COMMENTS TO HUMAN SPACE FLIGHT APPLICATION CHECKLIST

General Comments:

Organization: since compliance matrices have been developed for each of the applicable regulations including Part 460, recommend guidance be formatted as a text document, with emphasis on means of compliance. Recommend a structure/sequence for occupant safety that aligns with equivalent Part 450 sections to allow mapping of related requirements, such as:

- Policy Review: (number of occupants, crew/SFP ratio, docking orbital station(s) owner/operator, ITAR, etc.
- Safety Review: systems with manual command capability, description of ECLSS, occupant systems, provisions, emergency equipment, escape systems, thermal/radiation/debris shielding, etc.
- Safety Criteria: human factors design, survivability, protection against occupant hazards
- System Safety: occupant hazard analysis, public safety [delta] analysis for occupant error and contingency landing/escape
- Occupant Safety Analysis: vehicle record, human flight record, probability of occupant casualty
- Prescribed Hazard Controls: agreements, occupant qualifications (general, crew, and SFP), occupant readiness, communication with control center, additional factors in launch/reentry commit criteria, collision avoidance criteria for occupied vehicles, additional mishap notifications, terms and conditions

For means of compliance, recommend each section reference applicable standards, such as International Environmental Control and Life Support System Interoperability Standards (IECLSSIS), ASTM standards, and many of the references cited in sections 2.1 and 2.2 of CCT-Req-1130 (combination of government and commercial standards).

Part 460 requirements should stand on their own, independent of licensing and permitting regulations focused on public safety. This would also enable evolution into any future framework for licensing of a commercial orbital platform.

Definitions:

- Distinguish between safety-critical for public safety and occupant safety
- Add definition of occupant as generic term that includes both crew and SFPs who inhabit a vehicle
- Describe roles/authority currently assumed to be accomplished by the Pilot that could apply whether or not they have control of vehicle maneuvering: situational awareness of vehicle performance, life support and emergency systems, occupant safety, public safety (could apply to a non-pilot lead crew member)
- Amend definition of crew (reference *49 U.S.C. § 70102(2)*) to refer to “any person who is onboard a launch or reentry vehicle and performs activities directly relating to the launch, reentry, or other operation of or in a launch vehicle or reentry vehicle that

carries human beings." This accounts for various contractual arrangements without impacting crewmember responsibilities and requirements.

Requirements: Many system capabilities critical to occupant safety and crew control of public risk need to be addressed or expanded in detail. Consistent with recent rulemaking efforts, it is critical that such capabilities be expressed as minimally necessary performance-based criteria vs. prescriptive requirements. These capabilities/areas of focus could potentially include:

- System Safety:
  - Occupant hazard analysis (including cargo)
  - Human (crew and SFP) error-induced failure analysis
  - Failure tolerance to catastrophic events
- Human Factors:
  - Environments: acceleration, vibration, thermal, radiation, noise, space debris
  - Vehicle/occupant systems design: ECLSS, restraints, masks, pressure suits, emergency lighting, flotation devices
  - Occupant provisions (based on mission duration): potable water, nutrition, biowaste, bathing, clothing
  - Entry/egress at launch/landing location
  - Sleep cycles
- Monitor and Control:
  - Crew ability to locally monitor and control occupant safety and life support systems, and environments critical to occupant safety.
  - Recording safety-critical health and status data
  - Vehicle tracking
- Operations:
  - Crew must be on flights with SFPs (precludes solely remote or autonomous operation)
  - Communications coverage for vehicles in flight
  - Pre- and post-flight SFP entry/securing/egress, including assistance (as needed) and accommodations for deconditioned occupants.
  - Occupant recovery following flight abort

COMMENTS TO HUMAN SPACE FLIGHT APPLICATION CHECKLIST

14 CFR Part 460
Human Space Flight – Application Checklist

RESPONSIBILITIES OF LICENSEE and PERMITTEE CHECKLIST

Version 2.0
1/4/2008

COMMENTS TO HUMAN SPACE FLIGHT APPLICATION CHECKLIST

14 CFR Part 460
Human Space Flight – Application Checklist

Item #	✓	Section Number	Application Requirement	Detailed Requirements
			Sections from License or Experimental Permit Application	
1		**415.8**	**Human Space Flight (Launch License)**	**To obtain a launch license, an applicant proposing to conduct a launch with flight crew or a space flight participant on board must demonstrate compliance with 460.5, 460.7, 460.11, 460.13, 460.15, 460.17, 460.51 and 460.53.**
		431.8	**Human Space Flight [Reusable Launch Vehicle - RLV)]**	**To obtain a license, an applicant proposing to conduct a reusable launch vehicle mission with flight crew or a space flight participant on board must demonstrate compliance with 460.5, 460.7, 460.11, 460.13, 460.15, 460.17, 460.51 and 460.53.**
		435.8	**Human Space Flight (Reentry Vehicle Other than an RLV)**	**An applicant for a license to conduct a reentry of a reentry vehicle other than an RLV with flight crew or a space flight participant on board the vehicle must demonstrate compliance with 460.5, 460.7, 460.11, 460.13, 460.15, 460.17, 460.51 and 460.53.**
		437.21 (b)(3)	**Human Space Flight (Experimental Permit)**	**To obtain a permit, an applicant proposing launch or reentry with flight crew ~~or a space flight participant~~ on board a reusable suborbital rocket must demonstrate compliance with 460.5, 460.7, 460.11, 460.13, 460.15, 460.17, 460.51 and 460.53.**
			Crew Qualifications and Training	
2		460.5 (a)(1)	Crew training for public safety	Each Crew Member must: ● Complete training on their role on board and/or on the ground so that the vehicle will not harm the public.
3		460.5 (a)(2)	Crew training in nominal and non-nominal conditions	Each crew member must train for their role in nominal and non-nominal conditions including: ● Abort scenarios ● Emergency Operations
4		460.5(b)	Crew ability to withstand stresses of space flight	Each member of the flight crew must show their ability to withstand stresses of normal space flight (e.g. accelerating or deceleration, microgravity, and vibration) and still be able to carry out their duties so that the vehicle will not harm the public.
5		460.5 (c)(1-2)	Pilot and remote operator qualifications	Pilot and Remote Operators must possess the following items and knowledge:

Commented [A1]: Replace first three references with Part 450 requirements since applications are no longer being accepted under legacy regulations.

Commented [A2]: Per 460.17, verification, SFPs may not fly prior to completion of verification and successful flight of the mission profile. This seems inconsistent with eligibility for an experimental permit per 437.5.

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Human Space Flight – Application Checklist

				1) Possess and carry an FAA pilot certificate with an instrument rating 2) Possess aeronautical knowledge and experience necessary to pilot and control the launch or reentry vehicle that will operate in the National Airspace System (NAS)
		460.5 (d)~~e~~	Remote operator equivalent level of safety	Remote operator may demonstrate an equivalent level of safety to §460(c)(1) of through the license or permit process
6		460.5 (c)(3)	Pilot and remote operator training	Pilot and remote operator must receive vehicle and mission specific training for each specific phase of flight by using **one or more** of the following methods: ● A method or device that simulates the flight ● An aircraft whose characteristics are similar to the vehicle or that has similar phases of flight to the vehicle ● Flight testing ● An equivalent method of training approved by the FAA through the license or permit process
		460.5 (c)(4)	Pilot and remote operator training	If required as a hazard control strategy, pilot and remote operator m~~M~~ust train in procedures that direct the vehicle away from the public in the event the flight crew abandons the vehicle during flight
		460.5 (c)(5)	Pilot and remote operator training	Must train for each mode of manual control or propulsion, including any transition between modes, such that the pilot or remote operator is able to control the vehicle
7		460.5(e)	Medical requirements for crew member	Each **crew member with a safety-critical role** must possess and carry an FAA second-class airman medical certificate issued in accordance with 14 CFR part 67, no more than 12 months prior to the month of launch and reentry
Operator Training of Crew				
8		460.7(a)	Implementation of training.	Operator must train each member of its crew and define standards for successful completion in accordance with 14 CFR 460.5
9		460.7(b)	Training device fidelity	Operator must: ● Ensure that any crew-training device used to meet the training requirements realistically represents the vehicle's configuration and mission, or ● Inform the crew member being trained of the differences between the two.

Commented [A3]: This requirement is overly prescriptive. As with the remote operator equivalent level of safety provisions in 460.5(d), considering innovative software-driven vehicles without real-time control, FAA pilot certification should not be required if the vehicle is automated AND the pilot has no capability to command guidance and control systems. In such a case, an experienced space operations professional, such as a mission specialist astronaut or senior spaceflight controller may be equally qualified to monitor and report system status, control the local environment, direct crew/SFP actions, and evaluate commit criteria. On-orbit, pilot qualification requirements may be driven by host station owner/operator requirements, but orbital maneuvering and docking is vastly different from the aviation skills an FAA pilot certificate ensures, and requires extensive space operations training.

Commented [A4]: This capability is N/A for most vehicles, as steering is generally autonomous and some vehicles may lack escape capability. The real requirement is for the system, including pilot if applicable, to minimize public safety risk when occupant safety requires emergency procedures. This would remain an operational requirement, but verification may rely more on system safety analysis than operator training.

Commented [A5]: Is "safety-critical" role limited to public safety? If it includes occupant safety, crew members may not be pilots--can a non-pilot even acquire such a medical certificate?

Commented [A6]: This needs to address provisions for extended missions. Even if a medical certificate is issued only a few months before launch, mission duration and potential launch delays may leave little or no margin for reentry within 12 months of issue. Even if they can, is doesn't seem truly necessary. What is the real requirement – that they be healthy enough to perform the operation? If so, it should be stated in such performance based terms, not in a prescriptive manner.

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10		460.7(c)	Maintenance of training records	Operator must: ● Continually update the crew training to ensure that it incorporates lessons learned from training and operational missions. ● Track each revision and update in writing and ● Document the completed training for each crew member and maintain the documentation for each active crew member
11		460.7(d)	Current qualifications and training	Operator must establish a recurrent training schedule and ensure that all crew qualifications and training required by 460.5 are current before launch and reentry
Environmental Control and Life Support Systems				
12		460.11(a)	Environmental Control and Life Support System (ECLSS) pertaining to the vehicle	Operator must provide atmospheric conditions adequate to sustain life and consciousness for all inhabited areas within a vehicle. Operator or flight crew must monitor and control the following atmospheric conditions in the inhabited areas or demonstrate through the license or permit process that an alternate means provides an equivalent level of safety. ● Composition of the atmosphere, which includes oxygen and carbon dioxide, and any revitalization ● Pressure, temperature and humidity ● Contaminants that include particulates and any harmful or hazardous concentrations of gases, or vapors ● Ventilation and circulation
13		460.11(b)	Redundant oxygen supply	Operator must provide an adequate redundant or secondary oxygen supply for the flight crew.
14		460.11(c)	Preventing cabin depressurization	Operator must: ● Provide a redundant means of preventing cabin depressurization; or ● Prevent incapacitation of ~~any of the flight crew~~ occupants in the event of loss of cabin pressure
15		460.13	Smoke detection and fire suppression	Operator or crew must have the ability to detect smoke and suppress a cabin fire ~~to prevent incapacitation of the flight crew~~.
16		460.15	Human factors	Operator must take the precautions necessary to account for human factors that can affect a crew's ability to perform safety-critical roles in the following areas ~~by~~:

Commented [A7]: This section should be broader to include other aspects of vehicle design that are necessary for human flight. See general comments above.

Commented [A8]: This assumes a traditional system design; to address a variety of design concepts (including using air vs. pure oxygen), the requirement should be stated in terms of fault tolerance (for example: any systems critical to occupant safety—for which failure has catastrophic consequences must be dual fault tolerant or show reliability of .999 at 95% confidence.

Commented [A9]: This is better stated under a general system requirement such as: any failures critical to occupant safety (i.e., with catastrophic consequences as determined by hazard analysis) must be dual fault tolerant, including to human error. Emergency systems should not function as an element of failure tolerance. In the event loss of cabin pressure doesn't endanger occupants (such as potentially for suborbital flight), it's not catastrophic and masks could would be considered an adequate control.

Additionally, the first bullet is only a method of satisfying the true requirement stated in the second bullet. Normalizing performance requirements will ensure the true requirement is met while allowing discretion in how it's accomplished.

Commented [A10]: The purpose of smoke and fire suppression extends beyond flight crew incapacitation to overall occupant safety

Commented [A11]: Human factors is a common need for all occupants, not just crew. Neglect of human factors can result in casualties onboard as well as threats to public safety by inadvertent SFP errors.

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				• Design and layout of seating, restraints, crew displays and controls • Mission planning, including analyzing tasks and allocating functions between humans and equipment, and limiting flight environments • Restraint or stowage of all individuals and objects in a vehicle, and • Vehicle operation, so that vehicle will be operated in a manner that ~~flight crew~~occupants can withstand any physical stress factors, such as acceleration, vibration, and noise
17		460.17	Verification program	Operator must successfully verify the integrated performance of a vehicle's hardware and any software in an operational flight environment before allowing any space flight participant on board during a flight. Verification must include flight testing.
18		460.51	Space flight participant training	Operator must train each space flight participant before flight on how to respond to emergency situations, including smoke, fire, loss of cabin pressure, and emergency exit.
19		460.53	Security	Operator must implement security requirements to prevent any space flight participant from jeopardizing the safety of the flight crew or the public. A space flight participant may not carry on board any explosives, firearms, knives, or other weapons.

Commented [A12]: This implies that only a licensed mission--not a permitted mission—may carry SFPs, conflicts with checklist item #1 reference to Part 437.21 (b)(3). See related comment above.

RESPONSIBILITIES OF LICENSEE and PERMITTEE CHECKLIST

Commented [A13]: Reference comments to Informing Crew and SFPs of Risk

14 CFR Part 460
Human Space Flight – Responsibilities of Licensee and Permittee

Item #	✓	Section Number	Application Requirement	Detailed Requirements
1		460.9	Informing crew of risk	If a vehicle will not be government certified for human spaceflight by launch, the o~~O~~perator must inform in writing any~~-~~ individual serving as crew that the U.S. Government has not certified the ~~launch vehicle and any reentry~~ vehicle as safe for carrying ~~flight crew or space flight participants~~occupants. An operator must provide this information: ● Before entering into any contract or other arrangement to employ that individual as a crewmember or ● For any employed crew member ~~employed as of December 23, 2004~~, as early as possible and prior to any launch in which that individual will participate as crew.
2		460.19	Crew waiver of claims against U.S. Government	Each member of a flight crew and any remote operator must execute a reciprocal waiver of claims with the FAA of the DOT in accordance with the requirements of part 440. (Financial Responsibility)
Operator informing space flight participant of risk				
3		460.45(a)	Informing space flight participant of risk	Before receiving compensation or making an agreement to fly a space flight participant, an operator must: ● Inform each space flight participant in writing about the risks of the launch and reentry including the safety record of the launch or reentry vehicle type ● Information must be presented in a manner that can be readily understood by a space flight participant with no specialized education or training.
4		460.45 (a)(1-3)	Risk disclosure in writing	The written disclosure must include: ● For each mission, each known hazard and risk that could result in a serious injury, death, disability, or total or partial loss of physical and mental function ● That there are hazards that are not known and ● That participation in space flight may result in death, serious injury, or total or partial loss of physical or mental function

Commented [A14]: While FAA doesn't perform certification, it cannot be assumed that vehicles will not be HSF certified. The extremely robust NASA certification process exceeds Part 460 design, test, and operations requirements and serves as means of compliance. Even in the absence of FAA certification, NASA HSF certification should be recognized as US government certification, representing compliance with FAA HSF requirements. With interagency agreements in place, this reduces the burden on industry and avoids duplication on the government side.

Commented [A15]: General: consistent with the 401.5 definition of crew and part 440, clarification should be provided up front that crew requirements do not apply to government astronauts assigned as crewmembers.

Commented [A16]: To simplify language consistent with streamlined licensing requirements, remove references to vehicle classification (ELV or RLV); what matters is that crew will ride in or on the vehicle.

Commented [A17]: The term "occupant" simplifies language in discussion of common attributes or requirements. Categorizing by crew, SFP, or government astronaut is only necessary when covering distinct requirements of each.

Commented [A18]: It's possible that a qualified individual is already employed by the operator in a different capacity.

Commented [A19]: Clarify that this is for non-government flight crew. For a commercial remote operator, clarify if this pertains to each individual or if the waiver can be executed by a company to cover its employee(s).

5		460.45 (b)	U.S. Government has not certified vehicle as safe	Operator must inform each space flight participant that the United States Government has not certified the launch vehicle and any reentry vehicle as safe for carrying crew or space flight participants
6		460.45 (c)	Safety record of all vehicles that have carried humans	Operator must inform space flight participant of the safety record of all launch or reentry vehicles that have carried one or more persons on board, including both U.S. government and private sector vehicles. This information must include: ● Total number of people who have been on a suborbital or orbital space flight and total number of people who have died or been seriously injured on these flights, and ● Total number of launches and reentries conducted with people on board and number of catastrophic failures of those launches and reentries
7		460.45 (d)	Safety record of operator's vehicle	Operator must describe the safety record of its vehicle to each space flight participant. Operator's safety record must cover launch and reentry accidents and human space flight incidents that occurred during and after vehicle verification performed in accordance with 460.17, and include: ● Number of vehicle flights ● Number of accidents and human space flight incidents as defined by section 401.5 and ● Whether any corrective actions were taken to resolve these accidents and human space flight incidents
8		460.45 (e)	Space flight participant requesting additional information	Operator must inform a space flight participant that he or she may request additional information regarding any accidents and human space flight incidents reported
9		460.45 (f)	Opportunity for space flight participant to ask questions	Before flight an operator must provide each space flight participant an opportunity to ask questions orally to acquire a better understanding of the hazards and risks of the mission
10		460.45 (f)(1-3)	Space flight participant written consent	Each space flight participant must provide consent in writing to participate in a launch or reentry. Written consent must: ● Identify the specific launch vehicle the consent covers ● State that the space flight participant understands the risk, and his or her

Commented [A20]: Consistent with comments to Informing Crew and SFPs of Risk, recommend FAA define acceptable time limits for oral questions from SFPs. Time could vary based on flight frequency, orbital vs. suborbital, or timing/duration of SFP training. Acceptable limits could also be event based vs. time based.

				presence on board the launch vehicle is voluntary • Be signed and dated by the space flight participant
11		460.49	Space flight participant waiver of claims against U.S. Government	Each space flight participant must execute a reciprocal waiver of claims with the FAA of the DOT in accordance with the requirements of part 440 (Financial Responsibility)