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.