of reaching orbit likely will drop significantly. These are

incredible advancements that demonstrate an ongoing and ever-increasing technological evolution and the competitive nature of the industry.

An emerging segment of the suborbital space flight industry is space tourism. Several companies are working on plans for future operations that will take people to the edge of space, where they can observe the curvature of the Earth, peer into the blackness of space, and experience several minutes of weightlessness. Systems under development include launch vehicles that carry capsules that will land under a parachute, hybrid launch vehicles that take off and land on a runway, and high altitude balloons. The end game for these companies continues to evolve as they push the envelope on what is possible. Some of these companies would like to offer point-to-point travel that enables someone to take off from New York in the morning and land in Tokyo just a few hours later; some want to offer the opportunity to experience space as a thrill of a lifetime that tourists can remember forever; others want to open up suborbital space to researchers and scientists.

Although there are many types of operations and many different motives, one thing remains the same for all of them: they need a regulatory structure that allows them to be innovative while ensuring the safety of the public. Through our work with other stakeholders and our partners inside and outside the FAA, we are determined to provide this structure for all who want to be involved in this new commercial space race.

While there are many companies focused on low-Earth orbit and suborbital space, the FAA is working with others that want to push the envelope even further. Moon Express has recently announced its plan to send a payload to the Moon, and SpaceX has announced its intention to launch a spacecraft in 2018 to land on Mars. These ambitious plans require new ways of thinking about regulations and about what constitutes government authorization and

supervision. The challenges associated with these emerging space operations and their impacts on the agency are discussed in greater detail below.

Key Challenges

The FAA's strategic initiatives plan recognizes that great technological advancements require the FAA to safely integrate new types of user technologies, such as unmanned aircraft systems and commercial space vehicles, into the NAS. This is crucial as we anticipate increasing launch rates and complex operations. It is imperative that every FAA line of business has the tools, relationships, and infrastructure necessary to address the challenges associated with integration into the NAS.

In 2014, the NAS saw a dramatic rise in commercial space activity with 21 successfully completed space operations (18 launches and 3 reentries). The following year saw Blue Origin and SpaceX demonstrate successful flyback and landing of reusable launch vehicle stages.

To keep pace with the industry's growing launch rate and the increasing complexity of operations in the NAS, the FAA will continue working to improve the facilitation and integration of space operations into NAS planning. This effort includes evaluating safety technologies such as the Space Data Integrator, or SDI. AST is working in partnership with the Air Traffic Organization on SDI, which will enable us to track space mission progress as the vehicles fly through the NAS. SDI uses an automated process to take a space vehicle's real-time position and velocity and convert it into a format that the FAA's existing Flight Management System can interpret and display.

Perhaps most importantly, SDI provides near-real time error detection, giving the FAA early notification of abnormal activity that could affect air traffic. In the event of a failure, the

FAA can identify contingency Aircraft Hazard Areas and coordinate with air traffic facilities to mitigate the impact. We anticipate a demonstration of this tool as part of a partnership with SpaceX later this year.

Another interesting challenge relates to new and non-traditional space operations. Today, FAA licenses the launch and reentry of commercial space launch vehicles, but does not license their activity in Earth orbit or beyond. For example, if a company planned to launch a payload to the Moon, the FAA would license the launch of the payload, but not the activity the payload engages in after successful delivery to Earth orbit. However, Article VI of the Outer Space Treaty requires the U.S. government to authorize and continually supervise the activities of non-governmental entities in outer space.

Section 108 of the Commercial Space Launch Competitiveness Act (CSLCA), which Congress passed last year, directed the Office of Science and Technology Policy (OSTP) to develop an authorization and supervision approach that "would prioritize safety, utilize existing authorities, minimize burdens to the industry, promote the U.S. commercial space sector, and meet the United States obligations under international treaties." This recommendation was forwarded to Congress on April 4th of this year and includes legislative text that fulfills this reporting requirement. In these situations, the FAA Administrator, through the delegation in authority from the Secretary of Transportation, would "grant such authorizations to the extent consistent with the international obligations, foreign policy and national security interests of the United States, and United States Government uses of outer space." We support this approach.

Finally, perhaps one of the most pressing challenges associated with future space operations is how we keep pace with the congestion of space and the growing problem of orbital debris. To operate safely in space, operators must know where their systems are located and

when their systems will approach any of the approximately 18,000 other tracked and cataloged objects also on orbit. Safety-related space situational awareness data for these tracked objects provide space operators information necessary to safely plan maneuvers and mitigate collisions. Currently, the Department of Defense collects space surveillance data and compiles it to create space situational awareness to provide orbital safety. The CSLCA required the Secretary of Transportation in concurrence with the Department of Defense to provide a report on the feasibility of a civil agency processing and releasing this data and information. We hope to provide this report to Congress soon.

The Role of Congress in Supporting the Industry

The commercial space transportation industry has seen significant change since the passage of the first Commercial Space Launch Act in 1984. It is clear that the industry exists in large part because of the foresight of Congress in passing that important legislation. Congress remains an active participant in this industry and the recent CSLCA demonstrates how critical that role is.

As we wrestle with how to answer some of the challenges associated with this dynamic industry, Congress has asked us and some of our other partners in the federal government to take a look at various issues related to the commercial space transportation industry. We are working diligently to respond to those critical reporting requirements. These reports will help to inform stakeholders, including federal agencies and the Congress, and provide necessary data to make needed progress on many of the issues discussed in this testimony.

In addition to the policy guidance Congress gives us, the FAA also relies on Congress for the resources necessary to keep pace with the industry. Since 2006, the number of launch and

reentry operations we oversee has increased by 200 percent, the number of licenses and permits we issue has increased by 450 percent, and the number of inspections we perform to ensure safety compliance has increased by 725 percent. Over that same period, our staff has increased by only 42 percent and we have never missed one of our statutorily prescribed time limits for issuing a license or permit.

Our vision at FAA is to be recognized and respected as the world's foremost authority on commercial space transportation. Congress is critical in helping us realize that vision. As the commercial space transportation industry continues to grow, we must ensure that we maintain our ability to keep pace. The FAA appreciates that so far the appropriations committees have provided the full operations request for AST in fiscal year 2017. This funding is critical to the work we are doing to support the industry that Congress laid the ground work for over three decades ago. We cannot continue our efforts without your guidance and support.

In closing, I would like to quote my predecessor and a true visionary, the late Patti Grace Smith, who passed away just a few weeks ago. Speaking at a conference at the University of California, San Diego, Patti told the audience, "Space is an attitude. It's a set of capabilities, an acceptance of risk-taking activities to uncover potential breakthroughs and endless possibilities. That is precisely why we love it."

What a great insight.

Thank you for the opportunity to speak with you today. I would be happy to address any questions that you may have.

United States Government Accountability Office

GAO

Testimony
Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives

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COMMERCIAL SPACE

Industry Developments and FAA Challenges

Statement of Gerald L. Dillingham, Ph.D., Director,
Physical Infrastructure Issues

GAO-16-765T

GAO Highlights

Highlights of GAO-16-765T, a testimony before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives

June 22, 2016

COMMERCIAL SPACE

Industry Developments and FAA Challenges

Why GAO Did This Study

The U.S. commercial space launch industry has changed considerably since the enactment of the Commercial Space Launch Amendments Act of 2004. FAA is required to license or permit commercial space launches; however, to allow space tourism to develop, the act prohibited FAA from regulating crew and spaceflight participant safety before 2012—a moratorium that was extended to 2023. The U.S. Commercial Space Launch Competitiveness Act, enacted in November 2015, addressed other aspects of the commercial space launch industry.

This testimony summarizes and updates findings from GAO's 2015 report, specifically industry developments and FAA challenges, including FAA's launch licensing workload and budget. For its 2015 report, GAO reviewed FAA's guidance on its launch permit, licensing, and safety oversight activities; interviewed FAA officials, industry stakeholders, and experts who were selected on the basis of their knowledge of FAA's oversight of the commercial space launch industry; and visited spaceports where two 2014 launch mishaps occurred. To update this information GAO reviewed FAA information on the industry and FAA's budget request.

What GAO Recommends

In 2015, GAO recommended that FAA, in its budget submissions, provide more detailed information about the Office of Commercial Space Transportation's workload. FAA agreed with the recommendation. GAO is not making new recommendations in this testimony.

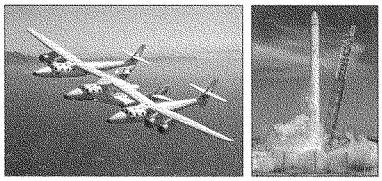
View GAO-16-765T. For more information, contact Gerald L. Dillingham, Ph.D. at (202) 512-2834 or dillinghamg@gao.gov

What GAO Found

In 2015, GAO reported that during the last decade, U.S. commercial space launch companies conducted fewer orbital launches in total than companies in Russia or Europe, which are among their main foreign competitors. However, the U.S. commercial space launch industry has expanded recently. In 2015, U.S. companies conducted eight orbital launches, compared with none in 2011. In addition, in 2015, U.S. companies conducted more orbital launches than companies in Russia, which conducted five, or Europe, which conducted six.

In 2015, GAO reported that the Federal Aviation Administration (FAA)—which is responsible for protecting the public with respect to commercial space launches, including licensing and permitting launches—faces challenges. According to FAA officials and industry stakeholders, FAA faces an increasing workload licensing and permitting launches for transporting cargo, and in the future, crew for NASA's commercial space programs, space tourism, and potentially launching small satellites. FAA also faces the challenges of whether and when to regulate the safety of crew and spaceflight participants—in 2015 Congress extended the moratorium to 2023—and overseeing new types of vehicles and technologies. (See figure for commercial space launch vehicles.) Challenges also include updating FAA's method to calculate maximum probable loss—the amount above which the federal government indemnifies the industry for catastrophic loss.

Virgin Galactic's SpaceShipTwo and SpaceX's Falcon 9



Source: Virgin Galactic. | GAO-16-765T

GAO reported in 2015 that FAA's budget requests for its commercial space launch activities generally were based on the number of projected launches, but that in recent years the actual number of launches was much lower than FAA's projections. GAO also reported that, according to FAA officials, more detailed information was not provided in FAA's budget submissions because the agency lacked information on its workload overseeing commercial space launch activities. In addition, GAO reported that the Office of Commercial Space Transportation did not track the amount of time spent on various activities. FAA has taken steps to implement GAO's recommendation that it provide more detailed information in its budget submissions regarding commercial space transportation activities. In its 2017 budget submission, FAA provided workload indices regarding authorizations under which companies conduct one or more launches; on-site inspections; licensing of spaceports; and staffing levels since 2006.

Chairman LoBiondo, Ranking Member Larsen, and Members of the Subcommittee,

Thank you for the opportunity to testify today on the commercial space launch industry. The U.S. commercial space launch industry, which the Federal Aviation Administration (FAA) reports had estimated revenues of $617 million in 2015, has experienced considerable change since the enactment of the Commercial Space Launch Amendments Act of 2004 ("the act").[1] The act promoted the development of the emerging commercial human spaceflight industry and made the Department of Transportation (DOT) responsible for overseeing the safety of the new industry—a responsibility that DOT delegated to FAA. As part of its safety oversight responsibilities, FAA licenses and permits launches as well as licenses launch sites. To allow the space tourism industry to develop, the act prohibited FAA from regulating the safety of crew and "spaceflight participants"[2] before 2012, except in limited circumstances—a moratorium that was extended to October 1, 2023 in the Commercial Space Launch Competitiveness Act enacted in November 2015.[3] In addition, in recent years, FAA has been licensing an increasing number of commercial space launches, including those for the National Aeronautics and Space Administration's (NASA) commercial cargo program, which contracts with commercial launch companies to transport cargo to the International Space Station (ISS). In 2006, we reported that FAA had provided a reasonable level of safety oversight regarding commercial launches, but that the agency faced several challenges in regulating the space tourism industry.[4] These challenges included FAA's ability to determine the specific circumstances under which it would regulate the

[1]Pub. L. No. 108-492, 118 Stat. 3974 (2004).

[2]Federal law currently defines a "space flight participant" as "an individual, who is not crew or a government astronaut, carried within a launch vehicle or reentry vehicle". 51 U.S.C. § 50902 (20).

[3]U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 111, 129 Stat. 704, 709 (2015). FAA is required to report to Congress on metrics that could indicate FAA's and the industry's readiness to transition to a safety framework that may include regulating crew, government astronauts, and spaceflight participant safety by August 2016 and every 30 months thereafter.

[4]GAO, *Commercial Space Launches: FAA Needs Continued Planning and Monitoring to Oversee the Safety of the Emerging Space Tourism Industry*, GAO-07-16 (Washington, D.C.: Oct. 20, 2006).

safety of crew and spaceflight participants and estimating its future resource needs to license and permit launch activities.

My testimony today focuses on (1) developments in the commercial space launch industry and (2) challenges FAA faces in overseeing and promoting the industry. This statement is primarily based on our August 2015 report[5] on commercial space issues.[6] For the 2015 report, we reviewed FAA's guidance on its launch permit, licensing, and safety oversight activities; interviewed FAA officials, industry stakeholders, and experts who were selected on the basis of their knowledge of FAA's oversight of the commercial space launch industry; and visited spaceports where two 2014 launch mishaps occurred. Additional information on the scope and methodology can be found in our August 2015 report. We updated information for this statement in June 2016 primarily by reviewing FAA information on the industry, FAA's budget request, and contacting FAA officials.

We conducted the work on which this statement is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The commercial space launch industry continues to develop and evolve, with changes in technology and facilities. Historically, commercial space launches carried payloads, generally satellites, into orbit using expendable launch vehicles that did not return to earth.[7] Figure 1 shows

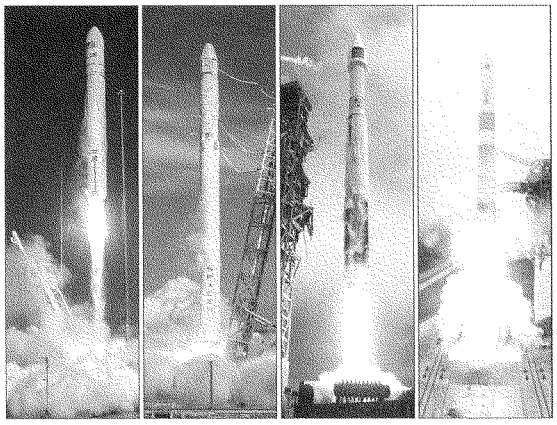
[5]GAO, *Federal Aviation Administration: Commercial Space Launch Industry Developments Present Multiple Challenges*, GAO-15-706 (Washington, D.C.: Aug. 25, 2015).

[6]We also reviewed previous GAO work including GAO, *Commercial Space Launches: FAA Should Update How it Assesses Federal Liability Risk*, GAO-12-899 (Washington, D.C.: July 2012) and GAO, *Commercial Space Transportation: Industry Trends, Government Challenges and International Competitiveness Issues*, GAO-12-836T (Washington, D.C.: June 20, 2012).

[7]An expendable launch vehicle is a single-use vehicle that is used to launch a payload into space.

examples of expendable launch vehicles. However, launch companies are testing reusable elements of expendable launch vehicles. For example, after launch, SpaceX has recovered four Falcon 9 first stages—three on a barge located at sea and one on land, according to FAA. United Launch Alliance is also developing capabilities to reuse the first stage of its Vulcan launch vehicle. Since the Space Shuttle fleet was retired in 2011, NASA has procured commercial cargo transportation services to the International Space Station from commercial providers such as SpaceX and Orbital ATK on these types of vehicles.

Figure 1: Expendable Launch Vehicles



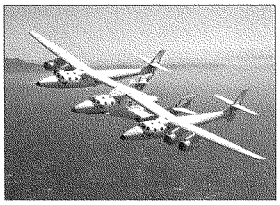
Antares | Falcon 9 | Atlas V | Delta IV

Sources: Orbital ATK (Antares), SpaceX (Falcon 9), and United Launch Alliance (Atlas V and Delta IV). Reprinted with permission. | GAO-16-765T

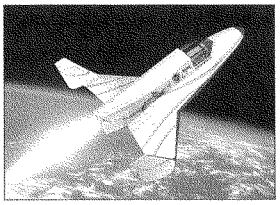
In addition, the commercial space launch industry is further changing technology with the emergence of suborbital reusable launch vehicles[8] that are capable of being launched into space more than once and could be used for space tourism. Several companies such as Virgin Galactic, Blue Origin, and XCOR are in the process of developing and testing manned, reusable launch vehicles for commercial space tourism. For example, according to Blue Origin it has launched, recovered, and re-flown the same booster four times. Companies like Virgin Galactic and Stratolaunch Systems are also developing vehicles that will have the capability to launch small satellites into orbit. See figure 2.

[8]According to FAA, suborbital spaceflight occurs when a spacecraft reaches space but its velocity is such that it cannot achieve orbit. FAA also indicates that many people believe that in order to achieve spaceflight, a spacecraft must reach an altitude higher than 100 kilometers (about 62 miles) above sea level. By contrast, according to FAA, orbital spaceflight occurs when a spacecraft is placed on a trajectory with sufficient velocity to place it in orbit around the earth.

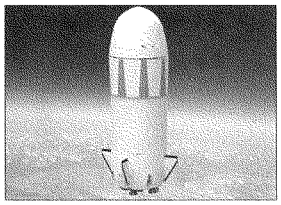
Figure 2: Reusable Launch Vehicles Under Development



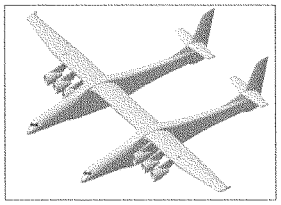
Virgin Galactic's SpaceShipTwo



XCOR's Lynx



Blue Origin's New Shepard

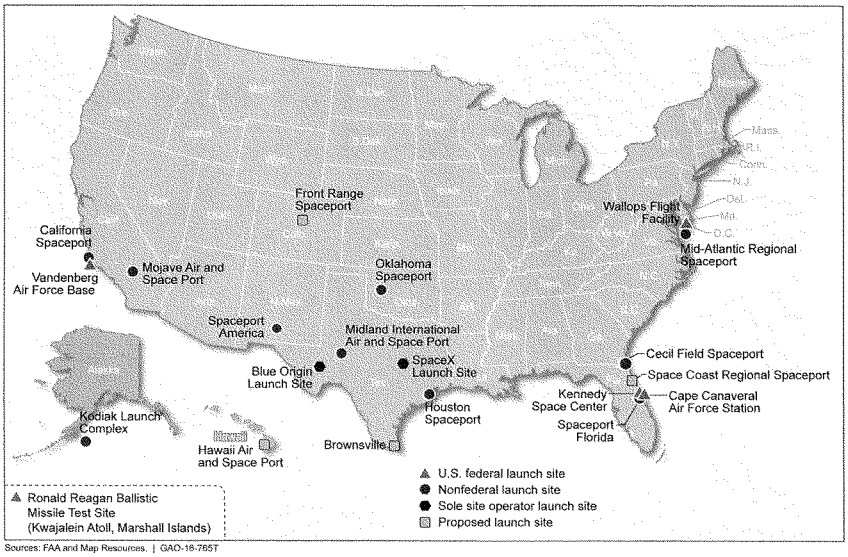


Stratolaunch aircraft

Sources: Virgin Galactic, XCOR, Blue Origin, and Vulcan Aerospace (for Stratolaunch). Reprinted with permission. | GAO-16-765T

Further, private companies and states are developing commercial spaceports—sites used for commercial space launches to support the expected growth in the launch industry. See figure 3.

Figure 3: Commercial Space Launch Sites and Proposed Sites as of June 2016



Sources: FAA and Map Resources. | GAO-16-765T

Note: FAA did not require the two sole site operator launch sites to be licensed because they were for the companies' exclusive use.

FAA's primary means of authorizing space launch activities is through its licensing process which includes: licensing launch and reentry vehicle operations, reviewing applications for experimental permits, reviewing safety approvals, and conducting safety inspections and oversight of licensed and permitted activities, among other activities. For fiscal year 2016 for the Office of Commercial Space Transportation, FAA's budget request was $18.1 million and 92 full-time equivalent positions. Congress provided $17.8 million for commercial space activities for fiscal year 2016.

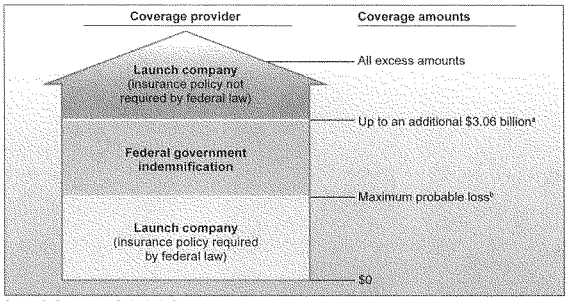
The federal government is authorized to provide catastrophic loss protection in the event of a launch accident for all FAA-licensed commercial launches through the Commercial Space Launch Amendments Act as amended.[9] Thus, subject to congressional appropriations, the U.S. government may pay third-party liability claims for injury, damage, or loss that result from a commercial launch-related accident in excess of the required "maximum probable loss," an amount which is calculated by FAA and is capped at $500 million per launch.[10] The federal government, subject to the availability of appropriations, is then liable for claims over the maximum probable loss up to $1.5 billion which when adjusted for post-1988 inflation is about $3.06 billion in 2015 dollars.[11] Launch companies are responsible for third-party liability claims up to the maximum probable loss and over $3.06 billion. Figure 4 illustrates this regime. FAA's risk methodology to calculate the maximum probable loss uses an "overlay" method that entails reviewing the specific circumstances of the launch including the planned launch vehicle, launch site, payload, flight path, and the potential casualties and fatalities that could result from varying types of launch failures at different points along that path. There has not been a commercial launch-related accident that has invoked indemnification and thus the federal government has not paid any third-party liability claims to date.

[9]51 U.S.C. § 50915.

[10]The launch company must purchase insurance to cover any damage up to the estimated maximum probable loss.

[11]51 U.S.C. § 50915(a)(1)(B) requires that the $1.5 billion maximum amount be adjusted for inflation. We used the Consumer Price Index (CPI-U) to calculate the adjustment to 2015 dollars.

Figure 4: Third-Party Liability Insurance Regime for FAA-Licensed Launches



Source: GAO analysis. | GAO-16-765T

[a]$3.06 billion is the $1.5 billion in law adjusted for inflation to 2015 dollars using the Consumer Price Index (CPI-U).
[b]The amount of insurance required based upon the FAA's determination of the maximum probable loss will not exceed the lesser of $500 million or the maximum third-party liability insurance available on the world market at a reasonable cost, as determined by FAA.

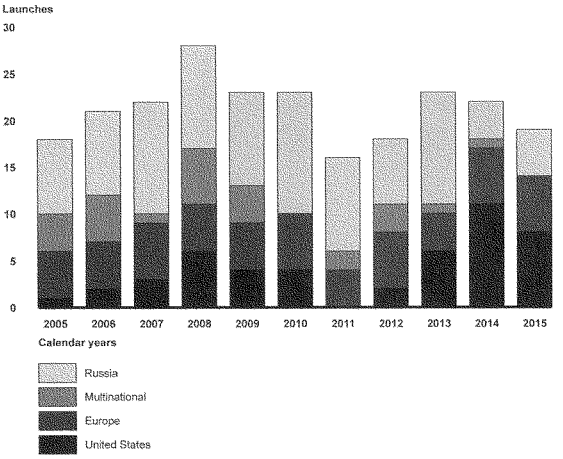
The U.S. Commercial Space Launch Industry Has Expanded in Recent Years

As we reported in our 2015 report, during the last decade, U.S. companies conducted fewer orbital commercial launches in total than companies in Russia or Europe, which are among the main foreign competitors.[12] However, in recent years such as 2014 and 2015, U.S. companies have conducted an increasing number of orbital commercial launches. As shown in figure 4, the number of orbital launches conducted by U.S. companies varied over the last 11 years. For example, recently the number of launches increased from zero in 2011 to eight in 2015.[13] In 2015, U.S. companies conducted more orbital launches than companies in Russia, which conducted five, or Europe, which conducted six.

[12]FAA data on international launch activity are only for orbital launches because, according to FAA, no commercial suborbital launch activity was conducted outside of the United States. Except for one licensed launch, the only suborbital launches conducted by U.S. companies from 2005 through 2015 were experimental. From 2005 through 2015, U.S. companies conducted a total of 47 orbital launches, compared with 101 conducted by companies in Russia and 58 conducted by companies in Europe. From October 2006 when the first experimental permit was approved to April 2016 there have been 42 experimental permits granted.

[13]According to FAA, the decrease in the number of launches in 2015 was due to launch failures such as SpaceX's Falcon 9 carrying a Dragon cargo capsule to the ISS.

Figure 5: U.S. and Foreign Orbital Commercial Space Launches, 2005 through 2015



Source: FAA. | GAO-16-765T

Notes: This graphic shows the number of orbital commercial space launches conducted by companies in countries that had the most orbital commercial launches. Some other countries that conducted orbital commercial space launches are not shown. Multinational represents the multinational consortium Sea Launch.

In 2015 we found that a number of factors are responsible for the recent expansion of the U.S. commercial space launch industry. First, increase in demand through federal government contracts, such as NASA's commercial cargo program, have supported the industry and have resulted in an increase in the number of U.S. commercial launches. For example, in 2015, SpaceX conducted three cargo resupply missions for NASA.[14] NASA also procured eight launches from Orbital ATK in 2008

[14]A fourth cargo resupply mission to the ISS ended in failure on June 28, 2015.

that were scheduled to occur between 2014 and 2016 with one launch taking place in 2015, one launch taking place in 2016, and another scheduled for July 2016.[15] In addition, in January 2016, NASA announced its selections for companies to conduct Commercial Resupply Services (CRS2) to the ISS. SpaceX and Orbital ATK were selected again, and Sierra Nevada Corporation was added as a new participant. According to NASA, these awards require a minimum of six missions to the ISS from each participant between 2019 and 2024. In addition to fulfilling government contracts, these companies also conduct launches for other customers, including international customers.

Second, according to representatives from two commercial space launch companies, including SpaceX, and an advisory group and an expert whom we interviewed for our 2015 report, the growth in the U.S. commercial space launch industry is largely due to SpaceX because it is more price competitive compared with foreign launch providers. The Chairman of the Commercial Space Transportation Advisory Committee said that SpaceX's prices are significantly lower than foreign providers. Some companies are seeking ways to further reduce costs. For example, Blue Origin is developing new main engine elements for United Launch Alliance's expendable launch vehicle. Representatives from one company and an industry association and an expert told us that reusable stages may further lower launch prices. In previous work, we reported that—according to industry stakeholders—launch prices, along with launch vehicle reliability, were the major factors that customers focus on when selecting launch providers.[16]

Third, the emerging space tourism industry and small satellite industry in the United States also may help the U.S. commercial space launch industry expand. As noted earlier, some U.S. companies are developing launch vehicles to carry spaceflight participants on suborbital flights and to place small satellites into orbit.

[15]United Launch Alliance carried Orbital ATK's Cygnus capsule with supplies to the ISS in December 2015 and March 2016 after Orbital ATK's mishap at the Mid-Atlantic Regional Spaceport damaged the launch pad. Orbital ATK plans to launch from the repaired launch pad in July 2016.

[16]GAO, *Commercial Space Transportation: Industry Trends, Government Challenges, and International Competitiveness Issues*, GAO-12-836T (Washington, D.C.: June 20, 2012).

FAA Faces Multiple Challenges Regarding Developments in the Commercial Space Launch Industry and Requested Additional Resources to Address Some Challenges

Challenges

In our 2015 report, we asked FAA officials, representatives from nine commercial space launch companies, and three experts to identify the challenges that FAA faces—and is likely to face in the near future—to address significant developments in the commercial space launch industry over the last decade. The challenges for FAA that they identified included: (1) determining whether and when to regulate the safety of crew and spaceflight participants and (2) handling an increased workload relating to licensing and permitting launches and launch sites. In addition, in our 2015 report, we noted that changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for launches.[17]

- **Determining whether and when to regulate the safety of crew and spaceflight participants:** In 2014, FAA released a set of recommended practices on human spaceflight occupants' safety that the agency indicated could be a starting point for the industry to develop standards, or if needed, for FAA to develop regulations.[18] In 2015, we reported that FAA officials said that the agency did not have

[17]Stakeholders identified two other challenges not discussed in our testimony—creating a safety reporting system and responding to launch companies' emerging business plans. For more information, see GAO-15-706.

[18]FAA, *Recommended Practices for Human Space Flight Occupant Safety Version 1.0* (Washington, D.C.: Aug. 27, 2014).

plans to issue regulations regarding the safety of crew and spaceflight participants but was looking to industry to develop industry consensus standards detailing validation and verification criteria that are needed to implement the agency's recommended practices. As part of the U.S. Commercial Space Launch Competitiveness Act, Congress required FAA in consultation with an industry advisory group—the Commercial Space Transportation Advisory Committee—to submit two reports to Congress on this topic.[19] The first report is on metrics that could indicate FAA's and the industry's readiness to transition to a safety framework that may include regulating crew, government astronaut and spaceflight participant safety and is due by August 2016. The second report is on the industry's progress in developing voluntary industry consensus standards and is required to be submitted by December 31, 2016 and periodically afterwards until December 31, 2021.

- **Increased workload relating to licensing and permitting launches and launch sites:**
  - Licensing more launches: In fiscal year 2015, FAA licensed and permitted 14 launches and re-entries, up from seven in fiscal year 2006 and compared with an average of about 11 launches and re-entries during each fiscal year from 2006 to 2015. We found a large part of this increase was due to launches for NASA's commercial cargo program. In the future, FAA also will need to license launches for NASA's commercial crew program and potentially launches of companies placing small satellites in orbit.
  - Conducting more inspections: In fiscal year 2015, FAA conducted 216 commercial launch inspections, up from 27 in fiscal year 2006 and compared with an average of 90 inspections during each fiscal year from 2006 to 2015. Officials said that FAA has conducted more safety inspections, especially those associated with pre-launch and reentry activities, to allow the agency to identify safety issues early for correction and to avoid launch companies' noncompliance with regulations and the conditions set forth in the launch license. FAA conducts different types of inspections such as launch and reentry operations and launch site operations, and FAA inspectors are present at launches.

[19]Pub. L. No. 114 -90, § 111, 129 Stat. 704, 709.

- Licensing new types of vehicles and technologies: Companies are developing a variety of new vehicles and technologies. For example, the space tourism industry is developing hybrid launch systems such as SpaceShipTwo, which have elements of both aircraft and rocket-powered components.[20] Some companies are also testing autonomous flight safety systems, which would allow a launch vehicle that is off course to be terminated without humans taking action. Most licensed launches as of August 2015 have involved flight termination systems that were human-operated.
- Licensing more and complex launch sites: Although launch sites traditionally have been located in coastal areas at federal launch facilities, in 2014 FAA licensed an inland launch site that is co-located with a commercial airport in Midland, Texas. In addition, FAA is licensing more nonfederal launch sites. As of June 2015, there were 10 FAA-licensed commercial launch sites, compared with six in 2006. In addition, as of May 2015, FAA had received partial applications for four additional launch sites.

Also, in our 2015 report we noted that changes in the number and types of commercial space launches could affect the government's overall exposure and indemnification for launches for several reasons. First, the number of launches and reentries covered by federal indemnification is forecasted to increase and the federal government's potential exposure to third-party liability claims would increase with the added volume. In general, by increasing the volume of launches and reentries, the probability of a catastrophic accident occurring is also increased. A catastrophic accident could result in third-party losses over the maximum probable loss, which would invoke federal indemnification. Second, forecasted types of launches and reentries include newly developed launch vehicles that have a shorter launch history than "legacy" launch vehicles. For example, Virgin Galactic's SpaceShipTwo, XCOR's Aerospace's Lynx, and Blue Origin's New Shepard are new vehicles. However, increased flights of a launch vehicle could also make a vehicle more reliable. We have previously reported that although some industry

[20]The Commercial Space Launch Amendments Act of 2004 defines the line between a rocket-powered airplane and a launch vehicle. According to the act, a suborbital rocket means a vehicle, rocket-propelled in whole or in part, intended for flight in a suborbital trajectory, and the thrust of which is greater than its lift for the majority of the rocket-powered portion of its ascent.

changes may alter the government's exposure, an accurate maximum probable loss calculation will mitigate the effects to some extent.[21] If the maximum probable loss calculation is accurate, the estimated losses will adjust for the risk profile of each license, in such a way that the likelihood the government would indemnify a third-party remains the same regardless of the industry change. However, in July 2012, we reported that FAA's risk methodology—which was first established in the 1980s—could be updated given advances in catastrophe modeling.[22] We recommended that FAA review its maximum probable loss methodology. Congress mandated that FAA review the methodology and report back to the Congress by May 2016. FAA officials told us that in June 2016 that they have drafted a report which is currently under agency review.

FAA Request for Resources

In 2015 we found that FAA's budget requests for its commercial space launch activities generally were based on the number of projected launches, but that in recent years the actual number of launches was much lower than FAA's projections. For example, during 6 of the 10 years from fiscal years 2005 to 2014, FAA generally based its budget submissions on the number of launches that it was projecting for the following year; none of those projections was realized in the actual number of licensed and permitted launches. FAA officials said at that time that although other metrics existed besides the number of projected launches, they were not consistently used in the agency's budget submissions. In addition, other activities, such as time spent on pre-application license consultations, were not included in the metrics used in preparing the budget requests. According to FAA officials, more detailed information was not provided in their budget submissions because the agency lacked certain workload metrics regarding its commercial space launch oversight activities. We also found that the Office of Commercial Space Transportation did not track the amount of time spent on the office's various activities. However, the officials indicated that they were continuing to develop a labor analysis methodology that began in fiscal year 2014 and that the office was considering implementing a new time recordkeeping system in 2016 to supplement the development of additional workload metrics.

[21]GAO, *Commercial Space Launches: FAA Should Update How It Assesses Federal Liability Risk*, GAO-12-899 (Washington, D.C.: July 2012).

[22]GAO-12-899

To provide Congress with more information about the resources requested to address developments in the commercial space launch industry, we recommended that FAA provide more detailed information in its budget submissions about its workload. FAA agreed with the recommendation, but DOT also had some concerns about how issues were presented. FAA has taken steps to implement our recommendation. In the 2017 budget submission, FAA provided workload indices based on the number of authorizations which the agency uses to authorize companies to conduct one or more launches, the number of licenses and permits, the number of on-site inspections as part of licensing launch sites, and staffing levels since fiscal year 2006. We will continue to monitor FAA's progress toward implementing this recommendation.

Chairman LoBiondo, Ranking Member Larsen and Members of the Subcommittee, this concludes my prepared statement. I would be pleased to answer any questions at this time.

GAO Contact and Staff Acknowledgments

For further information on this testimony, please contact Gerald. L. Dillingham, Ph.D., at (202) 512-2834 or dillinghamg@gao.gov. In addition, contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Individuals making key contributions to this testimony include: Catherine Colwell, Bob Homan, Dave Hooper, Maureen Luna-Long, Stephanie Purcell, Namita Bhatia Sabharwal, and Travis Schwartz.

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Questions for the Record from Rep. André Carson
to Gerald L. Dillingham, Ph.D., Government Accountability Office
Hearing on "FAA Oversight of Commercial Space Transportation"
June 22, 2016

Representative Carson: This is an exciting time for seeing new "possibilities" come to life. But as we've seen in other cutting-edge fields, from Silicon Valley and other places in the high-tech industry, diversity in the workforce lags behind the potential. What's your assessment of commercial space transportation industry in terms of the diversity of its workforce and its leaders? I'd appreciate any data you can provide me in writing, after the hearing. Also, please let me know whether or not you see any particular areas of concern? And if so, do you have recommendations?

Dr. Dillingham: The GAO has not conducted a study that included an assessment of the commercial space transportation industry in terms of the diversity of its workforce and its leaders. However, based on my experiences and interactions with the industry during the last several years, I would agree with your assessment that there is a good chance that, as in other high-tech industries, diversity in the workforce lags behind the potential.

I think a primary area of concern is the need for critical data collection and analysis that would be the basis for attempting to answer the question you have raised. For example, without knowing the set of "ready, willing, and able" potential participants for an industry, it's hard to know if there is any issue with hiring or if the lack of those types of characteristics in potential employees are related to potential diversity issues. Furthermore, even if the diversity breakdown in the industry tracks fairly well with the breakdown of ready, willing, and able candidates for jobs, we wouldn't know if there are other institutional issues that are steering certain segments of the population away from such industries so early in the process that they don't even become possible candidates. If GAO can be of further service to you in this area, please don't hesitate to contact us.

Hearing of the House Subcommittee on Aviation

"FAA Oversight of Commercial Space Transportation"

Wednesday, June 22, 2016 – 10:00 am – Rayburn House Office Building

Testimony of Michael Gold
Chair, Commercial Space Transportation Advisory Committee

Thank you Chairman LoBiondo, Ranking Member Larsen, members of the Subcommittee, and the Subcommittee staff, for this opportunity to discuss critical issues facing the FAA and the commercial space industry. My name is Mike Gold and I am the Chairman of the Commercial Space Transportation Advisory Committee ("COMSTAC"), a federal advisory committee comprised of private sector space executives from a wide variety space companies such as Boeing, SpaceX, Lockheed Martin, Virgin Galactic, and Blue Origin. Before I delve into the challenges and opportunities that the commercial space transportation industry faces, I would like to take a moment to acknowledge the passing of Dr. Nield's predecessor, Patti Grace Smith. Patti Grace Smith served as the Associate Administrator for Commercial Space Transportation for an unprecedented 11 years, and was the first leader of the office when it was transitioned to the FAA. Ms. Smith was a beloved and well respected trailblazer in the commercial space world, who helped to create an environment of growth, innovation, and cooperation between industry and government that we're still enjoying today. Moreover, while Ms. Smith's contributions to private sector space development certainly deserve praise, we should never forget another important part of Ms. Smith's life, particularly, her role as a civil rights activist. As a child, Ms. Smith courageously led the effort to integrate her high school in Tuskegee, Alabama, and her actions and those of her classmates culminated in the landmark decision of Lee v. Macon County Board of Education, which caused the blanket desegregation of public schools in Alabama. Ms. Smith will be greatly missed, but we in the commercial space industry will never forget her passion and idealism, and we will carry her spirit with us to the stars.

I. Mission Licensing

It's appropriate that I begin my testimony with a reference to Ms. Smith, because I first met her at a meeting with the FAA Office of Commercial Space Transportation ("FAA AST" or "AST") during which my question was who in the U.S. Government is responsible for licensing orbital commercial space transportation activities. The startling answer that Ms. Smith gave me then, and is still the case today, is that no one has such authority. The FAA AST is responsible for licensing launches and reentries, in other words, the AST is responsible for rockets that go up, and then capsules or other payloads that come down, but everything that occurs in between remains in a literal and legal vacuum. Like many in private industry, I'm not someone who is known for being a fan of burdensome government regulatory structures, however, this gap in the FAA's oversight responsibilities is already creating a problematic situation that could eventually cripple American competitiveness and innovation in the space field.

The conundrum that the commercial space transportation industry faces, is that the U.S. Government has already committed to 'supervising' private sector activities both in and beyond low Earth orbit ("LEO"). This commitment was made a long time ago when the U.S. signed the Treaty on Principles Governing the Activities of States in the Exploration and use of Outer Space, including the Moon and Other Celestial Bodies, known colloquially as the Outer Space Treaty of 1967 ("OST" or the "Treaty"). Specifically, Article VI of the OST requires that State Parties to the Treaty "shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by *non-government entities*" (emphasis added). Article VI goes on to state that the "activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty."

The key words from this clause for the Subcommittee's consideration are "authorization and continuing supervision". The FAA AST already has sufficient authority and an existing track record for authorizing the activities of non-governmental entities via the launch licensing process. It's the second half of this requirement, the mandate for "continuing supervision", which presents the greatest challenge. As Patti Grace Smith told me years ago and I believe Dr. Nield would confirm today, it's difficult if not problematic for the FAA AST to issue licenses for commercial space transportation activities in or beyond LEO without additional and explicit direction from Congress. For the first forty years of the OST, this provision for "continuing supervision" was never much of an issue. All space activities were being conducted by government agencies or were being performed under the continuing supervision of NASA, the Department of Defense, NOAA, or the FCC. The problem has arisen today because of emerging private sector space activities that have little or no connection to the U.S. Government. For example, private sector lunar rovers, a concept that U.S. officials could hardly have imagined back in 1967 when the OST was executed, fall into this regulatory gap. Spacecraft that conduct satellite servicing, private sector space stations, and missions to mine asteroids are also all examples of innovative American activities that will suffer from the confusion and uncertainty that reigns in this area.

The problem is not just that the U.S. agreed to the "continuing supervision" language in the OST, it's that the U.S. agreed to the provision and then failed to establish a means of actually meeting the requirement. This failure manifests in a problematic manner via the launch licensing process. Although the FAA AST ultimately issues launch licenses, the decision to approve or disapprove a requested license is made via an interagency process that often includes input from the Departments of State, Defense, and Commerce, as well as NASA and the FCC. The Department of State is charged with ensuring that any launch license issued by the FAA AST does not violate or interfere with international treaty obligations. When a company applies for a launch license or a payload review for an activity that isn't being supervised by a government agency, this puts the Department of State in a difficult position when addressing whether the activity runs counter to the U.S.'s international treaty obligations, since approving the launch would lead to non-governmental entities conducting operations in space without "continuing supervision" by the U.S. Government as required by Article VI of the OST. To be clear, the Department of State wants to encourage commercial space transportation activities and has been raising concerns over Article VI for years hoping to find a resolution before the situation

becomes problematic, but the Department of State's pleas for change have largely fallen upon deaf ears.

The solution to this issue can be simple and expeditious. Specifically, Congress should, as soon as possible, direct the FAA AST to update its regulations to support a 'Mission Licensing' process. Just like is done today for a launch license or a payload review, a Mission License would involve the commercial entity applying for a license with the FAA AST. The Mission License application process should be limited, requiring only basic information relative to the planned transportation activity, and assurances that the activity will be carried out in conformity with the U.S.'s existing international treaty obligations and will not harm 1) the national security interests of the United States, 2) public health or safety, 3) the operation of previously approved payloads or related activities; and 4) historic artifacts such as those that exist at the Apollo landing sites. Upon receiving such an application, the FAA AST would follow nearly identical procedures for a traditional payload review, convening an interagency meeting to review and approve the license. The requirement for "continuing supervision" would be met by Mission Licenses including a proviso that if the proposed commercial transportation activity were to experience a material change, the license holder will be required to inform the FAA AST. This concept would fully address the Article VI concern by meeting the OST's "continuing supervision" requirement with a benign, registration-based regime. Even without the OST's Article VI requirement, establishing a simple, benign means of registering commercial space activities in and beyond LEO would make sense, if for no other reason than to avoid collisions, prevent harmful interference between domestic and foreign outer space activities, and to generally protect the safety and health of the uninvolved public. The burden on the private sector would be minimal, since the information required for a Mission License and the review process proposed is largely if not entirely already required for a standard payload review or launch license.

Many countries, even those that are relatively new space entrants, are addressing the Article VI issue in an effective and comprehensive fashion. For example, the COMSTAC recently received a briefing from the United Arab Emirates ("UAE") whose space agency is in the process of finalizing a national space law. The UAE Space Agency plans to issue authorizations to entrepreneurial space companies and academic institutions to address the "continuing supervision" requirement in a manner that encourages innovation and business growth. The UAE Space Agency is determined to create an environment that is conducive to commercial space activities, and the U.S. would be wise to learn from the UAE's example and, more generally, the U.S. should continue to grow and expand the beneficial public and private partnerships between the UAE and the American aerospace sector.

Over a year ago, a recommendation was passed asking the FAA AST to express COMSTAC's support to Congress for the Mission Licensing process, and I have personally advocated for addressing the concern over Article VI and the lack of any regime for private sector LEO or beyond LEO activities for even longer than that. I have spent my entire career in the commercial space field, and I can assure the members of this Subcommittee that no two words scare me more than "government supervision".

In many space circles, I am best known for my efforts to combat the counterproductive implementation of the International Traffic in Arms Regulations ("ITAR"). As a matter of fact, upon being appointed to the COMSTAC in 2008, my first action as a member of the Committee was to establish the Export Control Reform Working Group, which I chaired for four years. Under the ITAR, many space activities including technical interchanges and launch campaigns were often conducted with the requirement of mandatory government supervision. This often manifested in Defense Technology Security Administration ("DTSA") personnel traveling with companies overseas to monitor private sector meetings. Not only was such government supervision sometimes irrelevant and superfluous, but the private sector companies attempting to engage in overseas business were asked to pay for their government monitors on an hourly basis, as well as reimbursing the government for all travel and overtime expenses. In my experience, conforming with export control requirements on a single foreign launch campaign would cost a private sector company millions of dollars, roughly $300,000 to $400,000 of which would be paid directly to the government as reimbursement for the presence of DTSA monitors. While working on launch campaigns in Russia I would often joke with my foreign colleagues that the KGB may have spied on them back in the day, but at least they had the good courtesy to do it for free. To be clear, I am not now and never was against export controls. There are numerous technologies, particularly in the nuclear arena, that warrant strong government protections. What I have opposed in the past and continue to oppose in the present is the overbreadth of the ITAR. The best example of this was a stand that was used in 2006 for the critical purpose of preventing a satellite from laying on the ground. The stand was round with four legs sticking out of it and, if placed upside down, was indistinguishable from a metal coffee table. Due to the ITAR and its requirement for government supervision, the company that I was working for at the time was forced to pay for two guards to monitor this metal coffee table on a 24/7 basis, and to also pay for two government monitors to watch the guards watching the coffee table. This is just one of many examples of how the ITAR was implemented in a counterproductive and occasionally even irrational manner. Scant government resources and critical personnel were wasted monitoring metal coffee tables as well as technologies that were widely available to anyone in the commercial marketplace.

The impact that the government supervision under the ITAR had on the aerospace sector was extraordinarily pernicious. Although there were many contributing factors, the ITAR played a significant role in wounding the American commercial space launch sector. America was at one point the only country capable of launching commercial payloads. Due in no small part to a counterproductive export control regime, America went from being the number one provider of commercial launch services, to often supporting only one commercial launch per year, sending an entire industry as well as thousands of jobs and billions of dollars to overseas competitors in Europe and Russia. Moreover, since the ITAR prevented many American companies from entering overseas markets, numerous domestic firms went out of business, particularly second and third tier parts suppliers, which forced the U.S. Department of Defense to purchase critical parts and components from foreign providers. The overall impact of the ITAR as it was previously implemented prior to the reforms of 2013, was to send American jobs overseas, weaken the U.S.'s industrial base, and increase dependence on foreign corporations.

Although this hearing isn't about export control reform, it's vital that we learn from the lessons of the past because we find ourselves in a very similar situation today. The ITAR

required government supervision of private sector activities, and that same word "supervision" is exactly what appears in the OST. I have seen the pernicious impact on American jobs, competitiveness, and capabilities that government supervision requirements can have and I implore this Subcommittee not to let history repeat itself. We are at an inflection point, a moment in history when we can address the Article VI requirement for "continuing supervision" and the need to maintain a safe environment for LEO and beyond LEO commercial space transportation and activities in a benign and productive fashion that will protect American jobs and encourage industrial growth. By moving forward expeditiously with the Mission Licensing concept, or some iteration thereof, we can lock in a benign, registration-based regime that mirrors the payload review process creating a regulatory environment that will encourage entrepreneurialism and maintain America's ability to compete in a lucrative and important commercial arena. Conversely, if we continue to do nothing, which is what we have done for the past several years, leaving the issue unaddressed, we run the risk of a future Administration interpreting "continuing supervision" in a much more aggressive manner, leading to a regulatory regime that, like in the case of poorly executed export controls, harms both America's economy and its national security by sending jobs and industrial capacity overseas to foreign competition.

I urge this Subcommittee to learn from history and to act with authority and alacrity, because what we are dealing with here are not simply regulatory issues the resolution of which will benefit the private sector, but what we are really talking about is no less than the future of American competitiveness as well as the security and economic vitality of this nation. In addition to serving as COMSTAC Chair I also recently joined Space Systems Loral ("SSL"), the world's most prolific commercial satellite manufacturer, as a Vice President of Washington Operations. Part of what drove my decision to join SSL is the unprecedented transformation that the satellite world is undergoing. We are at the very beginning of what I would call Satellite 2.0, wherein satellites are no longer constructed on the ground, launched, and then disposed of after ten to fifteen years, but instead are serviced, restored, and refueled in orbit by robotic systems, or actually assembled, manufactured, or even deployed from a space station.

We are on the cusp of a new era of commercial space transportation systems that will support next generation satellite capabilities which will transform our daily lives. Imagine a day when you can download hundreds of hours of video in a single moment, or the ability of every American to leverage personal satellite services for imagery data or tracking, or bringing robust Internet and remote learning capability to the U.S.'s most rural and in many cases impoverished locations - all of this can and will be possible. However, like any technological advance, the capabilities born out of a new era of satellite servicing, orbital assembly, and manufacturing can be used for both civil and military purposes. We cannot even begin to guess what the advances and benefits in capabilities that this new era of satellite servicing will bring. What I can assure the Subcommittee is that the companies and countries that are able to deploy and implement these technologies will be the economic and military leaders of tomorrow. Therefore, I would urge members of this Subcommittee not only to expeditiously address the regulatory issues such as Mission Licensing that stand before us, but to keep these capabilities in mind when addressing national security policy and funding for NASA's activities.

Currently, the Defense Advanced Research Projects Agency ("DARPA"), which has always been a stalwart for supporting American national security through industrial innovation, is

moving forward with the Robotic Services for Geosynchronous Services ("RSGS") program. Similarly, NASA Goddard is attempting to spur satellite servicing capabilities via the Restore-L program. However, two relatively small and limited government programs are not nearly enough. There is far too much at stake economically and militarily to ignore this critical capability. The lackadaisical course that this country is currently on risks the U.S. falling behind foreign capabilities, resulting in an inevitable blow to U.S. national security and the loss of a vital new field of industrial endeavor to overseas competition. More focus, funding, and support is needed in this area, and we ignore the Satellite 2.0 revolution at our peril.

Given what is at stake, the least the government can do is create a regulatory environment that is conducive to private sector investment and development. Both DARPA's RSGS initiative and NASA's Restore-L are designed to create different types of private sector satellite servicing capabilities. What Congress needs to do to ensure the success of the transition of these capabilities from government pathfinder programs to actual private sector industrial capacity, is to create certainty and safety via the Mission Licensing process. It's vital that we bring American commercial capabilities to bear not only to create jobs and enhance American competitiveness but to bolster American national security. Private sector companies and capabilities will result in dramatic savings for the government customer. Speaking for SSL, we recently submitted a bid for the Restore-L program that I'm sure will draw attention due its low cost. However, companies such as SSL, that operate in an extraordinarily competitive global marketplace, have by necessity learned to deliver quality products on schedule and in an affordable fashion. If Congress fails to take action and does not address the need for Mission Licensing or a similar regime, the ability of commercial space companies to bring private sector efficiencies to bear in the vital arena of satellite servicing could be substantially delayed, crippled, or fail to manifest entirely. Again, I urge Congress to address the regulatory issue at hand and to bolster funding and support for satellite servicing initiatives and capabilities.

II. FAA AST Funding

Whether it's issuing Mission Licenses, launch licenses, or conducting payload reviews, the FAA AST has a great deal on its plate. The commercial space industry is growing and evolving at a prodigious rate, far outstripping the relatively meager funding and staffing levels of the FAA AST. At nearly every meeting of the COMSTAC we have recommended increased funding for the AST. Trade associations such as the Commercial Spaceflight Federation have adopted similar positions.

I cannot think of another example of industry regularly and uniformly advocating for increased funding of a regulatory agency. This is a testament to the leadership and vision of Dr. Nield, and the high regard that he and his staff are held in. Additionally, safety is the guiding principle of the commercial space transportation industry and the FAA AST has a vital and unique role to play in guaranteeing the safety of the uninvolved public.

Since 2006, the number of launch and reentry operations overseen by the FAA AST has increased by 200%, rising from 7 in FY 2006 to 22 in FY 2014. Similarly, authorizations issued by the AST rose from 2 in FY 2006 to a total of 11 in FY 2014. Inspections performed to ensure

safety compliance at the AST has increased 725%, from a mere 27 inspections in FY 2006 to 223 in FY 2014. Several mishap investigations have also absorbed a significant amount of the AST's time and attention.

In stark contrast to the massive increased demand on FAA AST personnel and resources, AST staffing levels have only increased by a mere 42%, from 57 in FY 2006 to 81 in FY 2014. Not only will the amount of commercial space transportation activities continue to grow, but the pace of that growth is also increasing. FAA AST is facing a critical shortage of resources and personnel. In my opinion, we are on the verge of reaching a point where there simply aren't enough bodies at the FAA AST to deal with the number and diversity of activities that are occurring in the burgeoning domestic commercial space transportation field.

What is already a dire situation is only going to get worse and the impact of insufficient FAA AST funding could stall the progress of the American commercial space transportation industry, benefiting international competition and potentially sending some domestic operators overseas. Lack of funding for the FAA AST may become a choke point that could strangle the nascent commercial space transportation industry in its crib. I would therefore like to take a moment to thank Congressman Jim Bridenstine and Congressman Derek Kilmer for their bipartisan efforts to address this issue. Through the work of Congressman Bridenstine and Kilmer, the FAA AST is on track in the House to at least receive $19.8 million in FY 2017, matching funding levels in the Senate's appropriations bill and the Presidential Budget Request.

However, much more will need to be done in the future, and here again I commend Congressman Bridenstine's work and I hope that the members of this Subcommittee and the Congress as a whole will support a funding profile for the FAA AST that follows the recommendations of the Congressman's American Space Renaissance Act ("ASRA"). Beyond implementing a realistic funding profile for the FAA AST, the ASRA contains numerous other provisions related to the AST and its oversight of commercial space transportation, such as addressing the troubling situation we face today, wherein the Department of Defense has been placed in the role of playing 'traffic cop' for commercial space, providing the private sector with information about potential conjunctions in orbit, a responsibility that should be transferred to the AST.

In conclusion, I want to again thank Chairman LoBiondo, Ranking Member Larsen, members of the Subcommittee, and the Subcommittee staff. The Aviation Subcommittee has a critical role to play in this arena, and just holding this hearing has presented an invaluable opportunity to discuss critical issues and actions. The COMSTAC looks forward to interacting on a more regular basis with this Subcommittee and its staff, and hopes that this hearing is just the beginning of our work together. If Congress can address the regulatory concerns described in this testimony it will bolster American competitiveness, enhance the domestic economy, and support national security. I urge Congress to take action, allowing space entrepreneurs to focus less on lawyers and more on launches.

FAA Oversight of Commercial Space Transportation
Statement of Michael Lopez-Alegria
Vice Chairman, COMSTAC

INTRODUCTION

I was introduced to commercial spaceflight in 2006 when I flew to the International Space Station (ISS) aboard the Russian Soyuz TMA-9 capsule with spaceflight participant (SFP) Anousheh Ansari, a wealthy Iranian-born American businesswoman. Although initially I was not particularly in favor of "tourists" visiting an orbital laboratory that was still under construction, my opinion of Ms. Ansari in particular, and of the concept of the democratization of access to space in general, changed dramatically during the time we spent on orbit together. When I decided to leave NASA a few years later I eagerly accepted the position of President of the Commercial Spaceflight Federation, an industry group of companies working to make commercial human spaceflight a reality. I am a staunch advocate of the commercial spaceflight industry.

Although I have been asked to present testimony as the Vice Chairman of the Commercial Space Transportation Advisory Committee (COMSTAC), the thoughts and opinions reflected in my statement are my own and not those of any particular government or commercial entity.

STATE OF THE INDUSTRY

Commercial spaceflight is still in its infancy but there is no doubt that it's growing up fast. What was once the domain of only nation state governments is now a small but dynamic industry where entrepreneurship, innovation and efficiency are leveraging the advantages brought about by the advent of Computer Aided Technologies (CAX) to make business cases close and unleash the competitive forces of free markets to democratize access to space.

Next year will mark the 60th anniversary of the launch of Sputnik by the Soviet Union. Although the first few years thereafter certainly produced rapid gains in the development of rocket technology, the last several years stand out as being perhaps equally dramatic in the advancement of launch vehicle design, manufacturing and operations. Computer aided design and manufacturing, combined with modern techniques such as friction stir welding, 3D printing and other additive manufacturing processes, have made building rocket motors and the stages that hold them significantly simpler and more reliable. Ever higher-speed computer processors have allowed vast improvements in the accuracy of guidance, navigation and control systems. The explosion in the demand for small satellite launch services to low Earth orbit (LEO), combined with consistent requirement for larger payloads to geostationary altitudes, has created robust competition among potential launch providers that continues to push technological advances, such as the potential reusability of first stages that has been repeatedly demonstrated by two different companies. Finally, commercial launches on U.S. rockets, which had all but disappeared a decade ago, have again become commonplace. This trend is positive not only for commerce, but also represents redundancy of an important national strategic capability.

In the world of commercial *human* spaceflight, there is an array of possibilities for potential SFPs. At least two companies are developing the use of stratospheric balloons to take passengers to the edge of space, where the sky turns nearly black and the curvature of the Earth is clearly visible. Several other enterprises are contemplating taking their clients to the von Kármán line, 100 kilometers above the Earth's surface – commonly acknowledged as the boundary of space – and back to their point of departure. And yet others intend to carry crewmembers to orbital destinations. The first will be government astronauts to the ISS in LEO as part of NASA's Commercial Crew Program. This unique development effort follows on the footsteps of the revolutionary Commercial Orbital Transportation Services program, in which two private companies designed, built and demonstrated launch vehicles and spacecraft with far less NASA guidance and oversight than is typical of traditional development programs, and are now regularly delivering cargo to the ISS. The commercial crew program not only restores the key strategic national capability of launching humans to orbit – absent since the retirement of the Space Shuttle – it also frees NASA from paying Russia close to half a billion dollars annually to provide that service.

And far beyond LEO, several companies are in the early stages of developing the capability to extract resources from celestial bodies. One such possibility involves removing water ice – prevalent both on the Moon and in certain asteroids – and converting it into its constituents of oxygen and hydrogen. The former has obvious benefits to space-based life support systems, and the latter is the most efficient of any known rocket propellant. Current estimates of the cost of launching one kilogram of anything from the Earth to orbit are in the neighborhood of $50,000 to $100,000; it's easy to see why harvesting these resources from somewhere already in space, thus avoiding the cost of launching them, would be an attractive line of business.

Finally, back on Earth, there is a growing number of spaceports that serve as the ground-based operational infrastructure for the launches – and, in some cases, landings – of some of the vehicles mentioned above.

FAA OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION

The Federal Aviation Administration (FAA)'s Office of Commercial Space Transportation (AST) is the Secretary of Transportation's designee to oversee and coordinate commercial launch and reentry operations, as called out in the Commercial Space Launch Act (CSLA) of 1984. Its mission is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.

The CSLA was amended in 2004, known as the Commercial Space Launch Amendments Act (CSLAA), and several important phrases were added. One is ". . . the regulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew or space flight participants to avoidable risks as the public comes to expect greater safety for crew and space flight participants from the industry." This concept is fundamental to the success of the industry – striking the balance that allows the industry to innovate and solve thorny technical problems while keeping occupants safe from avoidable risks. The simple fact is that not enough is known about how to solve problems related

to spaceflight to prescribe solutions via regulation. While we have the considerable experience and knowledge of NASA on which to draw, their solutions were products of the circumstances and technology of the day, may not have been driven by cost-effectiveness or practicality, and so by no means should be considered the only answers to these problems. As legislated in the CSLAA, the Secretary (and AST as his designee) may only issue regulations governing the design or operation of a launch vehicle to protect the health and safety of vehicle occupants in the event of a serious or fatal injury to crew or SFPs, or an unplanned event or series of events that posed a high risk of causing such an injury, during a licensed or permitted commercial human spaceflight. This so-called "moratorium" or "learning period" had an initial duration of eight years, has been extended twice, and, with the passage of the Commercial Space Launch Competitiveness Act of 2015, will expire in 2023. Clearly, the industry has not progressed at the rate envisioned by those who crafted the CSLAA. But the concept of delaying regulation until sufficient experience – and therefore data on which to base regulatory decisions – is gained, is no less valid today than it was in 2004. It is also important to emphasize that while AST may not yet regulate occupant safety, they may – and do – issue regulations to protect uninvolved public and property.

While commercial aviation operates on the basis of certification, commercial space uses the principle of licensing. AST issues licenses for launch and/or reentry vehicles (either for single events or for operators that plan to perform multiple launches and/or reentries of the same or similar type. This mean that the U.S. Government (USG) makes no claim to certify the vehicle or its operation is safe for the occupants, and those who fly in them do so at their own risk. Instead of this government-backed certification, the crew and SFPs fly under informed consent. This intent is clear in the CSLAA, which recognizes that in the absence of a framework that allows the regulation of occupant safety, it would be inappropriate for the USG to certify the vehicle as safe for occupants. The licensing process does, however, take into account health and safety of uninvolved public as well as safety of property. AST also issues licenses for launch site operators (spaceports), experimental permits for reusable suborbital rockets that are not being flown for compensation or hire, and safety approvals for commercial launch operations.

An important thrust of the CSLAA was to designate one USG agency as a single point of contact for potential licensees. But although operators interface primarily with AST, there is significant intra- and inter-agency coordination that must be accomplished. An interagency review is held to determine whether a license application presents any issues affecting U.S. national security or foreign policy interests, or international obligations. Intra-agency coordination is required, for example, with the FAA's Air Traffic Organization (ATO) to determine airspace clearance requirements and feasibility for launches and reentries.

CHALLENGES AND OPPORTUNITIES

Safety

The fact that the occupant safety is not yet regulated in commercial spaceflight does not mean that it's not safe. Companies have every incentive to maximize safety – nothing is bad for business like a fatal accident. But it's reasonable for the USG to want something more than profit motive to protect its citizenry. There are many examples of activities – i.e., scuba diving, sport parachuting

– that are likewise not regulated externally, but rather demonstrate safety through self-regulation. It is therefore incumbent on the commercial space industry to likewise show its commitment to a robust safety culture; one way is through the adoption of standards and recommended practices.

Voluntary consensus standards that meet certain criteria can be used as the basis for regulation in accordance with Office of Management and Budget (OMB) Circular A-119. The commercial spaceflight industry, through its trade association, the Commercial Spaceflight Federation (CSF), is in early stages of producing such standards. There are significant challenges, including scarce resources, a great diversity of vehicles and operations, and lack of guidance from the FAA on the priorities.

Many of the companies involved in developing launch systems for commercial human spaceflight are small and lean. Dispatching one of a handful of engineers to work on developing a standard may be inappropriate. There is also a high degree of competition between these companies; they may be reluctant to participate in open discussions of their operations for fear of revealing the "secret sauce" of their technology.

As opposed to the recent successful example of how standards were used to in the regulation of Light Sport Aircraft, there is a huge variety of vehicle characteristics that are part of commercial spaceflight. Some take off vertically, others horizontally. Some are orbital, some suborbital. Some travel at Mach 25, others drift with the wind. These differences make "industry consensus" standards a difficult proposition.

Finally, industry has long looked to AST for guidance as to what areas, were the "learning period" or "moratorium" lifted, they would address first in the early stages of rulemaking. Unfortunately, it has been their interpretation of the law that any such information could be considered a violation of the moratorium. AST has, however, produced their "Recommended Practices for Human Space Flight Occupant Safety." This document provides 89 primarily performance-based recommended practices regarding human spaceflight on suborbital and orbital launch and reentry vehicles in the categories of design, manufacturing, and operations. The CSF has asked ASTM International, a globally-recognized standards development organization, to establish a commercial spaceflight committee. The activities of this committee will include not only drafting standards in compliance with OMB Circular A-119, but also defining a roadmap for development of standards and recommended practices. It is expected that this roadmap will draw heavily on the work represented in AST's Recommended Practices document. AST has indicated its willingness to participate in both of these activities.

Integration into the National Airspace System

At the current pace of launch and reentry operations, the existing system of coordination between operators, the Federal ranges from where some launches originate, and AST and ATO within the FAA, seems adequate. But it is hoped that the pace will increase dramatically over the next several years. Suborbital reusable launch vehicle operators are hoping to fly up to several times per day, and the aforementioned boom in the small satellite launch demand will see many more vehicles flying to orbit than do so now. The fundamental challenge is, and will continue to be, to reduce

the size of the footprint of the launch or reentry activity on the NAS, both in spatial and temporal dimensions.

The medium term outlook is relatively positive. Today, airspace is cleared and air traffic rerouted using prelaunch trajectory analysis, debris models with very conservative assumptions, and infrastructure whose technology was simply not intended for this use. Rather than using real-time information regarding the actual trajectory of a launch vehicle, a predicted path that includes significant dispersions for performance and environmental effects is used, unnecessarily enlarging the ascent footprint. The technology used to deconflict air and space traffic today – from the tracking of vehicles to the communication methods between various players – was designed for managing air traffic only. Hardware and software improvements are in development that will greatly ameliorate this situation. Orbital launch vehicles pass through the NAS rather quickly and almost vertically, but airspace below the ensuing flight path even once well out of the atmosphere must also be cleared to prevent debris from a possible destructive event from falling on air traffic below. The modeling of such potential damage is considered quite conservative, and could be updated.

Most air traffic today, including virtually all commercial airplanes, is tracked by secondary surveillance radar. Beacons aboard these aircraft are used to better indicate their position, as well as provide limited altitude information and identification. These systems are simply not fast enough to follow space vehicles during ascent or a reentry. As a result, ATO operators are forced to operate "open loop," knowing only when a launch is planned to occur, and where the launch vehicle is predicted to go. With that level of uncertainty, it is prudent to add significant margin to the predicted geographic footprint outside of which it is necessary to keep air traffic. And without having real-time information about launch and entry event timing, airspace is often closed artificially early and reopened much later than necessary. Yet most launch operators have, either through onboard systems, specialized ground-based radars at Federal ranges, or both, much more accurate data about the position and velocity (state vector) of their vehicles. A platform called Space Data Integrator (SDI), currently under development by AST in close cooperation with ATO, will gather this information from the launch operator or range, and synthesize it into a format useful to ATO operators. This will greatly reduce the artificially large volume of affected airspace, and unnecessarily long periods of rerouting air traffic. A further enhancement to tracking capability may come with Automatic Dependent Surveillance – Broadcast (ADS-B) technology that could be specified for use on launch and entry vehicles.

Reducing the uncertainty around the state vector of these vehicles only partially solves the problem. It is likewise imperative that ATO operators be afforded tools that could properly display this information. Today they are notified of a launch via email or a phone call. In an ideal world, software would deliver real-time SDI information on launch and reentry events seamlessly to the operators, minimizing the impact to air traffic.

The path below a launch vehicle that is already well out of the atmosphere is likewise problematic. A model is used to predict possible damage to air traffic below from debris resulting from a destructive event, and airspace below the rocket's trajectory is cleared accordingly (with the same geographic and temporal conservatism noted previously). The breakup of the Space Shuttle Columbia in 2003 caused debris to fall over a huge swath of the continental United States, with no

attempt to divert air traffic before reentry or during the event. Applying today's model to that scenario reveals a very high likelihood of significant damage to air traffic, yet in reality there were zero reports of impact of any kind. This is a strong indicator that the model should be revised. Because of the necessary open loop nature of today's airspace management surrounding launch and reentry events, consideration is not given to the time it would actually take for debris to fall from significant altitudes before potentially impacting air traffic. The updated model should include this consideration, and all of this data should be included with the SDI data presented to ATO operators. In an ideal world, it may even be possible to have an automated system alert the pilots of aircraft to make an immediate deviation to avoid potential debris via cockpit indications rather than having to be voiced over Air Traffic Control frequencies, further reducing reaction time and thus minimizing impact to air traffic.

The much longer term view is a bit less optimistic. If the commercial space industry continues to grow, sooner or later the sheer volume of launch and reentry traffic will outstrip the ability of technology to keep pace, and potential conflicts of air and space traffic will have to be adjudicated. This occurs today within the commercial aviation industry among air carriers. A process called Collaborative Decision Making is used to assign priorities for hubs, routes and in more tactical situations that arise when demand of air traffic exceeds the supply of resources due to outages, weather or temporary interest in a particular destination (often related to high-profile sporting events). A similar process will ultimately be required to help referee between commercial airlines and commercial space companies, all of which are businesses competing to maximize their profits, and whose profits depend on use of a limited resource.

Space Traffic Management

Once a space vehicle is out of the NAS and in orbit, it may be tempting to think of space traffic management as an extension of air traffic control. It is not. The equipment, skills and decision processes are as different as the speeds and maneuverability of their constituent traffic. Currently the Department of Defense (DoD) through the Joint Space Operations Center (JSpOC) performs this function, although not to the degree that some think will be necessary in view of the burgeoning number of objects orbiting the Earth. This includes tracking orbital objects and providing conjunction analysis and, when appropriate, notification to government and civilian satellite operators of the need to maneuver to avoid an impending collision.

The resources required to perform this task logically increase with the number of objects to be tracked. As commercial remote sensing and communication small satellites add significantly to those numbers, it is appropriate to ask whether DoD and JSpoC should continue to be saddled with this responsibility. Their priority is, and should remain, to protect national assets in space; as it becomes more challenging to do so, it is predictable that their ability to perform secondary tasks, such as notification of conjunctions, will diminish.

Should the FAA – or another civil agency – be given the task? Or should it be giving to a commercial entity? There are very specific capabilities and methods that DoD uses to track orbital objects. It may not be in the national interest to provide those capabilities to non-military organizations, nor to reveal their precision. At the very least the DoD should maintain its own Space Situational Awareness (SSA) using its unique hardware and software assets. Some

combination of sanitized data from these assets, voluntarily provided user data such as those available through the Space Data Association, and information from commercial solutions that may complement the DoD's resources, should be synthesized to provide both SSA and conjunction notification. Only after bona fide proposals emerge – whether from the civil government or private sector – on implementation of this process will it be appropriate to judge which organization is best suited to execute this function.

Space Support Vehicles

For several decades NASA has operated a fleet of high performance T-38 Talon aircraft to support Space Flight Readiness Training (SFRT) for its astronauts. Since the hiring of the first class of Space Shuttle astronauts in 1978, the demographics of the corps changed from all male, military test pilots to scientists, engineers and even medical doctors with backgrounds in aviation that varied from combat veterans to none. SFRT has proved to be an invaluable tool in adapting those with less flying experience to the rigors of operational spaceflight. Exposure to physiological stressors, wearing unfamiliar gear such as a helmet, oxygen mask and other equipment, having to make quick decisions with real consequences, and using the concept of Cockpit Resource Management (CRM) to work as a team in high performance military aircraft all combine to make SFRT a key ingredient in preparing non-aviators for spaceflight.

While SFPs on commercial suborbital flights will not be expected to perform duties as a crewmember, exposure to an experience similar to NASA's SFRT will go a long way toward providing familiarity with the physiological sensations that will be experienced, and will therefore significantly reduce the risk of the occurrence of a potentially safety-compromising outcome in spaceflight. Likewise, such a training experience could be used as an entry-level and much less expensive trial to help inform a decision on pursuing a suborbital flight. For this reason, several companies are interested in pursuing the training of SFPs in high performance military aircraft. These airplanes generally fly under a special airworthiness certificate in the experimental category, often called experimental airworthiness certificate or EAC, issued by the FAA's Aviation Safety organization AVS. Under 14 CFR 91.319, an airplane that operates under an EAC may not carry persons for compensation or hire. Unfortunately, high performance military aircraft are the only airborne platforms capable of the dynamic flight regimes necessary to give an SFP the requisite experience for SFRT. But it is effectively impossible to issue a type certificate for these aircraft, and so they must fly under an EAC.

Three items should be evaluated in deciding whether to allow these airplanes to fly for compensation. The first is a legitimate tie to commercial spaceflight. The Secretary's responsibility to "encourage, facilitate and promote" commercial spaceflight should include considering activities that, while may not involve actually flying to space, are materially associated with advancing the industry, particularly as regards continually improving its safety. One way to do this would be for AST to perform a review of an operator's proposed syllabus to verify that its contents in fact provide for reduction in risk of the SFPs having an unknown and unwelcome experience during actual spaceflight.

The second and third matters to be assessed are the pedigree of the pilots and the maintenance condition of the aircraft. AVS has tools in place to accomplish both of these tasks. Under the

Vintage & Experimental Aircraft Pilot in Command program, pilots must have aircraft authorizations on their pilot certificate (similar to a type rating). Similarly, annual condition inspections must be performed on aircraft that fly under an EAC.

Legislative authority could be granted to operators and aircraft meeting these criteria in a number of ways. One is that AST could be given authority to issue a license, similar to a launch operator or launch site. Crew and SFP would comply with informed consent requirements, along with many of the other stipulations currently in law regarding spaceflight. Another would be to establish a new type of special airworthiness certificate in the experimental category, or to modify the existing "crew training" purpose to include training of SFPs. Either would be a step toward reducing risk and promoting safety.

CONCLUSION

Commercial space is the only mode of transportation that can't get to its medium without going through that of a different mode – aviation and the NAS. It is imperative that the strong cooperative relationship that exists between the various lines of business within the FAA continue as the frequency of interactions of their constituents increases. As the commercial space sector grows in size and importance, expansion of AST is inevitable. Swelling demand for licenses, permits, safety reviews and other functions will drive a need to likewise increase its resources. Additionally, other responsibilities, such as eventual regulation of occupant safety, integration of commercial space traffic into the NAS, and potentially space traffic management and oversight of space support vehicles like high performance military aircraft, whether within AST or distributed elsewhere in the FAA, will continue to demand increased consideration. The passage of the CSLAA of 2004 was a watershed event for the commercial spaceflight. The FAA should capitalize on the considerable head start given to it by the Congress, and continue to lean forward as the industry grows and matures.

Testimony of Taber MacCallum, Chief Technology Officer, World View Enterprises

on

FAA Oversight of Commercial Space Transportation

before the Subcommittee on Aviation

Committee on Transportation and Infrastructure

U.S. House of Representatives

June 22nd, 2016

Chairman LoBiondo, Ranking Member Larsen, and Members of the Subcommittee:

FAA's oversight, regulation and promotion of Commercial Space Transportation has fostered a strong and growing American industry. The human spaceflight regulations that govern large segments of our industry are currently temporary and should be made permanent. This impermanence and subsequent uncertainty is one of the largest factors influencing the future success of our industry. Additionally, the industry's growth will require the FAA to seamlessly incorporate routine commercial space operations into the National Airspace System, without which we run the risk of conflict between airports, airlines and the commercial space industry. I will explain three actions that this subcommittee can take to continue to foster the commercial space industry and protect the public's interests.

First, some background. I am a founder and the CTO of World View Enterprises. Our Arizona based company is the operator of Spaceport Tucson, and is developing and operating balloon based vehicles working at the edge of space. Like an ice cube floating on water, our vehicles float on top of earth's atmosphere. Our vehicles have made numerous flights to high altitudes for research and we are the world record holders for human flight under a balloon, flying to 136,000 feet.

Here is Virgin Galactic's Spaceship One aircraft plus rocket system designed to take spaceflight participants to the edge of space on a suborbital rocket ride. Blue Origin's New Shepard rocket system uses a vertical take-off approach to provide participants with a spaceflight experience. The World View Voyager capsule will ascend to the edge of space under a large balloon, shown here.

All three of these companies' human spaceflight operations are regulated by the FAA Office of Commercial Space Transportation, with whom we have worked for many years. I am happy to say that the FAA Associate Administrator responsible for this office, Dr. Nield, runs a truly great organization.

Thank you for the opportunity to convey an industry perspective on FAA oversight of commercial spaceflight.

Spaceflight operations involving humans, called spaceflight participants, are regulated under a regime based on the participants being informed of the risks, and formally consenting to them. The regulations provide extensive protection of the uninvolved public, protection of property, and safe integration into the National Airspace System.

This informed consent regime ingeniously fosters innovation, technology development and investment by creating a market for tourists, researchers and astronauts to fly in space. This is like other tourism or sporting activities such as sky diving, paragliding and scuba diving, that involve informed consent, wavers and releases. Members of the public have the right and freedom to voluntarily engage in activities where they believe the benefits outweigh the informed risks.

However, unlike skydiving, the regime for human spaceflight operations is temporary. Called the *learning period,* it is subject to extension by congress, and under certain conditions all or part of this informed consent regime can be ended by the FAA. The idea behind the learning period was that a time will come when the entire commercial human spaceflight industry should be transitioned to a regime in which the safety of a spaceflight participant is regulated.

The informed consent regulatory regime is creating an industry and should not be subject to termination.

At the same time there is a desire and long standing vision to see the commercial space industry evolve into routine operations with the success and safety of the commercial airline industry.

I believe that the best solution is for two regulatory regimes to permanently exist in parallel - the existing informed consent regulatory regime or License, and a new Extended License, a regulatory regime that includes spaceflight participant safety.

An Extended License would be required for operations that constitute common carriage under Federal Aviation Regulations. For example, Virgin Galactic would offer regular one-hour service from New York to Sydney under an Extended License.

For services whose destination is space itself, common carriage does not apply and the current License protecting the public, property, and the national airspace is appropriate. Voluntarily garnering an Extended License for such activities would confer a great competitive advantage to operators.

It is in the government's interest to maintain our country's leadership in aerospace by creating a stable yet flexible regulatory system. I encourage Congress to take the lead in this area with three actions: First make the informed consent License permanent; Second direct the FAA to develop an Extended License to include participant safety; and Third, make it a high priority for the FAA to seamlessly incorporate routine commercial space operations into the National Airspace System.

Thank you.

Rick Larsen

STATEMENT BY VULCAN AEROSPACE CORPORATION

BEFORE

THE HOUSE TRANSPORTATION AND INFRASTRUCTURE COMMITTEE

SUBCOMMITTEE ON AVIATION

ON

FAA OVERSIGHT OF COMMERCIAL SPACE TRANSPORTATION

JUNE 22, 2016

Chairman LoBiondo, Ranking Member Larsen, and members of the House Transportation and Infrastructure Aviation Subcommittee:

Vulcan Aerospace Corporation greatly appreciates the opportunity to submit a written statement before your Committee in support of today's important hearing to discuss commercial space transportation opportunities for our nation.

Vulcan Inc. was founded in 1986 by Paul Allen and Jody Allen with the mission to find effective solutions for some of the world's toughest challenges – including improved access to space. Paul Allen believes convenient space access will yield transformative benefits for entrepreneurs and improve life here on Earth. In that spirit, Vulcan Aerospace Corporation is the company within Vulcan Inc. that plans and executes projects to change how the world conceptualizes space travel through cost reduction and on-demand access. Vulcan Aerospace also oversees Stratolaunch Systems and collaborates across Vulcan Inc. on projects dealing with space access and space commercialization.

Paul Allen and Vulcan played a key role in forging the new commercial space transportation industry with the investment in SpaceShipOne – widely considered one of the greatest breakthrough efforts in the space industry and winner of the Ansari X-Prize in 2004. The back-to-back suborbital flights of SpaceShipOne not only demonstrated that spaceflight can be achieved by private entities, but that it can be done differently. Today, SpaceShipOne is proudly

displayed in the Milestones of Flight exhibit of the Smithsonian Air and Space Museum, alongside the Spirit of St Louis and Chuck Yeager's Bell X-1.

The success of SpaceShipOne was followed by the emergence of entrepreneurial and private space companies that are now considered serious system providers within the industry. Even before SpaceShipOne, other trailblazers including Pacific American Launch Systems, Space Services Inc. of America, Orbital Sciences, Microcosm and Kistler Aerospace advocated the importance of commercial launch for space access. More recently, companies like Virgin Galactic, SpaceX and Blue Origin have made great strides in the same spirit, establishing commercial space transportation infrastructure as a transformational engine of change for the entire space industry.

Vulcan Aerospace is evolving a capability that breaks from the established terrestrial launch paradigm to a convenient, flexible and less expensive model. Vulcan Aerospace's Stratolaunch plane is an air-launch system capable of transporting payloads to low Earth orbit, with a carrier aircraft acting as a mobile launch range. This innovative new architecture will expand mission and operational flexibility for a wide variety of payloads by decoupling launch service from dependence on traditional ground launch ranges and the logistics infrastructure that complicates scheduling and launch from those fixed facilities. Currently, choices are limited for ranges capable of supporting orbital launches –

and those ranges are largely operated through government entities. Locations of launch pads and support equipment are fixed, wait times are long, delays and scrubs are common and revenue streams are routinely interrupted – burdens that government launch entities may be willing to bear, but that can be deal-breakers for commercial – especially fledgling commercial – entities. Regardless of advancements in launch vehicle systems, range and operational infrastructure is often the bottleneck in space access. The system is designed to reduce wait times with reliable and frequent launch operations, and decrease total launch costs through flexibility and customization options for customers requiring highly responsive launch in either time or inclination.

Vulcan Aerospace is focused on increasing the rate, accessibility and convenience of space launch to enable future manufacturing in space. This is the key to increasing the utilization of space and will be the next seminal enabling development for space transportation and exploration. Vulcan Aerospace calls this vision for the economic development of lower-Earth orbit "NextSpace", and believes this is reasonably attainable within the next 20 years.

The current structure of the mainstream space transportation industry remains one of the last remnants of the Cold War economy. Not coincidently, the current high cost of government-dominated U.S. launch services led to the near complete loss of commercial launch sales throughout the 1990s and 2000s. In

many ways, space launch technology and infrastructure have changed little since the early days of the U.S. space age, allowing other countries to reach technical parity and provide services at more competitive prices.

As the commercial satellite market grows rapidly with newly proposed disaggregated architectures, launch is quickly becoming the bottleneck for industry growth. SpaceX is making huge strides reducing launch costs, with a profound impact on the industry. Reusability will drive costs down further. If the launch problems are solved and launch costs get low enough (under $1000/kg), another exciting chapter in the evolution of space will be opened.

The focus on achieving responsive and affordable space transportation has increased significantly as demand from emerging commercial space markets puts pressure on launch companies to overcome launch inefficiencies. Some government entities – like the Air Force's Operationally Responsive Space (ORS) office – have been at the forefront of these efforts, and programs like DARPA's, recently canceled ALASA and XS-1 are motivated by similar needs. Trying to satisfy the entire spectrum of being "responsive" and "affordable" can be very challenging, and the ultimate success of these government programs has yet to be determined. Providing convenient and reliable access to space is perhaps one of this century's greatest challenges. Success in the field will expand the economic potential of the high frontier and transport humanity beyond Earth.

Looking at how other innovative industries have evolved helps to understand and predict how the space industry could change in the near future. Consider the evolution of the digital computer from large mainframes, to personal computers, to mobile computing. At each step computing became increasingly democratized, with growing numbers of people accessing the latest technology. The space business appears to be heading down this path, with more companies developing small satellites and a new push toward cheaper launches.

During the last year, our nation and indeed the world has been amazed to see U.S. companies launch payloads into space and then vertically land the main sections of a launch vehicle in order to reuse it. We have also witnessed a concurrent revolution in small satellites, microsats, and "cubesats" that are being embraced by private companies such as PlanetLab and OneWeb to provide improved services for their customers.

In the next few years, we are going see another revolution when multiple, low-cost, flexible commercial launch companies come on line. Companies such as Rocket Labs, Virgin Galactic, Firefly, and Vulcan Aerospace will all be launching rockets. Commercial satellite companies such as Blacksky, PlanetiQ, Hawkeye 360, One Web and many others will be launching satellites in record numbers.

Vulcan Aerospace is pushing to drive down prices, and radically improve the convenience and reduce the cost of getting to space. We are proud to be part of

the State of Washington's newly developing space industry that includes Spaceflight Industries, Tethers Unlimited, Blue Origin, Space X, and numerous smaller suppliers. We strongly support the FAA's Office of Commercial Space Transportation and its key role in fostering the U.S. space launch industry – we want these efforts to be successful so that we and others in our industry can be successful.

We also strongly encourage the Committee and the Congress to ensure that FAA's Office of Commercial Space Transportation will be provided the increased financial and personnel resources the need in the next few years as the activity in the commercial space industry expands and blossoms.

Although they are not under the jurisdiction of the Department of Transportation, there are two issues in other government agencies of interest to your Committee that are relevant to the emerging paradigm shift in commercial space launch:

(1) The first is NASA's very successful venture-class launch program which is aimed at facilitating the adoption of small, commercial, novel space launch activities. The Congress should support and expand NASA's program, as well as to require the Department of Defense to have a similar program to address growing space launch needs.

(2) The second is a recent proposal by a single company which seeks legislation to allow the Air Force to sell excess ICBM rocket motors to commercial launch providers. Since these obsolete rocket motors – in storage long after missile decommissioning – use solid fuel they are only of interest to a single company, not to the broader commercial industry. We and others in our industry oppose this proposal, which would damage private investment in new commercial launch vehicles and stifle investment and innovation. We urge your Committee to ensure that long-standing bipartisan legislation on commercial space launch policy and law not be changed just to benefit a single company which wishes to negatively impact the entire commercial launch market using obsolete Cold War technology.

Much like the evolution of the integrated circuit chip enabling transformational changes in the computer industry has altered the course of human history, Vulcan believes that versatile, low-cost access to space will do the same for the expansion of the physical boundaries of humankind. We thank and commend both the Committee and the FAA for your interest and leadership role in facilitating the nation's paradigm shift to modern, innovative, and low cost privately-financed space launch technologies in a fair, open, and competitive manner.

Thank you.

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