STATEMENT OF GEORGE D. ZAMKA (COLONEL, USMC, RET.), DEPUTY ASSOCIATE ADMINISTRATOR FOR COMMERCIAL SPACE TRANSPORTATION OF THE FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY, SUBCOMMITTEE ON SPACE, ON ORBITAL DEBRIS MITIGATION, MAY 9, 2014.

Chairman Palazzo, Ranking Member Edwards, and Distinguished Members of the Subcommittee:

Thank you for inviting me. This is my first opportunity to speak before the Subcommittee, and I am particularly fortunate to be asked to speak on the FAA's efforts regarding orbital debris mitigation, as it is an emerging issue very deserving of discussion. My role as Deputy Associate Administrator for the Office of Commercial Space Transportation places me in a good position to report to our nation on the FAA's role in protecting against orbital debris, and to identify where shortfalls may lie.

Operational Environment

The U.S. commercial space industry is growing, and the space operations in which the industry is engaging are becoming increasingly more complicated. Private industry is increasing activities on orbit for government and commercial customers. SpaceX and Orbital Sciences Corporation have successfully delivered cargo to the International Space Station (ISS). Boeing, Sierra Nevada, and SpaceX are developing new vehicles to carry people to and from the ISS. Bigelow Aerospace has entered into a Space Act Agreement with the National Aeronautics and Space Administration (NASA) to connect its expandable activity module (BEAM) to the ISS. The BEAM will be brought to the ISS

by SpaceX's Dragon, and will join two free-flying Bigelow demonstration habitats already on orbit.

Orbital Debris Environment

This Subcommittee is familiar with the orbital debris environment that consists of defunct satellites, spent rocket bodies, and smaller orbital debris traveling in different directions at different altitudes.

Objects in orbit travel 5-10 times the speed of a bullet, carrying tremendous energy. The kinetic energy released by a collision with such an object in orbit can be more than 10 times the explosive energy of an equivalent mass of TNT. The largest debris objects in orbit today are over a dozen second stages, at about 8.2 tons each. At the other side of the size range are about 8300 tracked objects less than 15 cm in size. If the projected commercial nanosat market materializes, it will further increase the number of small objects in orbit. Regardless of size, all orbital debris carries destructive kinetic energy into any collision.

Because of minimal atmospheric drag in Earth orbit, objects in orbit tend to stay there for a long time. Objects in LEO tend to remain in space on the order of decades, whereas objects in geosynchronous orbit remain in space for thousands of years. A Delta 1 rocket body that launched in July of 1961, did not reenter the atmosphere until this past February. TIROS-2, which was launched in 1960, recently was added to the 60-day

reentry prediction list. Many of us in this room were not even born when that vehicle was launched.

Collisions between orbiting objects can exponentially cause more debris. This domino effect increases the danger and operational difficulties to current and future space stations, satellites, and space-based services. It is estimated that a single 2009 collision between an Iridium communications satellite and a deactivated Russian Kosmos satellite created over 2,000 of the 23,000 tracked objects on orbit.

Using U.S. Space Surveillance Network (SSN) data, NASA has a process for predicting possible collisions between the ISS and orbital debris. The U.S. standard of protecting occupied spacecraft is to maneuver to avoid an object if it is calculated to have a higher than 1:10,000 chance of hitting the asset. The U.S. standard of protecting occupied spacecraft with a 200 km buffer zone provides less than 30 seconds of separation between the ISS and crossing orbital debris. NASA reported that in October 2013, over 800 cataloged objects, including 10 percent spacecraft, one-third rocket bodies, and the rest miscellaneous debris, posed a potential threat to the ISS. This represented a 60 percent increase from the number of tracked objects that were viewed as a potential threat to the ISS in November 1998. Over the life of the ISS, crewmembers have been required to shelter in their Soyuz craft serving as lifeboats three separate times when hazardous debris was detected with too little warning to plan and carry out a debris avoidance maneuver.

FAA Responsibilities and Authority

To best understand the FAA's responsibilities regarding orbital debris, it is helpful to review the operations to which the FAA's authority applies, and where it does not. The FAA is the sole federal government agency with authority to license commercial space transportation activities. That authority is derived from, and limited by, chapter 509 of Title 51 of the United States Code, the Commercial Space Launch Act. This Act provides FAA authority relating to the launch and reentry of a vehicle. The National Space Transportation Policy of 2013 highlights the importance of this FAA authority as it applies to debris mitigation for the transportation activities the FAA authorizes:

> [t]he Secretary of Transportation is responsible for authorizing and providing safety oversight for non-federal launch and reentry operations . . . . In performing these responsibilities, the Secretary of Transportation shall . . . [e]xecute exclusive authority, consistent with existing statutes and executive orders, to address orbital debris mitigation practices for U.S.–licensed commercial launches, to include launch vehicle components such as upper stages, through its licensing procedures.

The National Space Transportation Policy provides regulatory certainty to industry by making clear that only the FAA will address orbital debris mitigation for launch and reentry.

FAA licensing regulations require the operator of a launch vehicle to take measures regarding safety at the end of launch. These regulations may be found at 14 C.F.R. §

417.129 and 431.43, and they apply to launch and reusable launch vehicle components, including upper stages that are left in orbit. Launch operators must ensure that: debris generation does not result from conversion of energy sources that fragments the vehicle or its components; the vehicle does not come in contact with the payload after payload separation; and fuel is vented and other energy sources depleted to reduce risk of explosion. This may include leaving fuel line valves open, leaving batteries in a permanent state of discharge, and removing any other sources of stored energy. Under sections 417.107(e) and 431.43(c) of the regulations, the FAA also imposes operating limitations based on a launch Collision Avoidance Analysis (COLA) to avoid collision with habitable spacecraft such as the ISS. Launch operators must use the results of the collision avoidance analysis to determine acceptable launch windows.

The FAA's ability to mitigate the creation of orbital debris is limited. The FAA currently does not have statutory authority to regulate in-between launch and reentry of a vehicle. The only agencies with any regulatory authority between those two events are the Federal Communications Commission (FCC) for communications satellites and the National Oceanic and Atmospheric Administration (NOAA) for remote sensing satellites. Satellites that operate under FCC or NOAA licenses must address orbital debris mitigation considerations as part of the FCC and NOAA licensing processes.

Accordingly, once SpaceX's Dragon or Orbital Sciences' Cygnus reach orbit and transport cargo to the ISS, they do not have the FAA's regulatory oversight. Because Cygnus does not reenter substantially intact, it does so without FAA licensing. For

Dragon and Cygnus, NASA mandates orbital debris mitigation efforts on-orbit by contract prior to launch for NASA missions. Bigelow's sub-scale model habitats, which were launched from Russia, were not required to have FAA review of the safety issues associated with their operations and maneuvers.

In the execution of orbital debris mitigation responsibility, the FAA interfaces with agencies that have both affected interests and specialized experience. The FAA speaks with FCC and NOAA regularly, but our varying authorities translate into different approaches to orbital safety. Our primary partners in developing effective rules are the Department of Defense (DoD) and NASA. The NASA Orbital Debris Program Office has been a strong partner in the development of FAA rules and is an invaluable resource. The DoD's U.S. Strategic Command provides tracking information and debris detection data used to evaluate the effectiveness of launch debris mitigation practices and processes. The effectiveness of commercial operations from DoD ranges demonstrate the synergy provided by the partnerships in FAA and DoD range safety, experience the FAA is transferring to commercial spaceports.

So what is the issue? One challenge is oversight and enforcement authority over the increasing number of commercial space transportation vehicles that will operate differently from communications or Earth-observing satellites. Some commercial transportation vehicles will carry people and cargo. Some vehicles could carry fuel and conduct maintenance. A servicing vehicle would conduct maneuvers on orbit to perform phasing or other maneuvers as it travelled from satellite to satellite. Although, of course,

no operator wants to contribute to the debris environment, any given operator may lack the information and incentive necessary to act for the common good in a given circumstance. Maneuvers in space cost money, service life, and service coverage. Space transportation operators may weigh preservation of their propellants against their perceived risk of collision in a different manner than an independent observer would. An individual operator will not necessarily be concerned with the big picture. The Department of Defense, through its Joint Space Operations Center (JSpOC), has the only legislative authority and capability to share space situational information, including notifications of impending collisions and near collisions to cooperating space operators, but lacks any enforcement authority.

Orbital Transportation Safety

Earlier this year, Dr. George Nield, the FAA's Associate Administrator for Commercial Space Transportation, testified before this Subcommittee that it is time to consider closing the regulatory and safety gap between launch and reentry. As Congress explores the issue of orbital debris and transportation hazards, the FAA urges the Subcommittee to consider at least two possible options, separately or in combination. First, it should look to whether a regulatory agency should authorize transportation on orbit by license. In that scenario, an agency with the proper expertise would, as part of a license evaluation, review the operator's plans and mitigation measures in advance of operations. In a second scenario that may require additional discussion, we should look to the benefits of an agency with enforcement authority providing notices regarding impending hazards and

collisions. An agency with enforcement authority could ensure that maneuvers were carried out.

The United States Government, through the FAA, protects the public and property from the hazards of launches and reentries. Similarly, closing the regulatory and safety gap would help protect all space operators from the hazards of additional debris as the result of orbital collisions, and would ensure that all U.S. commercial space transportation vehicle operators employ orbital debris mitigation designs.

The 2009 Iridium-Kosmos collision was a watershed event. The accident brought to light that more work needs to be done to ensure the safe separation of space objects. As space transportation capabilities and operations continue to advance, and as the prospects of a greater number of objects in space increase, certainty in planning for collision avoidance on-orbit becomes ever more critical. It is time to explore orbital safety of commercial space transportation under the Commercial Space Launch Act licensing regime.

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