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CERTIFICATION VERSUS LICENSING FOR HUMAN SPACE FLIGHT IN COMMERCIAL SPACE TRANSPORTATION

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Safety oversight of commercial space transportation by the government can come in two forms: a certification regime or a licensing regime. Certification addresses design characteristics of a vehicle and is common in aviation. It is typically based on decades of extensive flight experience and data. While aviation certification can be expensive, there is a large and mature market to offset initial investment. However, certification may not be the best approach for a new industry such as commercial human space flight. Although there is a history of government funded orbital spaceflight, most commercial companies will not have the same resources as a government program. In addition, new suborbital vehicles have less in common with historical government suborbital test aircraft, and to date only a few commercial flights have been carried out. The market for carrying people into space shows great potential but is unproven for both orbital and suborbital vehicles. In 1984, the Department of Transportation (DOT), as the regulator of U.S. commercial space transportation, established a regime to license the safety of launch events instead of certifying launch vehicles. The Federal Aviation Administration's Office of Commercial Space Transportation (AST) has this authority within DOT today. Instead of imposing a prescriptive and limited set of design criteria, AST has performance-based requirements to ensure safe operations. Thus far, results indicate greater innovation by industry at a much lower cost, along with the ability to test designs and methods before entering the market. This paper will examine some of the key differences between certification and licensing in commercial space transportation and evaluate the U.S. approach to grow a new industry while maintaining safety. The paper may be useful to countries that are considering safety oversight during the development of new spaceports and vehicles.

I. Introduction

The commercial space transportation licensing process currently in place at the U.S. Federal Aviation Administration (FAA) ensures the safety of the public from risks associated with commercial space transportation launches. The FAA uses a licensing regime to provide flexibility for the commercial space transportation industry to grow and develop as it matures. This approach has proven effective for commercial expendable launch vehicles and is also being used for new suborbital and orbital vehicles designed to carry people. Applying a certification regime that is similar to existing aviation regulations may stifle the emerging commercial human space transportation industry. It has been demonstrated that safety can be effectively achieved without a certification regime. Historically, the U.S. Government did not require certification of airplanes until passage of the Air Commerce Act of 1926. Certification evolved and became practical as aircraft were being mass-produced and major airlines flew regularly to carry passengers and cargo to their destinations. At the time, there were several accidents that caused concerns about the longevity of the commercial aviation business.

The FAA Office of Commercial Space Transportation does not believe that the commercial space transportation industry has reached the point where certification is necessary or practical. In particular, for the commercial human space transportation industry, designs are new and continually evolving through extensive testing and modification, and the market is uncertain. There is also no mishap history based on flights to date to reflect the need for additional oversight. Currently, launch vehicles are not mass-produced; they embody unique, complex parts and systems that do not require the certification of production methods.

As the commercial space transportation industry grows and develops, the licensing regime will evolve as well. This paper will discuss why the FAA has chosen to implement a licensing regime and how it will evolve to accommodate the needs of the commercial space transportation industry.

II. Origins of FAA Certification

After Orville and Wilbur Wright made the first sustained, powered flight in 1903, new planes and technologies were developed, but a successful commercial airline business as we know it today proved elusive until passage of the Air Mail Act of 1925. The Act transferred air mail operations to private companies and led to the creation of a profitable commercial airline industry.[1] In 1926, the Congress passed the Air Commerce Act. This Act "charged the Secretary of Commerce with fostering air commerce, issuing and enforcing air traffic rules, licensing pilots, certificating aircraft, establishing airways, and operating and maintaining aids to air navigation."[2] By the mid-1930s, the four major domestic airlines that dominated commercial travel for most of the twentieth century began operations: United, American, Eastern, and Transcontinental and Western Air (TWA).[3] However, early aviation remained a dangerous business. The only navigation devices available to most pilots were magnetic compasses. Early air traffic control at some airports was done with flagmen. Fatal accidents were frequent. A 1931 crash that killed all on board, including popular University of Notre Dame football coach Knute Rockne, elicited public calls for greater federal oversight of aviation safety. Four years later, a DC-2 crash killed U.S. Senator Bronson Cutting of New Mexico.

To ensure a federal focus on aviation safety, President Franklin Roosevelt signed the Civil Aeronautics Act in 1938. The legislation established the independent Civil Aeronautics Authority (CAA), with a three-member Air Safety Board that would conduct accident investigations and recommend ways of preventing accidents. The legislation also expanded the government's role in civil aviation by giving CAA power to regulate airline fares and determine the routes individual carriers served. In 1940, President Roosevelt split the CAA into two agencies, the Civil Aeronautics Administration, which went back to the Department of Commerce, and the Civil Aeronautics Board (CAB). The offshoot of the original CAA retained responsibility for air traffic control, airman and aircraft certification, safety enforcement, and airway development.[4] Responsibilities of the CAB included safety rulemaking, accident investigation, and economic regulation of the airlines.

A series of midair collisions and the advent of jet travel highlighted the need for additional emphasis on safety and prompted passage of the Federal Aviation Act of 1958. This legislation gave the CAA's functions to a new independent body, the Federal Aviation Agency. The act transferred air safety regulation from the CAB to the new FAA, and also gave the FAA sole responsibility for a common civil-military system of air navigation and air traffic control. In 1966, the Federal Aviation Agency was eventually brought under the

auspices of the Department of Transportation and renamed as the Federal Aviation Administration.

The history, as described above, shows that the implementation of certification followed a long, sustained period of technological and economic development within the aviation industry. Certification did not really arrive in its current form until the commercial aviation industry was capable of flying regularly. The government enacted various levels of legislation, regulation, and organization commensurate with industry growth and capability. The commercial space transportation industry has not yet reached this level of maturity, and as such, the FAA believes a certification regime is not appropriate and could stifle innovation and possibly stop the industry from developing at this juncture. Instead, the Congress has put in place a licensing regime to allow the industry to develop and mature while ensuring operations are conducted in a safe and responsible manner. The following sections describe the benefits of the FAA licensing process and the limitations of a certification process, and elaborate on the future of regulatory efforts for commercial space transportation.

III. FAA Licensing for Commercial Space Transportation

U.S. regulation of commercial launch and reentry operations and the operation of launch and reentry sites is the responsibility of the Department of Transportation (DOT)/FAA. The Office of Commercial Space Transportation (AST) licenses commercial launch and reentry operations to ensure public health and safety and the safety of property, and to protect the national security and foreign policy interests of the United States during commercial launch and reentry operations. The 1984 Commercial Space Launch Act (CSLA, as amended) and Executive Order 12465 tasked the DOT to encourage, facilitate, and promote the commercial space transportation industry, and to develop licensing requirements and procedures to regulate the industry's impact on public safety. In 2004, Congress passed the Commercial Space Launch Amendments Act (CSLAA),[5] giving the DOT the authority to regulate commercial human spaceflight and create an experimental permit regulatory regime for the development of suborbital reusable launch vehicles. The CSLAA required that the human spaceflight regulations follow a phased approach, so as to allow the industry to grow.

Since 1989, the FAA has licensed over 200 commercial space launches and two reentries under its current licensing regime. The launch total includes both suborbital and orbital launches. Unlike a certification regime, which certifies the vehicle, airline, pilot, etc., the FAA Office of Commercial Space Transportation licenses the *launch operation*. This regulatory system was adopted, in part, to support the evolution of the commercial space transportation industry, which is very different from aviation in terms of flight profiles, operating environment, payloads, risks, and hazards. The costs associated with the development of the vehicles, as well as the challenges in testing and validating them, typically exceed aviation development costs. Considering the market volume of suborbital and orbital customers is significantly smaller than the aviation community, the FAA is challenged with balancing effective regulation which allows the industry to grow and innovate, without unnecessarily risking public safety. The FAA provides this flexibility by setting what are for the most part performance-based requirements and then enforcing them through a rigorous compliance monitoring system that has been the cornerstone of the FAA's successful safety record. For example, to ensure public safety, the FAA scrutinizes the flight termination system for expendable launch vehicles and the thrust termination system or equivalent for piloted reusable launch vehicles.

The U.S. Congress acknowledged the inherent risks associated with human space flight and thus established an informed consent regime for space flight participants in 2004. This is appropriate given the level of activity seen today. As the frequency of flights increases and the number of space flight participants becomes significant, there will be a need for additional requirements to incorporate lessons learned and further mitigate risk to those onboard. However, for the foreseeable future, the FAA anticipates no immediate changes to its statutory authority, such as the certification of commercial space launch and reentry vehicles.

IV. Limitations of Certification for Commercial Space Transportation

Orbital space transportation has a long history, with the first government operations dating back to the late 1950s. Commercially operated orbital launches began in the 1980s. While commercial human space flight is only now emerging, and space transportation itself is recognized by the United States Congress as inherently risky,[6] there are several reasons why imposing a certification regime may not yield the best results for continued growth and success of commercial space transportation.

Commercial suborbital space vehicles are still relatively new and it is unclear what designs will be

commercially successful. New vehicle types are constantly being developed, evaluated, and refined to identify optimal configurations. Some launch providers are developing vehicles that can be launched from airplanes, others have vehicles designed to use a runway to take-off and land under their own power, while some emulate the traditional launch vehicles that take-off vertically and return their payloads/passengers to the ground through a myriad of approaches. There are a number of vehicles in development today for suborbital and orbital markets that have yet to fly in space with configurations that carry people. To date there have only been five licensed commercially operated human suborbital flights, all by SpaceShipOne in 2004. With only limited flight data available, it is not possible to make informed decisions on how a certification regime should be implemented for commercial suborbital or orbital vehicles. Through the use of performance-based requirements, FAA licensing allows technology innovation and rapid development to give industry the flexibility to meet safety objectives without specifying how safety must be achieved.

Historically, human space flight has been achieved with capsule-based designs or by the Space Shuttle. While there are similarities among new orbital vehicle designs, new suborbital vehicles that plan flights up to 100 kilometers have few historical analogues. Suborbital vehicles will be rigorously flight-tested, but will not fly thousands of hours before commercial operations begin. For example, as of August 2012, SpaceShipTwo, built by Scaled Composites, had completed 22 glide flight tests, which typically last under 15 minutes each.[7] Rocket powered flight tests are scheduled in 2012-2013. Operational flights for suborbital vehicles may last from 30 to 60 minutes from takeoff to landing. Another firm, XOCR Aerospace, plans 30-minute flights with the Lynx Mark I vehicle that will experience powered flight for less than three minutes to reach an altitude of 60 kilometers.[8] Establishing an extensive historical data base for different suborbital designs that will resemble that of the airplane, will take a long time.

The cost to comply with a certification regime is viewed as an expensive and overwhelming burden by the commercial space transportation industry. Commercial space transportation requires large, up-front investment to support the development and testing needed before commercial operations are possible and revenue can be generated. A certification regime based on or similar to aviation would be crippling, especially for entrepreneurs and small companies that are pioneering commercial human space flight on limited budgets. Any certification regime would significantly add to development costs and increase the time frame needed for private investors to earn a return on their investment. Unlike commercial aviation, no one is really sure what the average return on investment in commercial space ventures will be, or what size market we will eventually see. In the aviation business, advance orders of aircraft help offset startup costs and increase business confidence. The suborbital and orbital space industry does not have this advantage.[9] In addition, some space companies are taking on both the cost of development and operations. The high cost associated with certification could also reduce the number of competitors interested in or capable of breaking into the market. This could prohibit innovative but cash poor entrepreneurial firms from advancing their vehicles and artificially limit competition.

A certification regime works best for vehicles that are to be mass-produced. For the new suborbital reusable launch vehicle industry, there may be only a few custom-built vehicles to begin initial operations. For example, The Spaceship Company is under contract to build a fleet of five SpaceShipTwo vehicles for Virgin Galactic.[10] In the expendable launch vehicle industry, vehicles are built in low quantities; about 3 to 10 per year, depending on customer needs. Most of the hardware needed for expendable launch vehicles to place a payload in orbit is not recovered and is used only once. While no one really knows how often the new suborbital vehicles will be flying and how many companies will enter the market, the commercial space transportation industry today is clearly not capable of supporting mass produced commercial space vehicles. Public demand for flights appears to be healthy and has room for multiple providers but may not be enough to warrant mass production. A market study released by the Tauri Group in 2012 found that there was global demand for about 370 seats (or cargo equivalents) per year in the first year that suborbital reusable launch vehicles are operating, increasing to over 500 per year in the 10th year of market operations.[11] Virgin Galactic reported 529 customers had signed up in advance as of July 2012.[12] SpaceShipTwo can carry two pilots and six space flight participants per flight and XCOR can carry one pilot and one space flight participant.

Countries looking to attract a suborbital U.S. vehicle operator to serve domestic or tourism markets will likely have a difficult time doing so if they chose to impose a certification regime. Differing regulatory regimes with potentially differing requirements will be viewed as an additional risk by the launch operator and investors. In the future, interoperability will be critical to fostering the global growth of the commercial space transportation industry. Point-to-point space travel will likely be the next step to creating a successful,

globalized industry. For that to come to fruition, it is important that the world have a complimentary set of standards by which it ensures safety and measures regulatory compliance.

V. The Future of Licensing for Commercial Space Transportation

It has been twenty-eight years since the Commercial Space Launch Act was signed into law. Since then, the industry has grown significantly and safely.[13] Two drivers that have advanced human space flight endeavors have been the X-Prize Foundation and National Aeronautics & Space Administration's (NASA) adoption of commercial capabilities to supplement their missions. Each organization has challenged the industry to develop a vehicle to meet very specific requirements with appropriate financial incentives. The requirements ranged from demonstrating reusable suborbital passenger carriage to space for the Ansari X-Prize competition, to very specific and difficult to achieve mission requirements levied by NASA for orbital missions to and from the International Space Station. The financial incentives ranged from a ten-million dollar prize for achieving the Ansari X-Prize's suborbital flight requirements[14] to hundreds of millions of dollars in NASA's Commercial Crew Program funding to provide for development contracts seeking a commercial capability to carry astronauts to the International Space Station and to return safely.[15] Carrying passengers "for-hire" brings with it the burden of achieving profitability while still maintaining safety. The industry recognizes that failures could significantly impact profitability and seriously damage the fledgling industry. The industry also recognizes the implications of the Commercial Space Launch Act, as amended, which allows the FAA to issue design and operational requirements should an accident occur or an event pose a high risk of injury or fatality to the space flight participants.

Like the commercial space industry, the FAA recognizes the potential risk of an accident involving a launch vehicle designed to carry humans. Thus, the FAA is exploring what kinds of human space flight regulations may be appropriate. The FAA must be prepared to promulgate additional human space flight regulations after an accident, should one occur, or potentially to codify any lessons learned during the first few years of operations, while under the moratorium imposed by Congress.[16] While the future is uncertain, the FAA and the Congress have indicated that it is necessary to begin talking about regulatory development because of the significant time-period it takes to prepare and propose regulations.

In an effort to prepare for the future of human spaceflight, the FAA Office of Commercial Space Transportation, in coordination with the industry-led Commercial Space Transportation Advisory Committee (COMSTAC), held the first of at least three public teleconferences on August 18, 2012, to discuss with the public the future of human space flight regulations. The meetings specifically address the development of regulations to protect occupants of commercial suborbital and orbital spacecraft.

Although the FAA has not yet seen the need for, or targeted a date for proposing regulations to protect the health and safety of crew and space flight participants, the FAA believes that the development of sound and appropriate regulations for human space flight can only be achieved with a deliberate, focused, multi-year effort. Moreover, the FAA believes that early industry input into this regulatory effort is critical, prior to any formal proposal by the FAA.[17]

The first meeting in August covered what level of safety the FAA should adopt to adequately protect occupants. The FAA discussed the following: whether one or multiple levels of safety are necessary, should there be different safety requirements for crew or space flight participants, and if there should be a threshold and acceptable risk limit. The level of safety criteria is key to determining what design and operations requirements will be developed. Future public meeting topics are expected to examine:

1. FAA Oversight – Managing safety of crew and space flight participants through governmental oversight with the least amount of intrusion so as to prevent an excessive cost burden and allow for technology growth;

2. Licensing – Managing the current permit and licensing regime through the incorporation of human space flight requirements; and

3. Requirements and Guidance – Development of performance requirements and Advisory Circulars, while incorporating industry standards.

It is vitally important to recognize that the U.S. Government seeks to encourage, facilitate, and promote a safe and successful commercial space transportation industry with the least amount of governmental oversight necessary to protect the uninvolved public as well as ensure safety of future space flight participants and crew. Figure 1, below, shows a conceptual regulatory progression the FAA Office of Commercial Space Transportation could follow as the industry develops. The current licensing regime is set to evolve

to include regulations for occupant safety. This could be hastened if there is an accident.

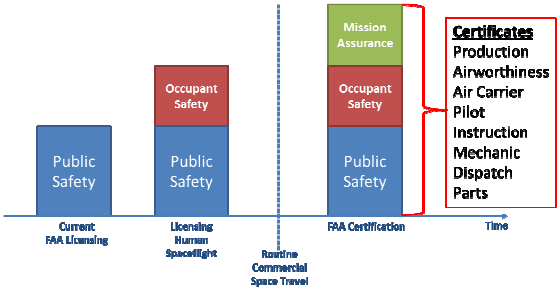

Fig. 1: The Evolution of Commercial Space Transportation Regulation

VI. Conclusion

The nascent commercial space transportation industry made it very clear to Congress in 1984 that the industry could not develop under the same FAA regulatory structure the present aviation industry operates under. The growth of commercially operated space transportation offers the opportunity for private human space travel and opening new markets, including the support of the International Space Station. It can also allow governments to focus resources on pure research or exploration of space. In order to accommodate industry expansion and innovation, while ensuring safe commercial operations, the Federal Aviation Administration's Office of Commercial Space Transportation continues to advocate for regulations designed to ensure public and occupant safety while allowing development and innovation within the commercial space industry. The U.S. Congress acknowledged the inherent risks associated with human space flight and thus established an informed consent regime for space flight participants in 2004.

As the frequency of flights increases and the number of space flight participants becomes significant, there will be a need for additional requirements to incorporate lessons learned and further mitigate risk to those onboard. The licensing regime in place allows the FAA to fulfill its mission of ensuring public safety, while maintaining its mission to encourage, facilitate, and promote a very promising commercial space industry. This mission has been successfully implemented and is supported by the commercial entities that must adhere to its requirements as it provides a progressive approach for regulating this developing industry. It is the hope of the FAA Office of Commercial Space Transportation that the international community will adopt a similar approach so as to allow the fledgling commercial space industry to mature into a viable transportation business that will benefit all of humanity.

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[4] Ibid.

[5] http://www.faa.gov/about/office_org/headquarters_offices/ast/media/PL108-492.pdf

[6] The Commercial Space Launch Amendments Act of 2004, Public Law 108–492. http://www.faa.gov/about/office_org/headquarters_offices/ast/media/PL108-492.pdf

[7] SpaceShipTwo Test Summaries, August 2012, http://www.scaled.com/projects/spaceshiptwo_test_summaries

[8] XCOR Lynx Payload User's Guide, Version 3B, July 24, 2012, XCOR Aerospace, page 10.

[9] Although over 500 space flight participants have put down deposits as of summer 2012 for their $200,000 ticket on SpaceShipTwo, Virgin Galactic's president estimated that it would cost the company about a half-billion dollars to get its space flights under way. "Private Space Travel Predicted," Omaha World Herald, February 16, 2011, http://www.omaha.com/article/20110216/NEWS01/110219787/1003479

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[12] "Virgin Galactic Reveals Privately Funded Satellite Launcher and Confirms SpaceShipTwo Poised for Powered Flight," Virgin Galactic, July 10, 2012, http://www.virgingalactic.com/news/item/xxx/

[13] Nield, George, Associate Administrator for Commercial Space Transportation, Federal Aviation Administration, Testimony before the House Committee on Science, Subcommittee on Space and Aeronautics, on the office of Commercial Space Transportations Fiscal Year 2013 Budget Request, March 20, 2012.

[14] On October 4, 2004 the X Prize Foundation awarded the 10 million dollar Ansari X-Prize to Mojave Aerospace Ventures LLC (a joint company formed by Paul Allen and Scaled Composites) for flights of SpaceShipOne to 100 kilometers above the earth's surface twice within two weeks. The company spent more developing SpaceShipOne than the $10 million prize which led to the Virgin Galactic investment in SpaceShipTwo and spurred other companies to develop suborbital vehicles. NASA is also supporting suborbital vehicle development by purchasing flight services in its Flight Opportunities Program. See https://flightopportunities.nasa.gov/

[15] In August 2012, NASA announced plans to invest in three industry partners for its Commercial Crew integrated Capability (CCiCap) program: Sierra Nevada Corp ($212.5 million), Space Exploration Technologies (SpaceX, $440 million), and The Boeing Company $460 million). "NASA's Commercial Crew Program Progressing for Future of U.S. Human Spaceflight," August 3, 2012, http://www.nasa.gov/exploration/commercial/crew/ccicap-announcement.html. In addition, SpaceX has received development money from NASA for the Falcon 9 and Dragon capsule as part of the Commercial Orbital Transportation Services (COTS) program.

[16] In February 2012, the Congress extended the regulatory "moratorium" on commercial human spaceflight from December 2012 to October 1, 2015 as part of the FAA Modernization and Reform Act of 2012 (Section 827). http://thomas.loc.gov/cgi-bin/query/D?c112:6:./temp/~c112Cqon8o::

[17] Notice of Commercial Space Transportation Advisory Committee – Public Teleconference, FAA-DOT, Federal Register-Notices/Vol. 77, No. 146/Monday, July 30, 2012, pg 44707-44708. See also http://www.faa.gov/about/office_org/headquarters_offices/ast/COMSTAC_working_group/