# Experimental Rocket Propulsion Society
# COMMENTS
# on the Federal Aviation Administration's
# Notice of Proposed Rule Making:
# Docket No. FAA-1999-5535; Notice No. 99-04

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## Report Contents:

## 1.0 Executive summary

The Federal Aviation Administration (FAA) has published a Notice of Proposed Rule Making (NPRM) on the licensing of Reusable Launch Vehicles (RLVs). The Experimental Rocket Propulsion Society (ERPS), a California-based 501(c)3 organization, is developing RLV and Single Stage To Orbit (SSTO) technology, with an interest in licensing its technology to commercial enterprises. ERPS' vehicles would be subject to FAA's proposed rule. As an interested party, ERPS is submitting comments on FAA's proposal. ERPS has commented on several issues that were raised in the NPRM; a summary of the points that ERPS believes to be the most important follows.

**RLVs as a new vehicle class.** The language of the NPRM makes clear that FAA's approach to licensing RLVs resembles their approach to licensing expendable launch vehicles (ELVs). ERPS believes that within the next 15 years RLVs will become a modal transportation system more similar to airlines than to ELVs. ERPS recommends that RLVs be clearly defined as a new vehicle class separate and distinct from ELVs. ERPS further proposes that aircraft only be considered RLVs if they are exoatmospheric vehicles that depart from, and return to, the surface of the Earth, with all parts of the craft actively guided during all parts of their flights.

**Definitions of mission phases.** The proposed rule defines RLVs as having two mission phases: launch phase and reentry phase. The proposed definition of the launch phase has launch ending when payload is deployed and separated. ERPS points out that RLV missions will not always include the deployment of payload into orbit, making this definition of launch inapplicable to some missions. ERPS recommends that RLVs be defined as having three mission phases: launch phase, on orbit phase, and reentry phase. ERPS further recommends that launch phase be defined as ending when the RLV's engine stops and the desired trajectory or orbit is achieved. On orbit phase would commence at this point and last until reentry begins. Reentry phase would begin, for vehicles in low Earth orbit, at preparation for retrofire; for other vehicles, at preparation for atmospheric interface. Reentry phase would end when the vehicle's engines stop and the vehicle is properly parked.

**Flight rate.** ERPS believes that FAA's estimates of the number of RLV flights likely to take place over the next 15 years is considerably too low. ERPS estimates that RLV flight rates will be in the thousands per year, and that RLVs will most often be used for fast delivery of cargo point to point on Earth. This "massive mission model" could result in amounts of paperwork and costs per vehicle that become burdensome to FAA.

**Reentry risk threshold.** Given the reentry risk requirements FAA has proposed, ERPS calculates that few RLVs could be licensed to land anywhere on Earth. A numerical analysis of this point is included in the detailed comments section (section 4.0) of this report. ERPS believes that the risk threshold for reentry sites should be identical to the risk threshold for launch sites. ERPS further points out that, as RLVs are reusable, they can be flight tested and prove their reliability over time.

**"Freight On Board" liability model.** At present, FAA regulations state that a launch operator is responsible for payload from delivery gate until payload separation. This model works well for ELVs but is not feasible for RLVs. RLVs will, in time, be simply another modal transportation system. Every other existing modal transportation system uses a "Freight On Board" liability model, in which the "cargo" owner takes delivery of, and assumes responsibility for, the "cargo" when it leaves the factory. The RLV operator, who is merely a carrier, should not be required to assume liability for cargo when other transportation carriers are not required to do so.

The above issues, as well as others, are discussed in greater detail in the body of this report.

ERPS commends FAA for their vision in crafting the proposed rule. While many sections could benefit from being revised with the idea that RLVs are a new, distinct, class of vehicle, there are sections of the proposed rule which clearly demonstrate that FAA has thought carefully about the future of RLV technology.

## 2.0 Introduction to these comments

The Experimental Rocket Propulsion Society (ERPS) was formed in 1993 as a nonprofit, liquid fueled rocket engineering design and test team based in the San Francisco Bay area. From its inception, ERPS has focused on developing low cost, high performance rocket vehicle technology. The goal of this development is to build reusable vehicles and dramatically lower the cost of access to space by as much as two orders of magnitude.

It is our belief that vast potential for economic growth in the 21st century lies in developing space resources. The development of space resources requires that the cost of getting from Earth's surface to low Earth orbit (LEO) be reduced by orders of magnitude.

ERPS has been developing low cost, high performance, safe, reliable rocket engine technology. We have developed a new catalyst for high test peroxide (HTP). This catalyst works with 100% HTP concentrations and does not deteriorate over time. We have also been developing small scale experimental aircraft-type platforms to test, implement, and demonstrate the advantages of this approach. After many years of being the lone voice in the wilderness touting the advantages of high density propellants (HTP and kerosene), we are now seeing established aerospace companies pay significant attention to the potential opportunities available to users of high density propellants.

ERPS' current development program includes building and test flying vehicles in an incremental "push the envelope" type approach, because this provides us the best opportunity to demonstrate reliability and reusability without incurring enormous development costs. The technology that ERPS is developing is being made available for nonexclusive licensing, and at present three separate companies have spun off from ERPS to develop markets for products based on ERPS research.

ERPS' own development programs include vehicles that would be regulated by FAA's proposed rule. We believe some sections of FAA's proposed rule to be well thought out, and have indicated this  in our comments. Other sections, we believe, rely too heavily on the expendable launch vehicle (ELV) paradigm, and we have suggested improvements in these areas.

It is our belief that reusable launch vehicle (RLV) transports will, in the near future, operate on flight rates much more similar to airlines than the current launch model. This "massive mission model" of flight operations will be required for RLVs to operate properly and succeed in substantially lowering launch costs.

ERPS commends FAA for their efforts in this area, and looks forward to a mutually beneficial relationship with FAA as we work together to open this new frontier.

## 3.0 Comments on issues raised by the NPRM

ERPS wishes to comment on several issues that were raised in different sections of the NPRM. Although many of the points made in this section are also covered in the page by page comments in Section 4.0, each of the following issues is important enough and broad enough to warrant separate comment.

### 3.1 RLVs as a new vehicle class

The language used in the NPRM makes it clear that FAA's approach to licensing reusable launch vehicles (RLVs) resembles their approach to licensing expendable launch vehicles (ELVs). This is understandable, as this is where FAA's experience is. However, looking 15 years ahead, as the NPRM does, it is clear to ERPS that this approach will be ineffective and burdensome. Some of these potential difficulties can be avoided by developing distinct and appropriate definitions of ELVs and RLVs.

FAA's proposal gives the impression that FAA wishes to regulate ELVs and RLVs in the same way; that is, to have one set of rules that will regulate both classes of vehicle. ERPS does not believe this is feasible. ERPS recognizes that FAA can regulate ELVs and RLVs differently only if the two classes are unambiguously defined. Therefore, ERPS proposes the following definitions:

> **RLV:** A reusable launch vehicle is an exoatmospheric vehicle which departs from, and returns to, the surface of the Earth; with all parts of the vehicle actively guided during all phases of their flights.
>
> **ELV:** An expendable launch vehicle is a space vehicle, any part of which is discarded during flight, such that any discarded piece is unguided, or impacts the surface of the Earth, or both.

These definitions clarify the fact that RLVs constitute an entirely new class of vehicle, and require regulations distinct from existing classes of rocket vehicles.

By FAA's proposed definition, a vehicle can still be called an RLV even if it is designed to have pieces detach and remain on orbit or return to Earth unguided. But by ERPS' definition, if pieces are designed to detach from the craft and are not subsequently guided back to a safe landing, the craft cannot be considered an RLV. The space shuttle is not an RLV by ERPS' definition. Major portions of the shuttle are designed to be thrown away during flight and never reused. ERPS does not consider this to be safe, efficient, or cost effective, and surmises that many, if not most, RLV developers will see this issue the same way.

Given this definition, the risk of flying an RLV should not be greater than that of flying an ELV. The vehicle flight rate of an ELV is one, since the ELV, or at least major parts of it, is only used once. This means that the ELV must work perfectly the first time to complete its mission. An RLV, on the other hand, since it is reused, has the opportunity to develop and demonstrate reliability.

An example that shows why RLVs and ELVs need to be defined and regulated differently has to do with the definition of when a flight ends. By the current FAA definition a flight ends with the licensee's last exercise of control over the launch vehicle. This makes sense for an ELV, but for an RLV this definition can be construed to read that a flight doesn't end until the vehicle is finally and permanently retired from use. FAA should consider that RLV operations will be much closer to airline operations than ELV operations.

Another example of why it is important to define RLVs as a new class of vehicles separate from ELVs, and to regulate them differently, has to do with payload deployment. The main purpose of an ELV launch is to put a payload into orbit; this is not necessarily the purpose of an RLV mission. There are multiple other roles that an RLV may fulfill, such as carrying passengers on a tourist flight, delivering cargo point to point on Earth, performing on orbit inspection of payload, and other things that don't fit the current definition of payload deployment because they can't be done with ELVs.

Also, however FAA chooses to define RLVs, the definition should not include the tow plane, tanker, or any other support airplanes. Airplanes should not be considered RLVs even if they are part of the system that supports an RLV; support airplanes should continue to be regulated as airplanes under the appropriate FAA part. Space tugs (interorbital vehicles which never leave Earth's atmosphere) should also not be considered RLVs, nor should tugboats.

### 3.2 Definition of space

FAA has not defined an altitude where space begins. ERPS recommends that FAA adopt the Fédération Aéronautique Internationale's defined altitude of 100 km. An acceptable, although less preferable, definition to adopt would be the USAF's defined altitude of 50 miles.

### 3.3 Definitions of mission phases

ERPS recommends that FAA change its definition of reentry. FAA proposes to define the reentry phase as beginning when the launch phase ends. Launch phase is defined as ending when the payload is deployed into orbit. This makes sense for an ELV, but not for an RLV. It only makes sense for reentry to immediately follow launch if the purpose of every mission is to deploy a payload into orbit. If the RLV's mission is something other than deploying a payload into orbit, such as quickly delivering payload point to point on Earth, then by FAA's own proposed definitions of launch and reentry, the reentry phase would never begin for that mission. Since the RLV would not "deploy" its payload until it returned to the Earth's surface, technically it would return and land without ever entering a reentry phase. RLVs need to have at least three defined mission phases instead of only two: launch phase, optional on orbit phase, and reentry phase.

FAA's guidelines for ELVs define payload deployment and separation as launch operations. This makes sense for an ELV, but not for an RLV. With RLVs, launch is over when the engine stops and the desired orbit or trajectory is achieved. Deployment of payload is an on orbit operation, not a launch operation. This is because the purpose of an RLV mission is not necessarily to put a payload into orbit. An RLV may have multiple purposes for a single mission, which may or may not include deploying a payload into orbit. It doesn't make sense to consider deployment of payload to be a launch operation when it comes after orbital insertion and engine shutdown, and when it may not happen at all on a particular mission. FAA should license the launch and reentry of RLVs, not their on orbit operations.

ERPS believes that reentry begins, for vehicles in low Earth orbit, at preparation for retrofire; for other vehicles, at preparation for atmospheric interface. Examples of other vehicles include vehicles on suborbital trajectories, which do not need retrofire; vehicles in GEO, which make retrofire hours before atmospheric interface, and may not land immediately after their first atmospheric interface; and vehicles returning from the Moon, which make retrofire—called Trans-Earth Injection—days before atmospheric interface.

FAA also implies in the proposal that the next launch for an RLV begins as soon as reentry is complete. This implies that the unloading of any passengers happens after the next launch begins. The reentry phase should end when the vehicle's engines stop and the vehicle is properly parked. This is equivalent to an airline taxiing to the terminal, stopping, and shutting down its engine.

### 3.4 Flight rate

FAA proposes to license RLVs essentially the way ELVs are currently licensed: that is, for a few flights per year. ERPS believes the RLV market will support several flights per day within 15 years. This will lead to burdensome regulatory requirements if ELV-type regulations are implemented for RLVs.

If FAA's estimate, that in 15 years only a few companies will be making about seven RLV flights a year, is correct, it is unlikely that RLV technology will be developed at all. If a business attempted to raise capital based on FAA's estimate that they would fly seven missions per year, they would find it difficult to raise any money. Investors would have no reason to fund the development of new vehicles when there are existing vehicles that can already do missions at that rate.

ERPS believes that FAA's estimate of seven missions per company per year is off by orders of magnitude. ERPS envisions operation of hundreds of flights per vehicle per year, by multiple companies, within 15 years. The flight rate will eventually be many flights per day. This is because, as with airlines, operating costs (and company profitability) will be directly related to flight rates. High flight rates will allow the operator to get volume discounts on fuel, food, power, and other consumables. High flight rates will also allow the operator to amortize his fixed costs (hangar space, administration, debt service) and his sunk costs (development, construction) over more flights, thus lowering the overhead costs per flight. In addition, as with an airliner, the RLV will only make money for the company when it is flying.

From reading the proposed rule it is apparent to ERPS that the "massive mission model" has not been taken into account by FAA. FAA is (naively, in our opinion) expecting a minimal launch rate. Given the likelihood of a considerably higher actual launch rate, the costs of compliance could become burdensome to FAA. The regulatory burden will not be insignificant to either RLV operating companies or FAA.

### 3.5 Reentry risk threshold

Another problem is reentry risk. Again, FAA has drawn on their previous experience. However, FAA's previous experience involved licensing an unguided reentry vehicle, not a guided RLV; and the proposed risk threshold for reentry would preclude most RLVs from landing anywhere on dry land until FAA considers them "proven." ERPS, itself, could live with the proposed reentry risk threshold if necessary, as we plan to operate small vehicles out of unimproved sites. However, ERPS may be the only RLV developer not grievously impacted by the proposed risk threshold; so in the interests of the industry, ERPS proposes refinements in this risk threshold.

FAA proposes to require that the risk to the population in the immediate vicinity of the reentry site be no higher than "background." Background is defined as one in one million. But the launch risk is defined as 30 in one million. This imposes a risk threshold for reentry sites that is 30 times stricter than the corresponding risk threshold for launch sites. ERPS believes that the risk threshold for reentry sites should be identical to the risk threshold for launch sites; further, that this is the will of the people as expressed by the Congress in the Commercial Space Act of 1998 (HR 1702).

FAA also proposes a 100-mile buffer zone around the reentry site, to account for off-nominal reentries. This 100-mile buffer zone was required for COMET/METEOR, an unguided ballistic reentry vehicle licensed in 1992. As FAA says in the proposal (page 50, line 20), "*An uncontrolled or ballistic vehicle, such as the COMET/METEOR reentry vehicle, required a large three-sigma area because of imprecise orientation of the vehicle at the point at which reentry was initiated and the varying effects of atmospheric forces on the vehicle.*" RLVs will not be uncontrolled, the vehicle orientation at retrofire will not be imprecise, and the vehicle guidance system will compensate for the varying effects of atmospheric forces on the vehicle. RLVs are guided vehicles. Thus, while a 100-mile buffer zone may be appropriate to limit the public risk for an unguided reentry vehicle, it is overkill for a guided RLV.

Another factor involved in the reentry risk problem is that FAA recommends a vehicle probability of failure factor of one for the risk assessment.

The fourth factor in the reentry risk assessment is the vehicle casualty area. This is the area onto which the vehicle, or pieces thereof, falls. In the case of a vehicle which has not exploded or crashed, this is as follows: for vertical landers, the footprint of the vehicle; for horizontal landers, the product of the wingspan and the length of the landing roll.

When the one in one million casualty requirement, the 100 mile radius, the probability of failure of one, and the vehicle casualty area are combined, ERPS finds that most proposed RLVs could not get a reentry license to land on dry land. If the space shuttle is used as an example, the shuttle could not get a license to land anywhere in the United States, as there is no facility capable of landing the shuttle in an area with a sufficiently low population density.

A numerical analysis of this issue will follow in the detailed section, section 4.0, of this report.

### 3.6 Licensing spacecraft separately from licensing payloads

An RLV operator should not be responsible for licensing the payload; that should be done by the payload owner/operator. FAA may intend that this be so, but this is not made clear in the proposed rule. The proposed rule says that the RLV launch operator must get a payload determination, but doesn't specify from whom. FAA should clarify that the payload owner/operator is the person responsible for obtaining a payload determination from FAA. The launch operator will then be responsible for obtaining a copy of the payload determination from the payload operator in sufficient time to include it in the license application.

### 3.7 "Freight On Board" liability model

ERPS notes that every existing modal transportation system other than rocket vehicles [trucks, planes, ships, rail] uses a liability model where the payload "owner" takes delivery and assumes reliability when the "payload" leaves the factory. This is known as the Freight On Board (FOB) model. As RLVs will become just another modal transportation system, ERPS recommends that liability be assigned using the FOB model rather than the ELV model.

Currently, FAA's final rule on ELV launch licensing states that the launch operator is responsible for the payload from delivery to the launch range until payload separation. This model is not appropriate for RLVs, since RLVs will simply be another modal transportation system. RLV operations will not be limited to payload delivery to orbit; for many missions there will not even be a payload being delivered to orbit. As such, FAA's proposed definitions of mission phases, such as launch, are inaccurate.

Compared to ELV payloads, RLV payloads are likely to be much less tightly integrated into the vehicle system, if they are integrated at all. Payloads may simply be cargo; therefore, the RLV operator is merely a carrier, and should not be required to assume liability for cargo when other transportation carriers are not required to do so. ERPS proposes that "payloads" should be owned and insured by the payload owner/operator upon departure from the manufacturer, instead of being the responsibility of the launch provider.

### 3.8 Compliance costs

ERPS notes FAA's estimate that RLV license applicants will each incur first year compliance costs of $757,000, and comments that if the estimate is accurate, these costs will be burdensome for startup RLV companies. However, ERPS contrasts this compliance cost with the cost to type certify a new aircraft design: RLVs are not merely a new aircraft design; they are an entirely new class of vehicle. Under the circumstances, ERPS believes that FAA's estimate is reasonable.

As a self-funded, all volunteer nonprofit research organization, ERPS expects its compliance costs to be lower than those estimated by FAA.

### 3.9 "Impact" vs. "Landing"

ERPS notes that the reusability of an RLV is substantially reduced by a landing impact, and believes that RLV operators will not intentionally impact their vehicles upon landing. The proposed rule should be revised to reflect the fact that RLVs land, and are not intended to impact.

Although this may seem like a semantic quibble, it is important because this use of language shows that FAA is still thinking in terms of ELVs, which do impact. RLVs land, are serviced, and then are reflown, as airplanes are.

The word "impact" implies that the craft is landing in an uncontrolled fashion, and creates the impression that RLVs are dangerous and unsafe.

## 4.0 Detailed comments on the NPRM, page by page

### Page 2

*Comments Invited: "Substantive comments should be accompanied by cost estimates."*

ERPS is unclear on what costs, and whose costs, should be estimated.

### Page 5, line 14

*"...intentionally return to Earth from Earth orbit or outer space...:"*

ERPS notes that "outer space" is not defined in U.S. law, and proposes that FAA adopt either the Fédération Aéronautique Internationale's definition that outer space begins at 100 kilometers above sea level, or the USAF's definition that outer space begins at of 50 miles.

### Page 5, line 16

*"...containing landing impacts...:"*

ERPS notes that the reusability of an RLV is substantially reduced by a landing impact, and believes that RLV operators will not intentionally impact their vehicles upon landing.

**Page 6, line 10**

*"... means of terminating flight:"*

Because of the association with Flight Termination Systems aboard ELVs, ERPS suggests this be changed to "...means of abbreviating flight."

**Page 7, line 1**

*"... program must ensure that they impact Earth...:"*

Because RLVs will not impact the Earth, ERPS suggests this be changed to "program must ensure that they return to the surface of the Earth..."

**Page 7, line 5**

*"... limit risks to the public from an off-site landing, explosion or release of toxic substances."*

ERPS is pleased to note this inclusion, as the final rule on ELV licensing does not address risks from blast effects or toxic exposure on non-Federal ranges.

**Page 7, line 22**

*"Not all RLVs are reentry vehicles."*

ERPS requests clarification on this statement, as it is unclear to us how a vehicle can be reusable if it does not return to Earth, or how a vehicle can return to Earth without reentering.

**Page 14, line 3**

*"... the immediate vicinity of the landing site (that is, the area within 100 miles of the designated landing site)..."*

ERPS notes with skepticism that in the absence of thermonuclear devices, the definition of a 100 mile radius as "the immediate vicinity" is novel at best. ERPS requests clarification on FAA's basis for using a 100 mile radius in this criterion. (We suspect you pulled it out of your hat, and we want you to put it back there.)

**Page 18, line 19**

*"...deliberate intent to reenter...must exist."*

ERPS notes that licensing an applicant based on the applicant's stated intent is subject to abuse by the applicant.

**Page 19, line 8**

*"The Delta II second stage is not a reentry vehicle under the statutory definition because it was not designed to survive reentry. However, even if it were a reentry vehicle, the event would not be subject to FAA licensing jurisdiction because there was never any deliberate intent by an operator to return the Delta II second stage to Earth ...:"*

ERPS believes licensing should be based on vehicle design, not operator intent. In the example, the Delta II would not have needed a reentry license because it was not a reentry vehicle. If it had been a reentry vehicle, it would be intended—by design—to reenter and land, and should have been licensed as such. Licensing a vehicle for reentry according to its design—a reentry vehicle—would eliminate potential abuse by operators.

**Page 21, line 15**

*"... Outer Space Treaties ...:"*

ERPS is familiar with a single United Nations Outer Space Treaty (1967), and requests clarification on FAA's use of the plural in this regard.

**Page 21, line 21**

*"The measure of safety would not vary on the basis of whether an RLV's flight and return to Earth meet the statutory definition of a 'reentry:'"*

ERPS notes that this could be read to include Orbital's L-1011, Kelly's tow plane, and Pioneer's tanker as RLVs. ERPS suggests FAA clarify this verbiage so that these airplanes continue to be regulated as airplanes, by defining RLVs as "exoatmospheric".

**Page 21, line 23**

*"In other words, the public should not be exposed to greater risk because a vehicle achieves Earth orbit or outer space, or is maneuvered in its return to Earth rather than returning through ballistic flight:"*

ERPS does not understand this statement, and requests clarification.

**Page 23, line 1**

*"FAA requests public comment on the circumstances, if any, under which it may be appropriate to separately assess the reentry risks of a reentry vehicle from those presented by the entire mission of launching a reentry vehicle into space and its subsequent reentry."*

ERPS believes the single risk criterion of $E_C \leq 30 \times 10^{-6}$ is valid unless the reentry vehicle is intended to reenter after the mission license expires. Consider a hypothetical case: A SSTO RLV carries into orbit a payload that is itself a reentry vehicle (RV). The mission risk cannot exceed $E_C \leq 30 \times 10^{-6}$, even though there are three events of interest: the RLV launch, the RLV reentry, and the RV reentry. The risks for the RLV launch and reentry are allocated to the RLV operator, and the risk for the RV reentry is allocated to the payload operator. If the RLV operator and the payload operator are different persons, then they must negotiate their respective risks, so that the mission risk does not exceed $E_C \leq 30 \times 10^{-6}$. In any case, a mission license should not be granted unless and until FAA is satisfied that the mission risk is within acceptable limits.

Since the launch event precedes the other events of interest, and the RLV operator would receive the mission license, it would be incumbent on the RLV operator to certify to FAA that the mission risk is within acceptable limits.

**Page 25, line 22**

*"Most of the RLV and reentry activities currently contemplated by the aerospace industry involve very limited time on orbit."*

ERPS believes FAA should regulate RLVs, not based on the very limited capabilities of their first generation, but looking farther ahead—life and free markets evolve quickly, and current RLV limitations will soon be exceeded. Examples of such missions include, but are not limited to:

- 24 hour return to launch point missions
- multi-day science deploy and retrieve missions (e.g. Spartan 201)
- extended space station delivery/resupply missions
- delivery and retrieval of two separate satellites
- space junk removal missions
- microgravity test/production flights
- early space tourism flights

**Page 26, line 5**

*"Except for extended microgravity experimentation...regulation of on orbit activity of orbital reentry vehicles would be limited to that necessary to ensure reentry readiness, capability and safe return to a designated destination."*

ERPS notes that this could be read to mean that FAA will regulate extended microgravity experimentation. ERPS requests that FAA clarify this statement to make it clear that FAA does not intend to regulate on orbit activity not associated with launch or reentry.

**Page 26, line 8**

*"Because additional time on orbit would raise costs and otherwise interfere with RLV objectives of prompt delivery and return services, FAA envisions that the only on orbit time spent by an orbital reentry vehicle would be that required to assure reentry-readiness through reentry safety-critical system check-out and attitude and orientation adjustment for return to the reentry site."*

ERPS does not share FAA's vision in this area, and believes FAA should not regulate on this basis. In addition to extended microgravity experimentation, payload retrieval, space station resupply, tourism, astronomy, and reconnaissance are all valid orbital missions. "There are more things between heaven and Earth than are dreamt of in your philosophy." Also, for some orbital inclinations, there are missions for which vehicles with little cross range must wait for their landing site to rotate underneath their ground track.

**Page 29, line 4**

*"Accordingly, FAA defines the end of licensed launch activity for an RLV launch at deployment of a payload."*

ERPS notes that this presents problems for RLVs which will not carry payloads, as their launches would never end. ERPS proposes an alternative definition: that launch ends at the conclusion of powered flight, when the vehicle has attained its intended initial orbit, or its intended suborbital trajectory. ERPS notes that this would make payload deployment and separation an unlicensed activity, and believes this is proper—payload operations are on orbit activity, and as such ought not be subject to launch licensing.

This would have the effect of allocating launch risk differently for RLV launches than for ELV launches. Again, RLVs are an entirely new class of vehicle, and need not share the current risk allocation paradigm. The total risk associated with space launch would not change (except for secondary benefits, as from on orbit inspection of payloads prior to deployment); the same risk would merely be reallocated in that payload manufacturers, launch operators, and payload operators would not share the risks in same proportions for RLV launches as they do for ELV launches.

**Page 29, line 5**

*"The licensed reentry phase of a mission begins immediately thereafter [after the end of licensed launch activity] for vehicles that are intended to reenter when reentry-readiness is verified. In other circumstances, such as a planned or designed-in delay of reentry for an extended duration FAA requests comments on the appropriate point for commencing reentry licensing authority."*

ERPS believes that launch ends when the vehicle—not the payload—achieves its intended initial orbit or its intended suborbital trajectory.

ERPS believes that reentry begins, for vehicles in low Earth orbit, at preparation for retrofire; for other vehicles, at preparation for atmospheric interface. Examples of other vehicles include vehicles on suborbital trajectories, which do not need retrofire; vehicles in GEO, which make retrofire hours before atmospheric interface, and may not land immediately after their first atmospheric interface; and vehicles returning from the Moon, which make retrofire—called Trans-Earth Injection—days before atmospheric interface.

**Page 30, line 8**

*"A quantitative number is derived through analytic techniques in lieu of empirical launch data, because the actual number of launches of a particular type of launch vehicle is too small to be statistically significant."*

ERPS requests a definition of what would be "statistically significant" number of launches to determine reliability performance.

**Page 30, line 12**

*"Applicants will be required to utilize a system safety process. In some respects, this is similar to FAA systems approach to examining aviation systems such as that contained in 14 CFR 25.1309."*

ERPS requests clarification on whether compliance with 14 CFR 25.1309 would satisfy FAA(AST)'s requirement for a system safety process.

**Page 32, line 2**

*"Absent operational proof of vehicle reliability..."*

ERPS inquires as to what would constitute operational proof of vehicle reliability. ERPS will be conducting an incremental flight test program, and we would like to know how many flights we should allocate to FAA compliance.

**Page 32, line 13**

*"The Nuclear Regulatory Commission and the Department of Energy, for example, have made extensive use of risk analysis in analyzing, licensing, and regulating the operation of nuclear power plants; prioritizing nuclear waste disposal safety issues; and performing environmental impact analyses. The Department of Defense (DOD) also has used risk analysis to develop and test nuclear weapons systems."*

ERPS notes that neither nuclear power plants nor nuclear weapons systems are renowned for their public safety records, and is concerned that regulatory association with nuclear reactors and weapons will color RLVs as unsafe in the public perception. ERPS recommends and requests that FAA drop these references as unnecessary.

**Page 33, line 3**

*"The term 'public' for purposes of $E_C$ calculation means all persons who do not participate in the operation of the vehicle, hence, the term 'public' would not include the crew on a manned vehicle."*

ERPS applauds this clear, concise definition. This answers a long standing ERPS question about the inclusion of second parties (interested and/or invited observers) in the risk assessment: as non-essential personnel, they are included.

**Page 34, line 6**

*"Whether a system is safety critical such that a failure of the system might affect public safety would depend on a number of factors..."*

ERPS disagrees vehemently. A system cannot be conditionally safety critical. Either it is safety critical, or it isn't. What is conditional is whether or not failure of the system causes an unacceptable risk.

**Page 34, line 14**

*"The casualty area of the vehicle would consider the potential for casualties related to secondary explosions, hazardous material exposure..."*

ERPS applauds this consideration. The final rule for ELV launch licensing does not consider secondaries or toxics on non-Federal ranges. This can be bad, as was recently demonstrated in Kazakhstan.

**Page 39, line 4**

*"Examples of acceptable techniques for determining failure conditions include, but are not limited to, the following:"*

**Page 39, line 18**

*"In the aviation industry, typical hazard control and risk mitigation includes the following:"*

ERPS gratefully thanks FAA for the free engineering and development outlines. We have already started using them.

**Page 41, line 3**

*“Others have stated that [an applicant’s submission] [the documents] should outline the applicant’s ‘philosophy’ but that FAA should require evidence supporting the documentation.”*

ERPS agrees. Philosophy is not enough. FAA should require actual plans. If they’re adequate for engineers to build the thing, they are probably adequate for FAA to evaluate it.

**Page 42, line 21**

*“Moreover, because of the costs and disadvantages of flight testing, FAA expects that many RLV and reentry vehicle operators will propose to validate vehicle design through the use of sophisticated computer simulations, ground testing, or other detailed analyses.”*

ERPS views this opposition to flight testing with dismay. It is this attitude—“we can build it right if we just think about it hard enough”—that is responsible for ELV launch failure rates seeing no improvement in forty years of ELV development. To make vehicles reliable, you must fly them, and fly them a lot. The only hope of long term RLV reliability is high flight rates, starting with flight test programs. Also, an incremental flight test program would allow an applicant to demonstrate the reliability of their design to satisfy both investors and FAA.

**Page 43, line 16**

*In the definition of "dwell time", ERPS would like to see the term "populated area" used, as dwell time over an unpopulated area would not be a safety risk.*

**Page 45, line 3**

*"For example, dwell time in the first seconds of a launch would not be tolerated because of the risk of vehicle failure."*

ERPS notes that as worded, this prohibits launch from the surface of the Earth. ERPS requests that FAA reword this so that it reflects FAA's intent that dwell time over populated areas, rather than dwell time over any area, be restricted.

**Page 45, line 21**

*"For example, if an operator proposes to operate its vehicle over populated areas and to rely on an abort capability to achieve required levels of safety, the operator would be required to demonstrate that the vehicle can perform the critical abort and recovery maneuvers necessary to fly safely."*

ERPS notes that as worded, this would not achieve FAA's objective. ERPS recommends that the operator be required to demonstrate, over an unpopulated area, that the vehicle can perform the critical abort and recovery maneuvers necessary to fly safely. This is similar to FAA's Experimental Aircraft Phase 1 requirements.

**Page 46, line 11**

*"flight lifetime"*

ERPS notes that an RLV's lifetime should be several years, and proposes that this be changed to "flight duration."

**Page 46, line 13**

*"That said, FAA is not specifically mandating adherence to a flight test regime to demonstrate vehicle capability."*

ERPS recommends that FAA should, at the least, strongly recommend a flight test program to demonstrate the vehicle's capability, reliability and operational safety.

**Page 46, line 14**

*"... flight testing has not been required of ELVs."*

ERPS concedes that flight testing a non-reusable vehicle is not productive but feels this limitation should not be used to preclude flight testing of RLVs, which benefit greatly from it.

**Page 47, line 4**

*"While an aircraft may conduct tests of it's full flight envelope within a remote site, conducting full flight test of an RLV or RV would require suborbital and/or orbital flights over substantially large areas."*

While FAA is accurate in determining that a full flight test would not be distinguishable from an operational flight in terms of risk assessment, ERPS feels compelled to point out that a considerable regime of flight testing can (and in our opinion, should) be conducted to demonstrate the reliability, recoverability, and abort mode handling (among others) of RLVs while remaining inside a test range or similar facility.

**Page 47, line 21**

*"The operator of an RLV or reentry vehicle must be able to monitor and verify the status of launch and reentry safety-critical systems before launch, during launch flight, and before reentry flight."*

ERPS notes that in practice, this requires either telemetry or a pilot on the flight deck. ERPS is pleased that FAA is not requiring telemetry per se. ERPS bets Pioneer Rocketplane is even more pleased.

**Page 50, line 8**

*"large enough to contain the landing impacts"*

ERPS notes that RLVs will not normally impact; they will land. ERPS requests that "landing impacts" be changed to "landings."

**Page 50, line 18**

*"the three-sigma area for an airplane may be a narrow ellipse because the pilot can stand otherwise control the vehicle's descent such that it touches down within a narrow band."*

ERPS does not understand the use of the word "stand" in this regard, and requests clarification.

**Page 52, line 6**

*"An RLV launch operator would be required to possess the ability to monitor the status of launch and reentry safety critical systems during countdown to launch."*

ERPS notes that this could be read to require countdowns. ERPS does not use countdowns; we use pre-flight checklists. ERPS proposes that "countdown to" be changed to "preparation for." ERPS also notes that FAA defines launch to begin when the vehicle enters the launch site, and that this definition is not appropriate here. ERPS proposes that "launch" be changed to "liftoff" or "takeoff."

**Page 53, line 22**

*"FAA does not propose a requirement that an operator would have to be able to incapacitate the vehicle so that it would not survive a random return to Earth."*

ERPS notes a sigh of relief among manned RLV operators.

**Page 55, line 5**

*"Mission-specific licenses can be structured so as to accommodate a proposed flight test program that may consist of a series of flights within an envelope of approved parameters."*

ERPS applauds this approach and recommends it over the apparent reluctance of industry to implement a flight test program.

**Page 56, line 15**

*"The agency considers that no less stringent safety criteria should be imposed upon a reentry because it occurs as a separate event, either by time or function, from the launch that placed it in Earth orbit or outer space."*

**Page 56, line 25**

*"FAA wishes to utilize an appropriate measure of risk for reentry capability and requests comments on its proposed approach of applying mission risk."*

ERPS does not have a solution, but admires the problem greatly. ERPS abstains, courteously.

**Page 65, line 14**

*"FAA would consider safety issues from a policy perspective rather than an engineering perspective."*

ERPS notes that this process may be subject to political abuse—a license might be denied because the Senator from Boeing said the vehicle was unsafe, rather than because it really was—and requests clarification.

**Page 68, line 15**

*"The safety official would evaluate an applicant's readiness to safely conduct an RLV mission by conducting operational dress rehearsals and completing a readiness determination."*

ERPS applauds the concept but notes that the execution is flawed. The operational dress rehearsals are conducted by the Flight Director, not by the safety official. The safety official cannot conduct the dress rehearsals; during the rehearsals, he will be busy officiating safety. In addition, if a flight organization wants to be safe and effective, it trains the way it flies, and flies the way it trains. Again, this means that the Flight Director conducts the dress rehearsals. The safety official will be responsible for ensuring that the dress rehearsals occur, but he will monitor and evaluate them, not conduct them.

**Page 69, line 22**

*"authorize the resumption of the countdown or a recycle procedure"*

ERPS, following a flight rather than launch philosophy, does not do countdowns, and suggests that "countdown" be replaced with "countdown or preflight procedure."

**Page 70, line 13**

*"The safety official would be responsible for evaluating an applicant's readiness to safely conduct an RLV mission by monitoring compliance with the applicant's safety policies and procedures, completing a readiness determination, and conducting operational dress rehearsals."*

The safety official monitors compliance with safety policies and programs. The safety official does not do readiness determinations other than for safety systems. That's the Flight Director's job. The safety official also does not conduct dress rehearsals. That's also the Flight Director's job. Again, the safety official ensures that dress rehearsals take place, but monitors and evaluates them, not conducts them. Train the way you fly.

**Page 71, line 1**

*"reentry or other return to Earth"*

ERPS requests clarification on how a vehicle might return to Earth without reentering.

**Page 71, line 2**

*"The expected average number of casualties from a proposed RLV mission could not exceed .00003 ($30 \times 10^{-6}$ ) casualties for any launch and reentry mission and .000001 ($1 \times 10^{-6}$ ) casualties for persons in the areas adjacent to the reentry site."*

**Page 71, line 23**

*"The one hundred mile area surrounding the proposed reentry site was utilized in COMET/METEOR because it limits public risk exposure in the event of a minor system failure during reentry causing a somewhat off-site, but not random, landing."*

ERPS notes that COMET/METEOR was an unguided reentry vehicle, and this proposed rule will regulate guided RLVs. The RLVs may be human piloted, remotely piloted, autonomously piloted, or otherwise guided, but if the vehicle is not somehow guided, then it does not meet the definition of an RLV as proposed by ERPS, and would not be licensed under this rule.

An unguided RV might need a 100 mile radius exclusion area, if its retrofire system is inaccurate or it has significant uncontrolled cross range. A guided RLV would not need such a large exclusion area, and the 100 mile radius should be stricken as burdensome.

In addition, the one per million risk in a 100 mile radius, combined with the 30 per million risk at the reentry site and for the rest of the surface of the Earth, effectively divides the surface of the Earth into three areas: the reentry site, where acceptable risk is 30 per million; the 100 mile buffer around the reentry site, where acceptable risk is one per million; and the rest of the surface of the Earth, where the risk is 30 per million. The area with the lowest acceptable risk is the area immediately outside the reentry site, where a stricken RLV or RV would be most likely to attempt a landing. This would provide a disincentive for an RLV operator with an off-nominal reentry and/or a guidance problem to try to land at the reentry site. ERPS believes that the RLV operator should not face such a disincentive.

**Page 72, line 15**

*"Proposed paragraph (d) would specify the data that must be provided by an applicant as part of the demonstration of acceptable risk under this subpart. Included are drawings and schematics for each safety critical system, a timeline identifying all safety critical events and empirical data to substantiate the risk analysis required by this section."*

ERPS notes that gathering empirical data requires a flight test program, a flight test program requires one or more mission licenses, and mission licenses require empirical data. ERPS admires this catch-22, but requests that this requirement be modified to allow licensed flight testing.

**Page 73, line 4**

*"Launch and reentry readiness procedures must include dress rehearsal procedures covering nominal and non-nominal situations and provide bases for doing away with dress rehearsals under certain circumstances."*

ERPS believes FAA should not require a licensee to provide bases for doing away with dress rehearsals, as this would be intrusive. FAA should allow a licensee to provide bases for doing away with dress rehearsals, but not require it. If the licensee wants to rehearse every mission, that's his business.

**Page 74, line 5**

*"An applicant also would be required to submit a communications plan that describes personnel communications procedures during the mission. This requirement would be substantially similar to the current requirement for a launch license applicant to submit a communications plan describing communications procedures during launch, but the procedures would be required to apply throughout the mission."*

ERPS understands that FAA will regulate communications during launch and reentry. As worded, however, the above implies that FAA will regulate communications throughout the mission, including during on orbit operations unrelated to launch or reentry. ERPS requests clarification on this matter.

**Page 74, line 14**

*"Personnel with decision-making authority over launch and reentry would be available on the same predetermined channel during launch countdown and reentry countdown, if any."*

ERPS does not do countdowns, and suggests that "countdown" be replaced with "preparation."

**Page 74, line 16**

*"Safety-critical communications would have to be recorded and would include hold/resume, go/no go, and emergency and contingency abort commands, and any other irrevocable decisions that could affect public safety or the safety of property."*

ERPS requests clarification on what constitutes an acceptable record. Video recordings, audio recordings, radio transcripts, and mission logs have all been used in the past. Does FAA have a requirement for the format of the communications record?

**Page 75, line 9**

*"activating a flight safety system during the launch flight phase to safely terminate flight in the event the vehicle is not operating within approved limits."*

To avoid association with flight termination systems used aboard ELVs, ERPS suggests that "terminate" be changed to "abbreviate."

**Page 75, line 16**

*"landing dispersion and other landing impacts"*

Because RLVs will not typically impact, ERPS suggests that "landing impacts" be changed to "landings."

**Page 76, line 18**

*"For example, even though an applicant has satisfied the agency's risk criteria of $E_C$ no greater than 30 casualties in a million missions, if the consequence of a mission accident at a particular location would result in a significant number of actual casualties, then FAA would view that area as densely populated for safety purposes."*

ERPS believes that "a significant number" provides insufficient direction for mission planning. Rather than request that FAA define an acceptable number of casualties, ERPS recommends that FAA require that a vehicle not exceed $E_C \leq 30 \times 10^{-6}$ at any time during flight. $E_C$ is a product of population density, casualty area, dwell time, and probability of failure. If a vehicle's $E_C$ is graphed over time, the graph will rise as the instantaneous impact point (IIP) passes over population centers, fall as the vehicle's dwell time decreases, etc.. The total risk of the mission is the area under the curve, divided by the flight time. ERPS proposes that even if the total mission risk falls below $E_C \leq 30 \times 10^{-6}$, the instantaneous mission risk must also remain below $E_C \leq 30 \times 10^{-6}$ at all times during flight. Thus, an RLV operator who wished to overfly a population center would need to demonstrate that the vehicle dwell time, casualty area, and probability of failure were low enough that the increase in population density did not bring the instantaneous mission risk over $E_C \leq 30 \times 10^{-6}$.

**Page 79, line 6**

*"RLV operator would be responsible for contacting local officials"*

ERPS suggests that "responsible for contacting" be changed to "responsible for immediately contacting."

**Page 79, line 15**

*"Subpart D—Payload Reentry Review and Determination"*

ERPS is not entirely clear on the payload reentry review process. While ERPS believes it is reasonable to require the RLV to have a favorable payload reentry determination for the payload he intends to launch, it is unclear to us who is responsible for the payload reentry determination. ERPS believes this is the responsibility of the payload owner or operator. The RLV operator would attach to his mission license application a copy of the payload owner's or operator's payload reentry determination, if one has been issued, or payload reentry review application, if a payload reentry determination has not been issued. This is similar to current freight shipping: if the shipper is shipping hazardous materials, he must have a DOT permit to do so, and the freight operator must also ensure that the shipper has a DOT permit.

**Page 81, line 7**

*"The proposal would describe the specific information that an applicant would be required to provide to FAA to perform a payload reentry review and conduct any necessary interagency review. In cases that present potential unique safety concerns, FAA would require considerable detail*

*regarding the physical characteristics, functional description, and operation of the payload, and its ownership."*

FAA seems to be placing the burden of providing payload-specific information on the RLV operator. ERPS believes this is the responsibility of the payload owner or operator. The explanation of section 431.61 comes close to ERPS' position: *"The licensee must ensure that the payload owner or operator reports any such changes to the licensee so that the licensee is in compliance with the requirement."* ERPS believes that the payload owner or operator should report such changes to FAA directly, and be directly responsible to FAA for a payload review determination. This shifts the regulatory burden for payload reentry reviews from the RLV operator to the payload owner or operator. ERPS believes this is proper; they are, after all, payload reentry reviews.

**Page 84, line 9**

*"other modal administrations of the U.S. Department of Transportation."*

ERPS requests clarification on what other modal administrations of DOT might be interested in space launch. FAA covers airplanes and the Coast Guard covers ships; all other modes (rail, truck, barge, etc.) would seem to be covered under provisions for the general public.

**Page 85, line 2**

*"In the event of a launch or reentry accident, or launch or reentry incident, the proposal would require a licensee to preserve all records related to the event until FAA advises the licensee that the records need not be retained."*

ERPS notes that FAA might never so advise a licensee, and this would require the licensee to retain all related records forever. ERPS believes this is burdensome, and suggests that FAA allow the licensee, after 3 years, to forward all related records to FAA, or destroy them, at FAA's option.

**Page 85, line 8**

*"Under the proposal, a licensee would be required to report certain information to the Associate Administrator at least 60 days before each RLV mission."*

ERPS requests clarification on this matter. What information is required?

**Page 85, line 9**

*"Not later than fifteen days before a mission, a licensee would be required to report the time and date of the planned RLV mission to the Associate Administrator."*

ERPS requests clarification on this matter. ERPS understands that a mission can consist of a series of flights, and that the licensee must make a report to FAA no later than 15 days before beginning the flight series. Does FAA concur?

**Page 85, line 13**

*"FAA invites public comment on the time frames proposed for reporting requirements in light of operator plans for rapid RLV launch and reentry services."*

ERPS believes that 24 hour notice of individual flights is appropriate to high tempo operations.

**Page 85, line 20**

*"Proposed section 431.83 explains that a licensee is required to cooperate with FAA's compliance monitoring policy."*

ERPS requests clarification on this matter. What is FAA's compliance monitoring policy?

**Page 86, line 3**

*"certain information must be reported to FAA regarding placement of objects in space."*

EPRS requests clarification on this matter. Does this requirement apply only to objects placed in orbit? Section 431.85(b)(4) requires orbital parameters. While these could certainly be supplied for suborbital objects, they would be meaningless.

**Page 86, line 21**

*"Use of a new vehicle, or reentry of a payload with characteristics falling measurably outside the parameters of existing environmental documentation, would also be subject to FAA environmental review requirements."*

ERPS notes that this could be read to subject each new individual vehicle (of a type) to FAA environmental review requirements. ERPS suggests that this be reworded to clarify FAA's intent.

**Page 88, line 13**

*"Section 433.9 provides that a reentry site operator must submit information to support environmental review of reentry impacts at the site, if not already covered in existing documentation."*

ERPS requests clarification on this matter. Are the reentry impacts subject to environmental review "environmental" impacts or "vehicle" impacts?

**Page 89, line 1**

*"assessed on a per mission basis so that it encompasses the risks to public safety presented by the launch of a reentry vehicle in addition to its reentry, operational requirements and restrictions, and utilization of a system safety process."*

It is unclear to ERPS against whom RV launch risks are proposed to be assessed. ERPS recommends that RV launch risks, as with any other launch risks, be assessed against the RLV operator.

**Page 89, line 6**

*"Any person seeking a license to reenter a reentry vehicle should refer to part 431 regulations governing RLV missions. Only those requirements and licensing considerations that are unique to reentry of a reentry vehicle that is not also an RLV would be expressly stated in part 435."*

ERPS disagrees with this approach. ERPS recommends that part 435 be complete in and of itself, to avoid confusion.

**Page 89, line 18,**

*"...for issuing launch."*

ERPS believes this should read "...for issuing launch licenses."

**Page 96, line 2**

*"The proposed rule implements certain policies developed by AST in 1992 with respect to public safety for the first commercial space reentry operation. However, the safety criteria proposed in this rulemaking uses different measures that better reflect current agency and range safety practices."*

ERPS does not understand this statement. As nearly as we can determine, the COMET/METEOR reentry criteria and the proposed reentry criteria are identical. The proposed criteria would have the effect of requiring ocean landings for any but the smallest "unproven" vehicles. Since FAA has not defined "proven" in this context, RLV developers can have no certainty that they will ever be granted licenses for dry land landings.

**Page 97, line 5**

*"the proposed requirement for each commercial space operator to have an independent safety inspector"*

ERPS believes this requirement states that the safety inspector shall be independent of Operations, but does not preclude the safety inspector from also having a role in development. ERPS requests clarification on this matter.

**Page 97, line 15**

*"over the next 15-year period, five commercial operators of RLVs or RVs would be impacted by the regulations."*

This assumes that no new commercial operators will enter the RLV market. ERPS does not believe this to be a valid assumption.

**Page 98, line 3**

*"Compliance with this proposed section would result in an estimated cost of $400 per operator to assemble the data and submit each application or $2,000 (5 x $400), in 1997 dollars, for all five operators over the 15-year period. The cost estimate of $400 per operator assumes an employee with an annual loaded salary of approximately $103,000 (with fringe benefits) and a level of effort of eight hours."*

ERPS notes that this is less than one half hour per year. ERPS also notes that it takes longer than that to read FAA's proposed regulations.

**Page 98, line 13**

*“the proposed requirement to '...designate a qualified safety official ...to monitor independently compliance...with...[all] safety policies and procedures’ is not necessarily customary and usual practice. Inclusion of this proposed requirement suggests that it is a refinement of industry baseline practices designed to mitigate safety risks to the public. For example, to be ‘responsible for the conduct of all...mission activities...’ implies a degree of comprehensiveness that may not be common practice in industry.”*

ERPS notes apparent confusion over the respective roles of the Safety Officer (safety official, in FAA parlance) and the Flight Director. The Safety Officer will “monitor independently compliance...with...[all] safety policies and procedures.” The Flight Director will be “responsible for the conduct of all...mission activities.” The two roles are quite distinct, and they will be filled by two different people.

**Page 98, line 21**

*“Furthermore, the magnitude of responsibilities of the safety official suggests that the level of effort required to perform this function would exceed part-time employment.”*

ERPS disagrees with this statement under some circumstances. In our case, there are no full time employees in the organization; we are all volunteers, including the Safety Officer. When we are in the field testing, there are a number of full time positions, including the Safety Officer. ERPS recommends that FAA keep this language as it stands, and not require an applicant to have to a full time Safety Officer.

**Page 100, line 8**

*"This exercise would result in a paperwork cost to a commercial entity of approximately $4,000 per application submittal over the 15-year period. For all entities, this proposed requirement would impose an estimated cost of compliance of $20,000 (5 x $4,000) over the 15-year period."*

ERPS believes that FAA has made an error here. The above clearly implies that each applicant will make only one submittal in the 15-year period. RLV licenses are valid for only two years. Clearly each applicant will need to make several submittals over the 15-year period, just to renew their licenses, let alone make more than one application per year.

**Page 115, line 13**

*"Each of the five potentially impacted small RLV entities is expected to average about seven missions per year over the next 15 years. Using $50 million as an average expected revenue per mission, each entity would be expected to receive about $350 million in revenue ($50m x 7 missions annually) for all missions annually."*

ERPS believes this model to be economic death for RLVs as a class. If launch rates were going to be this low, there would be no point in developing RLVs. The development programs would never be amortized enough to pay for themselves. ERPS believes a mature RLV operation in 2014 may make $350 million in revenue, but it will make it by flying 350 flights at $1 million each, not 7 flights at $50 million each.

**Page 115, line 16**

*"FAA has determined that none of the five small entities would incur a significant economic impact, since the average annualized cost of compliance ($700,000) would be only 0.2 percent of the anticipated average annual revenues of $350 for missions conducted annually."*

ERPS notes that $700,000 is very burdensome to an amateur or nonprofit organization.

**Page 121, line 19**

*"The term launch includes the flight of a launch vehicle and pre-flight ground operations beginning with the arrival of a launch vehicle or payload at a U.S. launch site."*

ERPS notes that while this definition is valid for ELVs, it cannot reasonably be applied to RLVs. If the definition was shortened to "launch includes the flight of a launch vehicle and pre-flight ground operations," it would be applicable to RLVs. The first problem with the proposed definition is that payload arrival has nothing to do with vehicle launch. Payload integration is part of pre-flight operations, but the payload may sit in a hangar for several days before it is loaded into the vehicle. The second problem with the proposed definition is that if the vehicle lands at its launch site, launch for the next mission begins immediately. This is clearly absurd.

What is needed is a recognition that RLVs will operate like aircraft. Their operations will have distinct phases:

1) pre-flight, which includes payload integration and/or cargo loading and/or crew/passenger embark;

2) flight, which includes liftoff, ascent, on orbit operation, retrofire, reentry, descent, and landing;

3) post-flight, which includes cargo unloading and/or crew/passenger disembark; and

4) maintenance.

Launch may reasonably include pre-flight operations, and reentry may reasonably include post-flight operations. Maintenance unrelated to any particular flight is not part of any launch, and today's post-flight is not part of tomorrow's launch, although the proposed definition would have it that way.

**Page 121, line 21**

*"Flight ends after the licensee's last exercise of control over its launch vehicle."*

ERPS notes that this definition is appropriate to ELVs, but when applied to RLVs, it means that flight ends after the licensee retires the vehicle into the boneyard. ERPS suggests this definition be made more specific to aviation type flight operations.

**Page 137, line 4, section 431.23**

*"(c) FAA advises an applicant, in writing, of any issue raised during a policy review that would impede issuance of a policy approval. The applicant may respond, in writing, or revise its license application."*

ERPS requests clarification on this matter. When does FAA advise an applicant of issues that would impede issuance of a policy approval?

**Page 139, line 3, section 431.31**

*"(c) FAA advises an applicant, in writing, of any issue raised during a safety review that would impede issuance of a safety approval. The applicant may respond, in writing, or revise its license application."*

ERPS requests clarification on this matter. When does FAA advise an applicant of issues that would impede issuance of a license application?

**Page 139, line 15, section 431.33**

*"(b) An applicant must designate a person responsible for the conduct of all licensed RLV mission activities."*

For ERPS, this person is the Flight Director. It is not the Safety Officer.

**Page 139, line 17, section 431.33**

*"(c) Safety official. An applicant shall designate by name, title, and qualifications, a qualified safety official authorized by the applicant to examine all aspects of the applicant's operations with respect to safety of RLV mission activities and to monitor independently compliance by vehicle safety operations personnel with the applicant's safety policies and procedures."*

For ERPS, this person is the Safety Officer.

**Page 140, line 2, section 431.33(c)**

*"The safety official is responsible for—(1) Conducting operational dress rehearsals in accordance with procedures required by section 431.37(a)(4), that ensure the readiness of vehicle safety operations personnel to conduct a safe mission under nominal and non-nominal conditions…"*

The Safety Officer is not responsible for the conduct of dress rehearsals. Dress rehearsals are conducted by the same person who will conduct the flights. That person is the Flight Director.

**Page 141, line 4, section 431.35**

*"(2) For persons within a 100-mile distance from the border of the designated reentry site and contingency abort locations, if any, the risk level associated with a proposed mission does not exceed an expected average number of .000001 casualties per mission (or* $E_C$ *criterion of* $1 \times 10^{-6}$ *)."*

ERPS regards the 100 mile buffer zone around the reentry site as nearly infeasible. FAA recommends that for unproven vehicles, applicants assume that their vehicle's probability of failure is 1. A probability of failure of 1, combined with a 1 per million risk of casualties, results in a maximum product of population density and casualty area of 27.8784 person square feet per square mile. This would restrict ERPS' first orbital vehicle, PROTO, to a population density of 0.557568 persons per square mile in the 100 mile buffer zone, for a total at risk population of 17,516. If this same logic is applied to the Space Shuttle—in other words, if FAA did not exempt NASA from regulation, and USA had to apply for a reentry license—for a scenario in which the orbiter landed intact, the maximum acceptable population density is 0.00557568 persons per square mile, for a total at risk population of 175 persons. For a scenario in which the orbiter fragments on impact, the maximum acceptable population density is 0.0000557568 persons per square mile, for a total at risk population of 1 person. This would prohibit the Shuttle, for example, from landing anywhere with more than 175 persons within 100 miles. There are no Shuttle capable runways that meet this requirement. Even if one assumes a reliability of 99%, Shuttle would still be prohibited from landing anywhere with more than 17,516 persons within 100 miles. There are few Shuttle capable runways that meet this requirement, and none of them are in the United States.

ERPS, itself, could live with the proposed reentry risk threshold if necessary, as we plan to operate small vehicles out of unimproved sites. However, ERPS believes itself to be the only RLV developer not grievously impacted by the proposed risk threshold; so in the interests of the industry, ERPS suggests the proposed reentry risk threshold be changed to $E_C \leq 30 \times 10^{-6}$.

| Organization | ERPS | NASA | NASA | NASA | NASA |
|---|---|---|---|---|---|
| Vehicle | PROTO | STS intact | STS frag | STS intact | STS frag |
| Cas area (ft^2) | 50 | 5000 | 500,000 | 5000 | 500,000 |
| Prob failure | 1 | 0.01 | 0.01 | 1 | 1 |
| $E_C$ | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.000001 |
| At risk area (mi^2) | 31,416 | 31,416 | 31,416 | 31,416 | 31,416 |
| At risk area (ft^2) | 8.75828E+11 | 8.75828E+11 | 8.75828E+11 | 8.75828E+11 | 8.75828E+11 |
| Potential casualties | 17516556288 | 175165562.9 | 1751655.629 | 175165562.9 | 1751655.629 |
| At risk pop (pers) | 17516.55629 | 17516.55629 | 175.1655629 | 175.1655629 | 1.751655629 |

The above table illustrates that even the U.S. Space Shuttle, with a 99% reliability record, could not get a license to land at any reentry site with more than 17,516 persons within 100 miles of the reentry site. Since all of the Shuttle landing sites in the U.S. have more than 17,516 persons living within 100 miles of them, the Shuttle would be unable to get a reentry license under this criterion. ERPS believes that RLVs will be more reliable than the U.S. Space Shuttle, but we do not believe that RLVs should be held to a stricter standard of risk than a government vehicle that is currently flying and currently exposing the public to risk.

**Page 145, line 3, section 431.41(a)**

*"(4) Communications affecting the safety of the mission are recorded."*

ERPS requests clarification on this matter. What format of record is appropriate and acceptable to FAA?

**Page 145, line 23, section 431.43**

*"(b) To satisfy risk criteria set forth in section 431.35(b)(1), an applicant for RLV mission safety approval shall identify suitable and attainable locations for nominal landing and vehicle staging impact, if any. An application shall identify such locations for a contingency abort if necessary to satisfy risk criteria contained in section 431.35(b)(1) during launch of an RLV. A nominal landing, vehicle staging impact and contingency abort location are suitable for launch or reentry"*

ERPS notes that RLVs meeting the definition proposed by ERPS will not have stages which impact. RLV stages, and all other components of the RLV, will be actively guided to a soft landing.

**Page 146, line 20, section 431.43(c)**

*"(2) The projected instantaneous impact point (IIP) of the vehicle shall not have substantial dwell time over densely populated areas during any segment of mission flight."*

ERPS believes that "substantial" and "densely" provide insufficient direction to applicants for mission planning. ERPS recommends FAA use the criteria in section 431.43(d)(2*), "such that the expected average number of casualties to members of the public does not exceed 30 x* $10^{-6}$ *(*$E_C$ *£ 30 x* $10^{-6}$*) given a probability of vehicle failure equal to 1 (*$p_f$*=1) at any time the IIP is over a populated area."*

**Page 147, line 16, section 431.43(d)**

*"(2) Such that the expected average number of casualties to members of the public does not exceed 30 x $10^{-6}$ ($E_C$ £ 30 x $10^{-6}$ ) given a probability of vehicle failure equal to 1 ($p_f$=1) at any time the IIP is over a populated area."*

ERPS recommends that this criterion be used during all phases of flight, including flight over populated areas. This will not cause excessive risk because with a $p_f$ of 1, the allowable population density under the IIP is inversely proportional to the casualty area of the vehicle. For a given vehicle, there will be areas over which the vehicle cannot fly without exceeding this criterion, and for most RLVs, this will be most large population centers.

**Page 149, line 8, section 431.45**

*"[(b) Report requirements. A MIP shall provide for- (1) Immediate notification to FAA Washington Operations Center in case of an event identified in paragraph (a) of this section. In addition to requirements of section 415.41(b), the notification shall include:] (xi) Potential consequences for other vehicles or systems of similar type and proposed operations."*

Potential consequences of incidents for other vehicles or systems will require research and analysis, and will not be available for inclusion in an immediate report. The immediate report should contain factual details about the particular incident or accident, but should not be delayed pending completion of required research and analysis. The potential consequences for other vehicles or systems of similar type and proposed operations should certainly be reported to FAA, but should be reported in the written preliminary report to FAA, submitted within 5 days of the event.

**Page 149, line 10, section 431.45**

*"(2) Submission of a written preliminary report to FAA Associate Administrator for Commercial Space Transportation in the event of a reentry accident or reentry incident, as defined in section*

*401.5 of this chapter, within 5 days of the event. The report shall identify the event as either a reentry accident or reentry incident and must include the information specified in paragraph (b)(1) of this section."*

In addition to the information specified in paragraph (b)(1) of this section, the written preliminary report should also identify the cause or causes of the incident or accident, if known.

**Page 150, line 17, section 431.47**

*"FAA notifies an applicant, in writing, if FAA has denied safety approval for an RLV mission license application."*

ERPS requests clarification on this matter. When does FAA notify the applicant of a safety approval denial? ERPS suggests FAA notify the applicant within 30 days of FAA's receipt of the application.

**Page 152, line 12, section 431.55(e)**

*"(e) FAA advises a person requesting a payload reentry determination, in writing, of any issue raised during a payload reentry review that would impede the issuance of a favorable determination to reenter that payload.."*

ERPS requests clarification on this matter. When does FAA notify the applicant of a payload reentry determination issue? ERPS suggests FAA notify the applicant within 30 days of FAA's receipt of the application.

**Page 153, line 8, section 431.59**

*"(a) FAA issues a favorable payload reentry determination unless it determines that reentry of the proposed payload would adversely affect U.S. national security or foreign policy interests, would*

*jeopardize public health and safety or the safety of property, or would not be consistent with international obligations of the United States."*

ERPS requests clarification on this matter. When does FAA issue a favorable payload reentry determination? ERPS suggests FAA issue a determination within 30 days of FAA's receipt of the application.

**Page 153, line 15, section 431.59**

*"(b) Any person issued an unfavorable payload reentry determination may respond to the reasons for the determination and request reconsideration."*

ERPS requests clarification on this matter. When may a person issued an unfavorable payload reentry determination respond and request reconsideration?

**Page 153, line 22, line 431.61**

*"FAA determines whether a favorable payload reentry determination remains valid and may conduct an additional payload reentry review."*

ERPS requests clarification on this matter. When may FAA conduct an additional payload reentry review?

**Page 154, line 19, section 431.73**

*"(b) After a license has been issued, a licensee must apply to FAA for modification of the license if—*

*(1) The licensee proposes to conduct an RLV mission or perform a safety-critical operation in a manner not authorized by the license; or*

*(2) Any representation contained in the license application that is material to public health and safety or the safety of property is no longer accurate and complete or does not reflect the licensee's procedures governing the actual conduct of an RLV mission."*

ERPS has grave concerns about this section. Section 431.73(b)(2) apparently says that any changes in a licensee's vehicles, operations, systems, policies, procedures, criteria, or standards renders the licensee's license invalid, and requires the licensee to apply for a modification to his license. This would also mean that any such changes must be approved by FAA, in writing, in advance, before they are implemented. This would slow the licensee's development program to a crawl. This would also likely discourage full disclosure by the licensee in the application on which the license is based.

ERPS believes that the mission license should set forth the designs, operations, systems, policies, procedures, criteria, or standards which, if changed, would render a license invalid, and require a licensee to apply for a modification to the license. In contrast to saying that if any safety-critical systems (in a rocket vehicle almost all systems are safety-critical) change from what is on the application, the license is rendered invalid, and the licensee must apply for a license modification, FAA should set forth specifically, in the license, what designs, operations, etc. must be "frozen" in order to remain in compliance with the license. This is essentially what FAA says in section 431.73(b)(1), but ERPS would like FAA to clarify this in the rule, and set forth the "frozen" designs, operations, etc. in the license, so that the licensee would be able to continue a development program without continuously submitting license modification applications to FAA.

**Page 157, line 9, section 431.77**

*"(b) In the event of a launch accident, reentry accident, launch incident or reentry incident, as defined in section 401.5 of this chapter, a licensee shall preserve all records related to the event. Records must be retained until completion of any Federal investigation and FAA advises the licensee that the records need not be retained. The licensee shall make all records required to be maintained under the regulations available to Federal officials for inspection and copying."*

ERPS requests clarification on this matter. If the licensee makes available to FAA all records related to the event, why must the licensee maintain the records in perpetuity? ERPS recommends that if FAA desires to maintain related records more than three years after the event, that the licensee forward the related records to FAA.

**Page 158, line 18, section 431.85**

*"(a) To assist the U.S. Government in implementing Article IV of the 1975 Convention on Registration of Objects Launched into Outer Space, each licensee shall provide to FAA the information required by paragraph (b) of this section for all objects placed in space by a licensed RLV mission, including an RLV and any components."*

ERPS requests clarification on this matter. Does this include objects placed in suborbital trajectories?

**Page 159, line 8, section 431.85(b)**

*"[licensee shall submit the following information not later than thirty (30) days following the conduct of a licensed RLV mission:]*

*(4) Final orbital parameters, including:*

*(i) Nodal period;*

*(ii) Inclination;*

*(iii) Apogee; and*

*(iv) Perigee."*

ERPS notes that nodal period, inclination, apogee, and perigee are not very useful in tracking space objects. ERPS requests clarification on this matter. Is there some reason FAA does not request two line element sets or state vectors?

## 5.0 Closing statements

While it is of concern to ERPS that FAA may not have completed the paradigm shift to RLV flight modes, there is much in the NPRM that we like and approve of. With review and revision we believe the proposed rule will well serve the emerging RLV industry and help realize the vast potential that will be available with the substantial lowering of launch costs.

ERPS commends FAA for its understanding of the implications of RLV technology; this vision is evident in many parts of the proposed rule. Some sections of the proposed rule caused our reviewers to remark, “Hey! They get it!” Other sections are attempts to port current rules to RLV technology, which met with less enthusiasm from our reviewers.

ERPS believes that the single most important issue facing FAA in regard to RLV regulations is the development of a definition of RLV that is accurate, useful, and distinct from the definition of ELV. Although RLV technology has developed out of ELV technology, and although they are both rocket based technologies, the future applications of RLV technology will create a working paradigm much more like airline operations than ELV operations. If FAA recognizes RLVs as a distinct class of vehicle, it will become much simpler to create workable regulations to govern RLVs, both now and in the future.

ERPS believes that FAA’s low estimate of the number of RLV flights that can be expected in the next 15 years is also an issue. Since RLVs can, unlike ELVs, be profitably and efficiently used to quickly deliver cargo from one point to another on the Earth’s surface, the development of less expensive RLV technology will likely lead to a demand for more vehicles to use in rapid delivery systems. This implies a future flight rate for RLVs that is many times what FAA has estimated. Again, developing an understanding of how RLVs differ from ELVs will help FAA to develop rules and risk assessment requirements which will more effectively regulate RLVs without undue burden on both RLV operators and FAA itself.

ERPS is pleased to have had this opportunity to comment on these and other issues, and to submit detailed comments on the NPRM. We hope that the information in this document has been useful, and that we have contributed in a positive way to a comprehensive and workable final rule. We additionally hope that FAA will be interested in calling on ERPS for further input on this and related issues. It is our pleasure to be of service in this endeavor.