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UPDATE TO STREAMLINING FAA COMMERICIAL SPACE TRANSPORTATION REGULATIONS

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Abstract

The U.S. Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) published a Final Rule on its website on October 15, 2020 and in the Federal Register on December 10, 2020 called "Streamlined Launch and Reentry Licensing Requirements" (Part 450). The Part 450 Final Rule creates a flexible and performance-based 21st century licensing regime that streamlines and simplifies licensing of commercial launch and reentry operations, enables innovation, results in net cost savings to US industry, and maintains public safety.

The Part 450 Final Rule is a result of U.S. Presidential Space Policy Directive-2 (SPD-2), "Streamlining Regulations on Commercial Use of Space," issued in May 2018. SPD-2 assigned the Secretary of Transportation to review regulations, including consideration of "(i) requiring a single license for all types of commercial space flight launch and re-entry operations; and (ii) replacing prescriptive requirements in the commercial space flight launch and re-entry licensing process with performance-based criteria." The Department of Transportation (DOT) delegated implementation of SPD-2 to the FAA's Office of Commercial Space Transportation. Since 1989, DOT/FAA has licensed (or permitted) over 460 commercial launches and reentries.

The final rule consolidates the safety requirements for the launch of suborbital and orbital expendable (ELV) and reusable launch vehicles (RLV), and the reentry of reentry vehicles into a new Part 450 of Title 14 of the Code of Federal Regulations (CFR). In addition, the final rule establishes a single type of vehicle license by eliminating the FAA's current launch-specific license and launch operator license for ELVs, mission-specific license and operator license for RLVs, and reentry-specific license and reentry-operator license for reentry vehicles. The final rule also allows operators to apply for a single license to authorize operations at multiple launch or reentry sites. Part 450 relies on a safety framework that provides the flexibility needed to accommodate current and future launch and reentry operations and encompasses both ground safety and flight safety.

This paper provides an overview of FAA's Streamlined Launch and Reentry Licensing Requirements final rule. The paper may be useful to countries that are considering new national frameworks for commercial space transportation, including hosting U.S. vehicles in their country that would be licensed by the FAA.

1. Introduction

In the United States, public safety and regulatory oversight of commercial space transportation is carried out by the Department of Transportation's Federal Aviation Administration. Licenses are issued by the FAA's Office of Commercial Space Transportation. The Streamlined Launch and Reentry Licensing Requirements rulemaking arose from work by the National Space Council that led to Space Policy Directive-2 issued by the President of the United States on May 2018, directing the U.S. Department of Transportation to streamline the regulations governing commercial space launch and reentry licensing. The goals of this streamlining include creating a single licensing regime for all types of commercial space flight launch and reentry operations, and replacing prescriptive requirements with performance-based criteria.

The goal of the new Part 450 rule is to provide both industry and the FAA a single set of vehicle licensing regulations with flexibility to use new methods that will enable innovative concepts and operations in launch and reentry. The rule amends 14 CFR parts 415, 417, 431, and 435 by consolidating, updating, and streamlining all launch and reentry regulations into a single part 450.

This paper provides an overview of the new streamlined rule, summarizes key topics of public comment, changes to the Notice of Proposed Rulemaking (NPRM), and regulatory innovations in Part 450.[1] The paper also identifies next steps.

The paper may be useful to countries that are considering new national frameworks for commercial space transportation, including hosting U.S. vehicles in their country that would be licensed by the FAA.

2. Background on FAA Office of Commercial Space Transportation

The FAA Office of Commercial Space Transportation licenses U.S. commercial launch and reentry activities and the operation of launch and reentry sites in the United States or by U.S. citizens. The Commercial Space Launch Act of 1984, as amended and codified at 51 U.S.C. §§ 50901–50923 (the Act), authorizes the Secretary of Transportation to oversee, license, and regulate commercial launch and reentry activities, and the operation of launch and reentry sites within the United States or as carried out by U.S. citizens.[2] Section 50905 directs the Secretary to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. In addition, § 50903 requires the Secretary to encourage, facilitate, and promote commercial space launches and reentries by the private sector. As codified at 49 CFR 1.83(b), the Secretary has delegated authority to carry out these functions to the FAA Administrator.[3]

Since the first licensed launch in 1989, there have been over 460 orbital and suborbital U.S. commercial launches and about 25 reentries conducted under licenses and experimental permits. The FAA has 12 active licenses for the operation of non-federal launch sites ("spaceports"). It is important to note that the FAA does not certify the design of commercial launch or reentry vehicles. Instead, the FAA licenses the operation of the launch or reentry vehicles for public safety.[4]

The U.S. Congress has incrementally given DOT/FAA additional oversight authority. Launch and launch site authority was originally granted in 1984 and reentry authority was added in 1998. Limited authority over human space flight and statutory authority to issue experimental permits for suborbital vehicle testing were added in 2004.

3. History and Streamlining

US Department of Transportation regulations for commercial launch activities became effective in 1988. Initially, commercial launches only included Expendable Launch Vehicles from federal ranges that had established safety practices. Over time, DOT simplified the licensing processes and expanded rules to accommodate the emergence of Reusable Launch Vehicles as well as for the reentry of a reentry vehicle, and the operation of reentry sites in 2000.[5]

The FAA decided to promulgate separate regulations for ELVs and RLVs. There was a long history of successful ELV launches from US Federal launch

ranges using detailed prescriptive regulations that the FAA adopted from the US Air Force to ensure public safety. Because commercial RLVs were relatively new, the FAA enacted flexible process-based regulations for RLVs and other reentry vehicles. As industry evolved, operators have developed unique launch and reentry concepts that eventually did not align well with traditional separation of ELV and RLV regulations.

3.1 The Rulemaking Process

The President of the United States issued Space Policy Directive-2, "Streamlining Regulations on Commercial Use of Space," on May 24, 2018.[6] The new policy stated that it is "important that regulations adopted and enforced by the executive branch promote economic growth; minimize uncertainty for taxpayers, investors, and private industry; protect national security, public-safety, and foreign policy interests; and encourage American leadership in space commerce."[7] The FAA chartered the Streamlined Launch and Reentry Licensing Requirements Aviation Rulemaking Committee (ARC) for a broad range of stakeholders to develop recommendations for a performance-based regulatory approach.

Based on the feedback from the ARC, the FAA published the Notice of Proposed Rulemaking on its website on March 26, 2019 and in the Federal Register on April 15, 2019. The NPRM proposed a number of amendments to the definitions in 14 CFR part 401, the administrative processes in part 404, the application procedures in part 413, and the title of part 414, with minor clarifying amendments to parts 420, 433, 437, and 440. Primarily, the proposal focused on the removal and consolidation of launch and reentry licensing regulations in parts 415, 417, 431, and 435 under the new part 450.

The FAA received 154 public comment submittals on the NPRM during the formal comment period between April 15 and August 19, 2019.[8] The commenters provided extensive and well thought out comments that would reshape the final part 450 rule that now applies to any new commercial launch and reentry vehicle operations. Legacy licenses issued under the previous regulations must be compliant with part 450 by March 10, 2026.

The final rule was posted on the FAA website on October 15, 2020 and was published in the Federal Register on December 10, 2020.[9] The final rule is flexible enough to enable new innovative designs while effectively protecting public health and safety, safety of property, and national security and foreign policy interests of the United States.

4. An Overview of Part 450 Safety Framework

The following sections provide details on safety framework of the final rule for Part 450.

4.1 Overview of Part 450

The final rule relies on a safety framework that provides the flexibility needed to accommodate current and future launch and reentry operations. The safety framework encompasses both ground safety and flight safety. Acceptable safety for ground operations is achieved primarily through a process-based hazard analysis and certain prescribed hazard controls. Acceptable safety for flight operations is achieved through a number of hazard control strategies and prescribed hazard controls as shown in Figure 1. The FAA identifies specific safety criteria and requirements in § 450.101 that must be met before a launch or reentry can take place, including collective risk, individual risk, aircraft risk, risk to critical assets, high consequence event protection, risk from the disposal of a launch vehicle stage or component, risk to people and property on orbit, and notification of planned impacts.

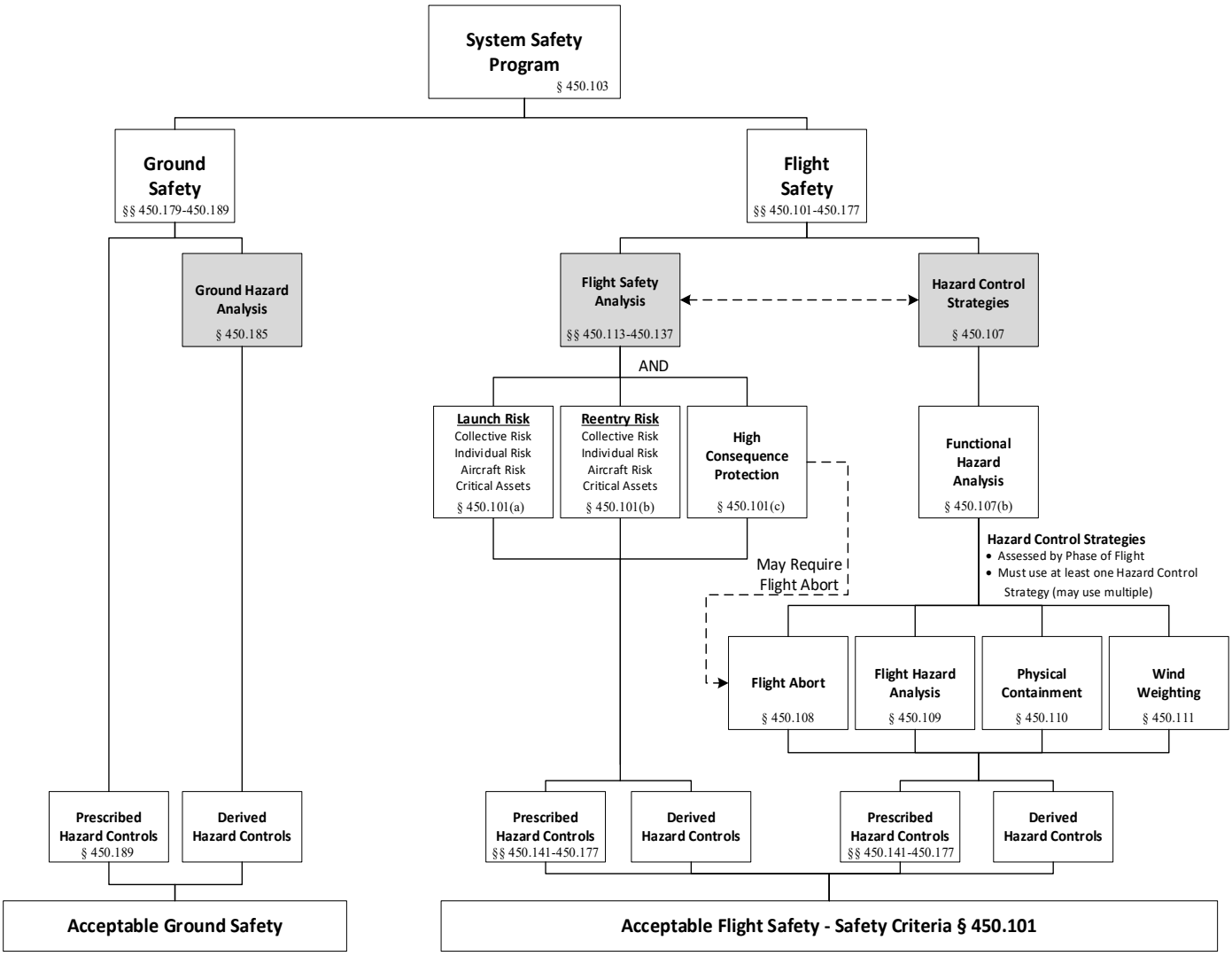

Figure 1. Part 450 Safety Framework

4.2 System Safety Program.

All operators are required to have a system safety program that establishes system safety management principles for both ground safety and flight safety throughout the operational lifecycle of a launch or reentry system. The system safety program includes a safety organization, hazard management, configuration management and control, and post-flight data review that requires an operator to evaluate and resolve any inconsistencies with pre-flight safety analyses.

4.3 Hazard Control Strategies.

To address the wide variety of commercial launch and reentry systems and operations concepts, the final rule includes four hazard control strategies. An operator can use multiple hazard control strategies during flight because different strategies may be appropriate for different phases of flight. Different or multiple hazard control strategies may also be appropriate during any one phase of flight to protect different sets of people and property. An operator determines and verifies the appropriate hazard control strategy by conducting a functional hazard analysis. The hazard control strategies are physical containment, wind weighting, flight abort, and flight hazard analysis.

- Physical containment would most likely be used for low energy test flights, when a launch vehicle does not have sufficient energy for any hazards associated with its flight to reach the public or critical assets.
- Wind weighting is traditionally used in the launch of unguided suborbital launch vehicles, otherwise known as sounding rockets, where the operator adjusts launcher azimuth and elevation settings to correct for the effects of wind conditions at the time of flight to provide impact locations for the launch vehicle or its components that will ensure compliance with the safety criteria in § 450.101.
- Flight abort is the traditional safety approach for expendable launch vehicles, and is a process to limit or restrict the hazards to public safety and the safety of property presented by a launch vehicle or reentry vehicle, including any payload, while in flight by initiating and accomplishing a controlled ending to vehicle flight. With the exception of phases of flight with demonstrated reliability, flight abort is mandated as a hazard control strategy if the potential for a high consequence event is above a certain threshold.
- Flight hazard analysis is the traditional safety approach for reusable launch vehicles, and is the most flexible hazard control strategy because an operator derives specific hazard controls unique to its launch or reentry vehicle system and operations concept.

Flight hazard analysis is mandated as a hazard control strategy if the other three hazard control strategies cannot mitigate the safety hazards sufficient to meet the safety criteria of § 450.101.

4.4 Flight Safety Analyses.

In addition to the hazard control strategy chosen or mandated, an operator is required to conduct several flight safety analyses. These include trajectory analyses for normal and malfunction flight, a debris analysis, a population exposure analysis, and a probability of failure analysis. These analyses provide input to a debris risk analysis, a far-field overpressure blast effects analysis, and a toxic hazard analysis that together demonstrate compliance with the safety criteria of § 450.101, and provide input to a flight hazard area analysis. With respect to flight operations, an operator would derive several hazard controls by conducting the flight safety analysis and, if utilized, a flight hazard analysis. Because hazard controls are derived from these analyses, they are not specifically addressed in part 450.

4.5 Prescribed Hazard Controls

In addition to the hazard controls derived from a flight hazard analysis and flight safety analyses, the FAA prescribes many other hazard controls. The first set of prescribed hazard controls includes requirements for computing systems and software, safety-critical systems, and highly reliable flight safety systems. The second set of prescribed hazard controls have historically been necessary to achieve acceptable flight safety. These include requirements for (1) written agreements, (2) safety-critical personnel qualifications, (2) work shift and rest requirements, (3) radio frequency management, (4) readiness, (5) communications, (6) pre-flight procedures, (7) control of hazard areas, (8) lightning hazard mitigation, (9) flight commit criteria, (10) tracking, (11) collision avoidance, (12) safety at the end of launch, and (13) mishap plans.

4.6 Ground Safety.

For the safety of ground operations, the safety framework includes (1) coordination with a site operator, (2) explosive siting, (3) a ground hazard analysis, (4) toxic hazard mitigations, and (5) prescribed hazard controls addressing visitors, countdown aborts, fire suppression, and emergency procedures. These together provide an acceptable set of public safety considerations for ground operations.

5. Part 450: Regulatory Innovations and Improvements over Legacy Regulations

The following sections provide details on key highlights of the final rule for Part 450.

5.1 Hazard Control Strategies

The goal of the streamlining rule is to create a single licensing regime for expendable and reusable launch vehicles and reentry vehicles. The legacy regulations differentiate between regulatory regimes based on a vehicle's reusability characteristics. Part 450 uses a safety framework for all vehicles based an operator's use of one or more hazard control strategies defined in §§ 450.108 through 450.111 to meet the safety criteria. As discussed in the overview section, the four hazard control strategies address the wide

variety of commercial launch and reentry systems and operations concepts.

5.2 Performance-Based Requirements

The final rule converts many of the legacy prescriptive requirements to more performance-based requirements that would allow for different means of compliance. The removal of unnecessary prescriptiveness provides additional flexibility while still preserving safety and providing regulatory clarity. The prescriptive parts of the proposed rule were moved to a corresponding AC as guidance on means of compliance. The final regulation combines elements from parts 415, 417, 431, and 435. Part 450 is shorter than parts 415 and 417 and more performance-based. Although it is longer than parts 431 and 435, part 450 is more flexible and encompasses more types of launch and reentry operations. The final rule allows operators to use a means of compliance that will accommodate customized operations, changing technologies, and innovation.

5.3 Means of Compliance Accepted by the Administrator

The final rule replaces many prescriptive regulations with performance-based rules, giving industry greater flexibility to develop means of compliance that meet their objectives while maintaining public safety. Where possible, the FAA has adopted performance standards, and considered the prescriptive requirements for placement in advisory circulars (AC) that will identify possible means of compliance, but not the only means of compliance, with part 450. The goal of this approach is to afford the industry and the FAA the added flexibility of using new methods to better enable future innovative concepts and operations. Compliance with the performance requirements in part 450 may be demonstrated by using a means of compliance that is accepted by the FAA.[10] Means of compliance may be government standards, industry consensus standards, or unique means of compliance developed by an individual applicant. During pre-application consultation, the FAA will work with applicants on compliance planning. The FAA will review the submitted means of compliance to determine whether they satisfy the regulatory safety standard.

For five requirements, an applicant must use a means of compliance the FAA has accepted in advance of submitting an application. Those requirements for which an applicant must use an accepted means of compliance in advance are identified in § 450.35 and include Flight Safety Analysis methods, airborne toxic concentration and duration thresholds for any toxic hazards for flight, highly reliable flight safety systems, lightning commit criteria, and airborne toxic concentration and duration thresholds toxic hazard mitigation for ground operations. For all other performance-based requirements, an applicant may include an accepted means of compliance or a means of compliance the FAA has not yet accepted as part of its application for the FAA to review during application evaluation. The FAA will publish any publicly available means of compliance that it accepts. An operator may request that the FAA publish the operator's unique means of compliance, once reviewed and accepted. The FAA anticipates other people or entities other than applicants may wish to submit a proposed means of compliance, such as operators that plan to be applicants in the future, and voluntary consensus standards bodies. The final rule allows these entities to request acceptance of a proposed means of compliance outside a license application.

5.4 Scope of License: Beginning and End of Launch and Reentry

A vehicle operator license authorizes a licensee to conduct one or more launches or reentries using the same vehicle or family of vehicles. The scope of a part 450 license offers additional flexibly compared to legacy regulations. An applicant must identify any pre- and post-flight ground operations at a U.S. launch site sufficient for the Administrator to determine the scope of activities authorized under the license. Activities that qualify as hazardous pre-flight operations, include but are not limited to, pressurizing or loading of propellants into the vehicle or launch system, operations involving a fueled launch vehicle, the transfer of energy necessary to initiate flight, or any hazardous activity preparing the vehicle for flight. To accommodate reusable vehicles, hazardous pre-flight operations do not include the period between the end of the previous launch and launch vehicle reuse when the vehicle is in a safe and dormant state. The end of launch or reentry includes language for impact and landing to encompass a broader range of activities because landing includes a soft vertical landing or runway landing of a vehicle or component, whereas impact is more accurate to describe a hard landing of a stage or component. The FAA also retains the ability to determine that licensed oversight is unnecessary for certain activities if the Administrator determines that they do not jeopardize public health and safety, safety of

property, and the national security and foreign policy interests of the United States.

5.5 Eliminating Duplicative Requirements When Launching From a Federal Range

The FAA has addressed concerns regarding duplicative government requirements through its largely performance-based requirements for both ground and flight safety that an operator could meet using Air Force and NASA practices as means of compliance.

In the final rule, an operator need not comply with the ground safety requirements contained in §§ 450.181 (Coordination with a Site Operator) through 450.189 (Ground Safety Prescribed Hazard Controls) if the conditions in § 450.179(b) are met. In making this change, the FAA preserves its statutory jurisdiction over those ground safety activities that are part of launch and reentry, but recognizes certain Federal processes and procedures as sufficient to meet the FAA's mandate. Under § 450.179(b), an operator is not required to comply with the ground safety requirements of part 450 if:

- The launch or reentry is being conducted from a Federal launch or reentry site;
- The operator has contracted with the Federal launch or reentry site for ground safety services or oversight; and
- The Administrator has determined that the Federal launch or reentry site's ground safety processes, requirements and oversight are not inconsistent with the Secretary's statutory authority over commercial space activities.

In making a determination to accept a Federal site's processes without specific compliance with ground safety regulations, under § 450.179(c), the Administrator will consider the nature and frequency of launch and reentry activities conducted from the Federal launch or reentry site, coordination between the FAA and the Federal launch or reentry site safety personnel, and the Administrator's knowledge of the Federal site's requirements. The FAA has made a determination that the following site's ground safety processes, requirements, and oversight are not inconsistent with the Secretary's statutory authority over commercial space activities:

- Cape Canaveral Space Force Station;
- Vandenberg Space Force Base;
- Wallops Flight Facility; and
- Kennedy Space Center.

For flight safety, the FAA will accept any safety-related launch or reentry service or property provided by a Federal launch or reentry site or other Federal entity by contract, as long as the FAA determines that the launch or reentry services or property provided satisfy this part in accordance with § 450.45(b). If the FAA assesses a Federal launch or reentry site and finds that an applicable safety-related launch service or property satisfies FAA requirements, then the FAA treats the Federal site's launch service or property as that of a launch operator's, and there is no need for further demonstration of compliance to the FAA. The FAA reassesses a site's practices only when the site changes its practice.

5.6 Critical Asset Protection

The final rule codifies current practice at Federal launch or reentry sites to protect critical assets that are of utmost importance to the U.S. and to extend the same protections for launch or reentry activity conducted at non-Federal sites. For launches from Federal sites, part 450 does not change current practice; rather it incorporates that practice in a regulation. This regulation consolidates the FAA's requirements for protection of critical assets and critical payloads in all commercial launch or reentry operations, in accordance with the FAA's statutory authority. Part 450 reduces the need for a Federal or non-Federal site operator to impose critical asset protection requirements on operators as a contractual condition for the use of its facility.

Critical assets are identified and evaluated by the government. Critical assets will be identified by Federal agencies, such as DOD and NASA, which own or otherwise depend on assets that are essential to the national interests of the United States, and the FAA will accept any identification by the Secretary of Defense that an asset is critical to national security. Note also that the FAA does not limit the definition of "critical assets" to assets that are owned or located on property owned by the U.S. Government. The FAA extended the protection of critical assets to non-Federal launch or reentry sites, which previously had no regulatory assurance of protection from loss of functionality of critical assets.

The FAA maintains the same safety standards for critical assets for launches that take place on a Federal launch or reentry site as those that take place on a non-Federal launch or reentry site, some of which are dual use, supporting both commercial and military operations. An operator does not need to

calculate risks to critical assets or provide any information on critical assets. The final rule only requires operators to add flight commit criteria that include confirmation from the FAA that the risk to critical assets satisfies the critical asset risk requirements.

5.7 Neighboring Operations Personnel

The final rule carves out separate individual and collective risk criteria for neighboring operations personnel to reduce the need to clear or evacuate other launch operator personnel during a commercial launch or reentry operation. Under the legacy regulations, an operator may be required to clear anywhere from a handful of employees to over a thousand employees from a neighboring site for a significant portion of a day. Neighboring operations personnel would still be members of the public, but would be subject to different individual and collective risk criteria. The rule enables neighboring operations personnel to remain within safety clear zones and hazardous launch areas during flight as long as their risk does not exceed the newly designated thresholds.

In the final rule, the FAA notes that the Federal or licensed site operator will determine those personnel who are eligible for neighboring operations personnel status in coordination with the launch operators, because the site operator is in the best position to identify which personnel are required to perform safety, security, or critical tasks at the launch site. Further, both the launch or reentry operator and the neighboring site operator benefit from this treatment of neighboring operations personnel. The designation of neighboring operations personnel is optional for FAA-licensed or exclusive use site operators.

5.8 High Consequence Event Protection

The use of high consequence event protection represents the a significant change from our legacy regulations because it introduces a new safety criteria pertaining to low probability, high consequence events and provides a means by which an operator can demonstrate that expensive, highly reliable flight safety system design and testing may be unnecessary to protect public safety. Conditional expected casualties (CE_C) is the quantitative criteria used to determine the need for flight abort as a hazard control strategy, setting reliability standards for a flight safety system, and determining when to initiate a flight abort. An applicant may use an equivalent level of safety to propose an alternative way to measure high consequence events other than by CEC. The final rule also allows multiple ways an applicant may protect against a low probability, high consequence event in uncontrolled areas for each phase of flight using either flight abort, demonstrating that CEC is below a certain threshold without flight abort, or establishing the launch or reentry vehicle has sufficient demonstrated vehicle reliability in consideration of CEC. The final rule allows an operator in certain circumstances to use a method other than flight abort to protect against high consequence events.

5.9 Flight Safety System (FSS) Tiers and Requirements

The final rule requires all FSS not required to meet the highly reliable FSS requirements in § 450.145 to meet the safety-critical systems requirements in § 450.143. This tiered regulatory approach should support ongoing innovation in the development of FSS. The commercial space transportation industry has continued to mature and operators have proposed FSS alternatives. These alternative approaches include fail-safe single string systems that trade off mission assurance and redundancy, other fail-safe consequence mitigation systems, and dual-purpose systems such as FSS that reuse the output of safety-critical GPS components for primary navigation avionics. For operations in which the consequence of a flight failure is lower, the FSS, while still being reliable, may not need to be as highly reliable as an FSS for a vehicle operating in an area where the consequence of a flight failure is higher. In order to make regulations adaptable to innovative operations while maintaining appropriate levels of safety, the FAA allows an FSS with less demonstrated design reliability for operations with lower potential consequences.

5.10 Safety-Critical Systems

A system is safety critical if its performance is essential to safe performance or operation. The safety-critical system requirements in § 450.13 covered fault tolerance, qualification testing, acceptance of hardware, and lifecycle management for all safety-critical systems except for highly reliable flight safety systems covered under § 450.145.

Additionally, to provide increased flexibility without reducing safety, the final rule also excludes certain safety-critical systems from the requirements of § 450.143 if an operator demonstrates through its flight

hazard analysis that the likelihood of any hazardous condition specifically associated with the system that may cause death or serious injury to the public is extremely remote, pursuant to § 450.109(b)(3). That is, the operator must show that specific requirements in § 450.143, which ensure that the system will function reliably, are not entirely necessary to mitigate the hazards specifically associated with the system to an extremely remote level.

5.11 Computing Systems

In the final rule, the FAA replaces prescriptive requirements with performance-based standards and provides increased flexibility for operators to demonstrate compliance with computing systems requirements. The final rule levies requirements for computing system safety items in proportion to their criticality rather than their autonomy; requires independent verification and validation for safety-critical computing system safety items; and retains focus on development and testing processes instead of direct inspection of software by the FAA. The FAA removed prescriptive requirements to increase flexibility in application to current and future computing system designs. The rule requires the identification and assessment of the public safety-related computing system requirements, functions, and data items, in order to streamline the evaluation of computing system safety. The explicit identification of the public safety related aspects of computing systems enables a reduction in the scope of FAA's evaluation compared to the legacy regulations.

5.12 Airworthiness Certifications

Part 450 accommodates all vehicle operators, including air-launched hybrid vehicle operators by providing performance-based requirements, alternatives to flight abort and flight safety analysis requirements based on demonstrated reliability, use of equivalent level of safety for the measurement of a high consequence event, and allowing application process alternatives as agreed to by the FAA. An applicant may make an equivalent level of safety case for a component of a launch vehicle, such as a carrier aircraft, if it holds an airworthiness certificate with an acceptable flight test history.

Possession of an airworthiness certificate alone does not guarantee that a vehicle or operation will have a level of reliability sufficient to meet the part 450 public safety requirements. The FAA considers other factors to determine reliability. The FAA will consider the aircraft's original certification, its current certification, and any modifications introduced through issuance of supplemental type certificates. For example, a transport category aircraft has held a standard airworthiness certificate and then been recertified to a restricted or experimental category. Any modifications to the aircraft design certification may affect the aircraft's reliability for the purposes of part 450, and the FAA therefore will take these modifications into consideration. An understanding of an aircraft's past and current operating environments and its maintenance history are also relevant to the current reliability estimate.

In addition, the FAA may consider other factors outside of certification, such as a rigorous flight test program. Some launch operators have or are developing new, purpose-built launch vehicles that may serve as a component of a hybrid launch or may be designed as rocket-powered aircraft and transitioned to licensed launch operations following flight testing. These operators may hold experimental airworthiness certificates for testing design concepts and aircraft operating techniques. Experimental airworthiness certificates may also be offered as part of a hybrid operator's application to establish the vehicle's demonstrated reliability. The FAA's Office of Commercial Space Transportation will continue to coordinate with the FAA's Aviation Safety organization on issuance of an experimental airworthiness certificate and the vehicle's developmental program to understand its demonstrated reliability.

5.13 Piloted Vehicles

The final rule adopts a definition of flight safety system, which means a system used to implement flight abort, for which a human can be a part of the flight safety system to initiate and accomplish a controlled end to vehicle flight. Most reusable launch vehicles use some method to achieve flight abort reliably, either in the form of a pilot that can safely abort flight using system controls or an automated system to terminate thrust. The FAA considers each crew member's level of pilot certification and flight experience, as well as the recency of that experience as evidence of demonstrated reliability of the launch or reentry system.[11] While part 460 requires flight crew to hold at least a private pilot certificate with an instrument rating, operators using flight crew with higher levels of certification, operationally related flight experience, and recent flight experience and training can demonstrate higher reliability. For example, a crewmember holding commercial and

airline transport pilot certificates have more flight experience and have been tested to a higher level of proficiency than a crewmember who holds a private pilot certificate. In addition, crewmembers with operationally related flight experience will have an understanding of the decision-making required for high-altitude flight and airspeed regimes, and the recent flight experience and training of all crewmembers is recognized as foundational to ensuring a safe operating environment of an aircraft or launch vehicle.

5.14 Incremental Review of Application Modules

The final rule will allow an applicant to submit an application for a safety review in modules using an incremental approach approved by the FAA. The safety review is typically the most complex part of the license application and usually involves submission of numerous documents. The FAA has concluded that a structured approach agreed to during pre-application consultation will reduce regulatory uncertainty by allowing the FAA to affirm at an early stage of development that the proposed safety measure or methodology meets the FAA's requirements. An applicant must have its incremental review approach approved by the FAA prior to submitting its application so that the FAA can ensure that the modules can be reviewed independently and in a workable order under an agreed time frame. The final rule continues to allow operators to submit the payload, policy, environmental, and financial responsibility portions of its application independently of each other.

Review of any modules prior to submittal of an application in its entirety will not initiate or be bound by the statutory review period. The review period will begin once the FAA has a complete enough application in its entirety. During pre-application consultation, an applicant seeking an incremental review may negotiate a time frame shorter than the statutory 180-day review period.

Submitting an application incrementally affords an applicant the approval of various systems and processes earlier than the current non-incremental review process. The FAA expects that the central value of an incremental approach is regulatory certainty for components of the application and flexibility for applicants rather than a reduction in overall review time. However, the FAA anticipates that a determination of an accepted application that utilizes safety element approvals or approved modules will be completed faster than a similar application that does not use safety element approvals or incremental review.

5.15 Flexible Time frames

The final rule allows an operator to propose different time frames for certain regulatory sections if "agreed to by the Administrator." The time frames adopted in the final rule are default time frames. An applicant can propose and the FAA can accept an alternative time frame. The FAA expects alternative time frames to be proposed and accepted during pre-application consultation or during the application process so that the agreed to time frames are then reflected in the license once issued. Time frames can be adjusted after a license is issued through the license modification process, as opposed to the waiver process under the current regulations. However, in most cases, the FAA expects flexible time frames to be negotiated for all the launches or reentries under the license prior to the first licensed activity.

5.16 Concurrent Safety Element Approvals

The final rule modifies part 414 to streamline the process by enabling applicants to request a safety element approval in conjunction with a license application. The FAA anticipates that a determination of an accepted application that utilizes safety element approvals or approved modules will be completed faster than a similar application that does not use safety element approvals. All launch vehicles, reentry vehicles, safety systems, processes, services, or personnel are eligible for safety element approvals.

5.17 Regulatory Tools for Flexibility

Part 450 accommodates all vehicle operators with flexibility that is primarily provided by performance-based requirements. However part 450 also incorporates a number of regulatory tools by allowing application process alternatives as agreed to by the FAA, the use of equivalent level of safety (ELOS), and waivers.

An applicant may clearly and convincingly demonstrate that an alternative approach provides an equivalent level of safety to the requirement. In theory, a performance-based regulation like part 450 could function without an ELOS provision, because, in concept, a performance-based rule allows many different means of compliance with the required safety standard. The FAA considered eliminating the ELOS provision from the final rule, but decided that eliminating the ELOS provision would remove a

useful regulatory tool that provides flexibility. Unlike means of compliance, which demonstrate compliance with the regulation, ELOS allows an applicant to propose and demonstrate a method that ensures an ELOS to the requirement, but not necessarily compliance with the requirement itself. The FAA has chosen to retain the option of ELOS to allow operators to propose unique processes and procedures. An applicant could use a safety case or other justification for ELOS.

For most of the requirements in part 450, an applicant may demonstrate an equivalent level of safety if the applicant is unable to meet a requirement. In addition, an operator may request a waiver to any requirement. An ELOS may be submitted in a license application and must clearly and convincingly demonstrate that an alternative approach provides an equivalent level of safety to the requirement. A petition for waiver must be submitted 60 days in advance and address why granting the request for relief is in the public interest and will not jeopardize the public health and safety, safety of property, and national security and foreign policy interests of the United States.

For some requirements, the FAA anticipated the need for additional regulatory flexibility without the burden of providing an equivalent level of safety or applying for a separate waiver. For those requirements, the FAA has incorporated the clause "as agreed to by the Administrator" to mean that an operator may submit an alternative to the proposed requirement to the FAA for review. Unlike an ELOS determination, an applicant need not demonstrate that this alternative satisfies an ELOS to the requirement. For each requirement where the FAA has provided additional flexibility by including the "as agreed to by the Administrator" clause, the FAA has also provided criteria that the Administrator will consider in determining whether to approve the alternative approach, including safety considerations when appropriate. For example, an alternative time frame will generally be accepted if it provides sufficient time for the FAA to review the submittal. These alternatives will typically be agreed to in pre-application consultation.

6. Next Steps:

Performance based regulations can present a challenge when it comes to determining what is an acceptable means to comply with a regulation. FAA is committed to publishing guidance documents to detail possible means of compliance to the more-flexible performance-based regulations.[12] With previous performance-based regulations, the FAA has received comments that some regulated entities (especially small companies) do not know how to comply with regulations that do not contain more specific direction on what is acceptable. It is necessary for the FAA to offer that guidance, but the FAA is seeking to move that information out of prescriptive regulations and into FAA advisory circulars. Some of the identified means of compliance are also likely to be existing governmental or industry standards. These advisory circulars or identified standards will ameliorate some of the ambiguity of performance-based rules and will give potential applicants at least one means of compliance that will be accepted by the FAA. As guidance, advisory circulars and accepted standards will pave the way for innovative approaches and means of compliance tailored to new operational practices enabled by outcome-based regulations. This approach recognizes that it is significantly easier to update guidance documents as safety practices change than it is to update regulatory language.

The FAA anticipates that as the industry matures, standards that can be used as means of compliance will be developed by operators, academia, and the government. Such standards would be voluntary and can be evaluated to determine compliance with performance based regulations. Once a standard is evaluated, it can be used by an operator to meet a regulation. The FAA intends to publish a list of acceptable means of compliance, including standards, on the AST website. As additional means of compliance become available, the FAA will update the published list.

Allowing operators to continue to operate under parts 417, 431 and 435 for up to 5 years presents unique challenges. Parts 417, 431, and 435 will continue to exist for 5 years after part 450 becomes effective. Operators can renew their licenses until the 5-year period expires. The FAA will not extend any renewals past the 5-year period. Regulations on collision avoidance and critical asset requirements contained in part 450 will still have to be complied with even if operating under parts 417, 431, or 435. Although the FAA is allowing this 5-year transition period, any operator that currently complies with parts 417, 431, or 435 would be in compliance with part 450. Part 450 allows additional flexibility and reduced requirements for some operations.

Operators that gain an advantage under part 450 are expected to transition quickly, other operators will

transition as they become familiar with part 450 and learn how to comply with the performance based regulations using existing practices. The FAA will monitor how effective part 450 is at allowing innovation while preserving public safety. Lessons learned from the implementation of part 450 will be used to inform a future rulemaking to make any adjustments necessary to ensure the regulatory framework functions as expected and public safety is maintained.

7. Conclusion

Through regulatory flexibility, enabled by performance-based regulations and requirements that are more adaptable to evolving business practices, the FAA seeks to open the door for a 21st century licensing process that can approve exciting new technologies for the growing launch and reentry industry. Improved processes for approving commercial space transportation operations clears the path for our economy and our future, while never losing sight of our responsibility to safeguard the public. The FAA hopes to build a regulatory regime that can unleash American innovation and secure the promises made about the potential of these exciting times.

References

[1] Part 450 FAA regulations can be found at: https://www.faa.gov/space/legislation_regulation_guidance/ The Final Rule is available at: https://www.govinfo.gov/content/pkg/FR-2020-12-10/pdf/2020-22042.pdf
Additional information is at: https://www.faa.gov/space/streamlined_licensing_process/

[2] 51 USC Chapter 509 is available athttps://www.faa.gov/space/legislation_regulation_guidance/

[3] Executive Order 12465 was signed by President Reagan in February 1984, before Congress passed the Commercial Space Launch Act of 1984. The Executive Order designated the Department of Transportation (DOT) as the lead agency within the Federal government for encouraging and facilitating commercial ELV activities by the United States private sector. In 1995, the Office of Commercial Space Transportation was transferred from the DOT Office of the Secretary to within the Federal Aviation Administration.

[4] See "Certification Versus Licensing for Human Space Flight in Commercial Space Transportation," Federal Aviation Administration, IAC-12-D6.1.3, (2012 International Astronautical Congress) Available at: https://www.faa.gov/space/additional_information/international_affairs/

[5] Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing Regulations, Final Rule. 65 FR 56617, Federal Register, Vol. 65, No. 182, September 19, 2000. See: https://www.federalregister.gov/documents/2016/08/30/2016-20815/commercial-space-transportation-reusable-launch-vehicle-and-reentry-licensing-regulations-technical

[6] "Space Policy Directive-2 Streamlining Regulations on Commercial Use of Space," The White House, May 24, 2018. https://www.federalregister.gov/documents/2018/05/30/2018-11769/streamlining-regulations-on-commercial-use-of-space

[7] Ibid.

[8] Ibid.

[9] The Final Rule is available at: https://www.govinfo.gov/content/pkg/FR-2020-12-10/pdf/2020-22042.pdf The part 450 rulemaking docket can be found at: https://www.regulations.gov/docket?D=FAA-2019-0229/

[10] The FAA maintains a Part 450 Means of Compliance Table at: https://www.faa.gov/space/streamlined_licensing_process/media/Part_450_Means_of_Compliance_Table_with_dates.pdf

[11] For Flight Safety Analysis (FSA) purposes, the vehicle failure probability accounts for any failure of the launch or reentry system because of the way failure is defined in § 450.131(b). In the context of FSA, any failure of the launch or reentry system, including pilot error, that produced vehicle failure as defined in § 450.131(b) must be accounted for to establish the demonstrated reliability. Therefore, the FAA would consider the pilot experience and training in making a demonstrated reliability determination.

[12] Guidance documents related to Part 450 and other regulations are available at: https://www.faa.gov/space/legislation_regulation_guidance/