# Testimony of Mike Moses
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# House Committee on Transportation & Infrastructure
# Subcommittee on Aviation
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Chairman LoBiondo, Ranking Member Larsen, and Members of the Subcommittee, thank you for giving me the opportunity to provide testimony for your hearing on "Building a 21st Century Infrastructure for America: Enabling Innovation in the National Airspace" I am here representing Virgin Galactic and our sister company, Virgin Orbit. I will provide an overview of our activities and our thoughts on commercial space activities at large and on commercial space operations within the National Airspace System (NAS).

I came to Virgin Galactic in 2011 from a career at NASA. While at NASA I worked as a flight controller on the Shuttle program and as a Flight Director at NASA Johnson Space Center where I led teams of flight controllers in the planning, training, and execution of space shuttle missions. Afterwards, I served at the Kennedy Space Center as the Launch Integration Manager, leading all space shuttle processing activities from landing to launch. My tenure at NASA gives me perspective and insight into the operations planning and execution of human spaceflight which carries over to what I am doing today.

I am currently the President of Virgin Galactic and oversee a team of more than 300 highly qualified engineers, technicians, and support staff working to make commercial spaceflight a reality through safe, reliable, and frequent access to space.

As the world's first commercial spaceline, Virgin Galactic is at the forefront of an important emerging market that is developing suborbital spaceflight experiences for humans, commonly referred to as "space tourism," as well as for research payloads. Founded by Sir Richard Branson and currently based in Mojave, California, we are opening access to space to change the world for good. Virgin Galactic's voyages will allow people to experience true microgravity, and to see the Earth from space. In addition, Virgin Galactic will also provide access to the microgravity environment for research, education and other industrial applications to develop and test new applications.

Based on the historic SpaceShipOne vehicle built by Scaled Composites —which safely carried human beings into space in 2004, claiming the Ansari X PRIZE and becoming the only privately-operated human spaceflight vehicle to do so to date—Virgin Galactic's vehicles have been designed with the intention of opening up frequent access to space while setting new standards for safety, frequency, flexibility, and cost. Our suborbital spaceflight system consists of two vehicles: WhiteKnightTwo (pictured in ***Figure 1*** below) is a four-engine, dual-fuselage jet aircraft capable of high-altitude heavy lift missions, including but not limited to fulfilling its role as a mothership for SpaceShipTwo (shown in **Figure *2***), a suborbital spaceplane designed to safely and routinely transport people and payloads to space and back. SpaceShipTwo will carry two pilots and as many as six spaceflight participants or about 1000 pounds of science and technology payloads to space altitudes, where they will have exposure to 3-4 minutes of a high-quality microgravity environment.

**Figure 1: WhiteKnightTwo Carrier Aircraft, VMS EVE**


**Figure 2: SpaceShipTwo, VSS Unity**

The current SpaceShipTwo, named the *VSS Unity*, is currently undergoing flight test, and was manufactured in Mojave, California by Virgin Galactic's manufacturing wing, The Spaceship Company. Commercial operations will be based in New Mexico at Spaceport America, the world's first purpose-built commercial spaceport.

The Commercial Space Launch Act as amended and re-codifed at 51 U.S.C. Ch. 509, §§ 50901-23, authorizes the Department of Transportation, and through delegations, the Federal Aviation

Administration's office of Commercial Spaceflight (AST) to oversee, authorize, and regulate commercial launch and reentry vehicles. Virgin Galactic received its Operator's License for SpaceShipTwo from FAA AST in July of 2016. The license was the culmination of years of interaction with the AST and required in-depth reviews of the vehicle's system design, safety and flight trajectory.

Today, FAA AST's regulatory authority over commercial launch & reentry is limited to protecting public safety, national security and U.S. foreign policy interests. This is, of course, significantly different than how the FAA regulates aviation activities today. However, this light regulatory approach is necessary to encourage the emerging commercial space industry while prioritizing safety. Virgin Galactic applies an incredibly rigorous approach to the safety of our customers, our vehicles, and our crew. Safety is our North Star, and we've been able to draw from our team's extensive experience overseeing safety for NASA, the US Air Force, commercial airlines, and other organizations to establish safety protocols and a disciplined safety culture.

Virgin Galactic's vehicles form a hybrid launch system involving both an aircraft and a rocket-powered vehicle. As part of the AST license issuance, Virgin Galactic coordinated with the FAA Air Traffic Organization (ATO) and the local Air Traffic Control (ATC) to receive Letters of Agreement (LOA) to define operations in the national airspace. Coordination continues prior to each flight ensuring minimal disruption to commercial and general aviation traffic during launch and reentry. WhiteKnightTwo climbs to the release altitude near 50,000 feet in under 50 minutes, following pre-planned routes and under the direction of local ATC. The actual SpaceShipTwo flight to space occurs within restricted airspace both in Mojave and at Spaceport America and lasts for about 20 minutes. We represent only one of several different commercial space launch vehicles operating today and while all are different, commercial space operations are not currently a large user nor disrupter of the NAS. Furthermore, because both their speed and their direction of flight is so different from an aircraft, rockets and spaceplanes typically occupy the NAS for only a few minutes or even seconds per flight, rather than lingering or passing through the airspace for hours at a time. However, as the industry's launch cadence increases, it drives the need for efficient and streamlined processes for continued seamless integration into the airspace.


**Figure 3: WhiteKnightTwo and SpaceShipTwo in their mated configuration during a test flight in March 2017**

In addition to human spaceflight, Virgin Galactic's sister company, Virgin Orbit, will provide dedicated, responsive, and affordable launch services for small satellites. Today, hundreds of companies around the world are experimenting with small satellites for everything from communications to remote sensing applications. To help this small satellite revolution, Virgin Orbit is developing LauncherOne, a flexible launch service for commercial and government-built satellites. The LauncherOne platform is dedicated to the task of lowering the cost and increasing the frequency of space access for payloads in the 150 kg – 500 kg weight range.

LauncherOne (shown in **Figure *4***) is a two stage, liquid propulsion (LOX/RP) rocket launched from a carrier aircraft. The carrier aircraft is a modified 747-400 (shown in **Figure *5***) that will carry the launch vehicle under the port side wing between the fuselage and inboard engine to the appropriate altitude before launch. Once released from the carrier aircraft, LauncherOne will fire its single main stage engine, a 73,500 lbf, LOX/RP-1 rocket engine. After stage separation, the single upper stage engine, a 5,000 lbf LOX/RP-1 rocket engine will carry the satellite (or satellites) into orbit. At the end of this sequence, LauncherOne will deploy our customers' satellites into their desired orbit.

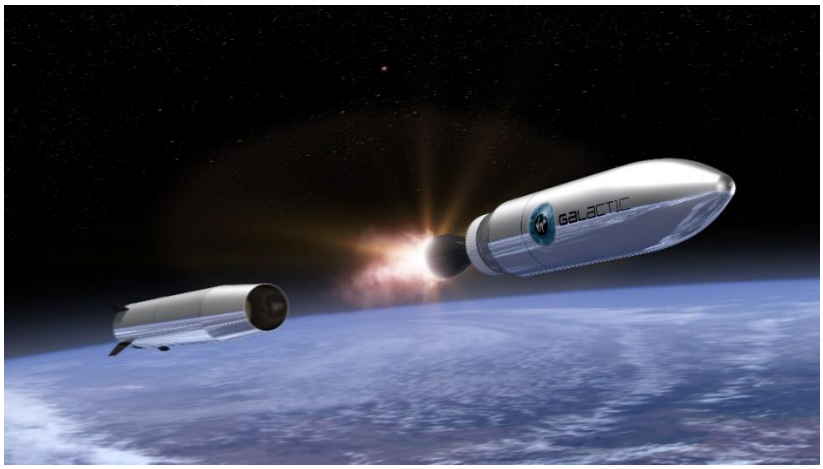


**Figure 4: LauncherOne vehicle**


**Figure 5: Modified Boeing 787-400 carrying the LauncherOne rocket**

Currently, Virgin Orbit is working towards initial test flights of the LauncherOne system. Virgin Orbit will operate LauncherOne under a FAA AST license and will initially launch from Mojave Air & Space Port, but will eventually operate from other licensed sites. Much like WhiteKnightTwo and SpaceShipTwo, the LauncherOne system operates as an aircraft and a launch vehicle in the various stages of its flight. In essence, our 'launch pad' is aircraft based, so 'pad operations' takes on a different meaning and offers a much more flexible approach in our flights. In addition, Virgin Orbit, through LOAs, will coordinate with ATO and local ATCs to define operations in the NAS to ensure minimal disruption to commercial and general aviation traffic during operations.

Virgin Galactic and Virgin Orbit are a part of a robust and growing domestic commercial space industry. This U.S.-based space sector is made up of companies with private financial backing working on a myriad of missions from rocket launch, human spaceflight, satellite constellations, to beyond Low-Earth Orbit (LEO) operations such as asteroid mining, lunar landers, and in-space habitats. The commercial space industry is already well underway and poised to continue its growth.

Companies are already launching medium and heavy lift rockets to loft large and small payloads to space. Satellites that are a part of larger constellations are already being deployed and providing communications services and earth imaging data for industrial and government use. In-space habitats are already being tested in LEO and development of deep space technologies is already in progress. The commercial space industry is not a future market, it is a present and thriving industry and will only continue to grow.

AST's mandate is to regulate commercial space launch and reentry to protect public safety which, when necessary, will require airspace coordination and closures to protect aircraft against potential hazards. Commercial launch vehicle operators are unique users of the airspace. On the one hand, we do travel through the NAS on our way to and from our final destination, but we do so infrequently and for brief periods of time when compared to traditional users. In addition, a high degree of sensitivity to weather conditions, combined with the constraints of the dynamics associated with the payload destination, can make our launch windows relatively inflexible. The U.S. is currently the leader in commercial space. Launch is absolutely critical for a thriving space economy and consideration for these and other elements of launch must be taken into place when coordinating use of the NAS for the commercial space industry.

The number of commercial launches has been increasing over the past few years and will continue to do so in the years ahead as the industry continues to grow. This drives the need for an efficient, defined process as well as technical tools and process advancements that will streamline integration of commercial space operations in the NAS. For example, the current process used to get a LOA – the letter of agreement for the use of an airspace - through the FAA is currently a lengthy process involving conversations with multiple elements within the FAA. A much more streamlined process should be in place for future operations. In addition, some technical efforts to improve efficiency of operations within our airspace are already under way at the William J. Hughes Technical Center in New Jersey where work is being done on analysis and software tools for commercial space such as visualization and fast-time modeling for launch and entry to better communicate operations in the NAS with other users. Virgin Galactic is also slated to test an automatic dependent surveillance broadcast (ADS-B) transmitter developed by Embry-Riddle Aeronautical University with the objective to further demonstrate the applicability of ADS-B technology for tracking commercial spacecraft to reduce impact to surrounding traffic within the NAS. We recommend increased FAA investment in NextGen tools such as these for air space integration with different users of the airspace to continually improve the efficiency and integration for future NAS operations. We look forward to working with the Committee and with AST on these future endeavors to continually make our skies a safe place to fly.