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1999-5535

Date: 8131199 11:24 AM
Sender: Jeff Greason <jgreason@hughes.net>
To: 9-AWA-NPRM-CMTS
Priority: Normal
Subject: Re: Comments on NPRM Docket No. FAA-I 999-5535, Notice No.

FAA-99-5535-24


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Comments on Docket No. FAA-1999-5535; Notice No. 99-04

FAA Notice of Proposed Rulemaking

Commercial Space Transportation Reusable Launch Vehicle and

Reentry Licensing Regulations

Bertram Greason, Inc.

Bertram Greason, Inc. (Hereafter "B-G")is pursuing two reusable launch vehicle designs that would be affected by the NPRM. We are seeking financing for both concepts, and potential investors have expressed concern whether these vehicles can be licensed for operation by U.S. entities. Correspondence to B-G on the NPRM should be directed to Jeff Greason, 21505 Stage Drive, Tehachapi, CA 93561, or by electronic mail to jgreason@hughes.net; we are quite willing to supply clarification on any of our comments that may be unclear.

Bertram Greason, Inc is a small business as defined in the NPRM.

It is our belief that one key reason for the U.S. Congress' requiring FAA regulation of the reusable launch vehicle industry is to reduce the uncertainty regarding vehicle licensing. The goal of these regulations should be to provide clear guidance whether a launch license can be expected for a given vehicle and launch profile. As drafted, the NPRM fails to achieve this objective in significant respects. This letter will suggest changes to the draft regulations, which improve the clarity of the regulations while protecting the public.

Definition of Launch: §401.5

B-G objects to the proposed definition of "launch" as applied to a reusable vehicle. In expendable vehicles, there is no distinction between the assembly of the vehicle and the initiation of pre-launch preparation activities. In a reusable vehicle, these are more sharply defined. In

expendable launch regulation, the definition of 'launch" was broadened to increase the scope of liability limitation (as discussed in the release of the final rules effective June 21, 1999).

Consider a reusable vehicle, which is manufactured at the same facility where launch will take place. A broad interpretation of "launch", as drafted, could interpret every act of assembling and maintaining the RLV as a "launch activity". The safety of workers engaged in routine activities of assembly and maintenance is already highly regulated by OSHA, and there is literally nothing different about assembly of an RLV from, for example, an aircraft or an ocean vessel which should cause a higher level of oversight. Nor do we believe that the intent of Congress was to limit liability for workers engaged in vehicle construction operations which do not differ materially from those in other industries.

This broad interpretation of "launch" will impose a substantial regulatory burden on the operations of RLV companies. §431.91 makes clear that the launch is subjected to special environmental scrutiny, and requires EPA review. This is a burden not faced by similar operations in other industries (aircraft, shipbuilding). B-G therefore suggests that 'launch' begin when the vehicle is loaded with propellants or other hazardous materials as defined in 49 CFR 172.101 -- normally this will involve loading propellants or pressurized gases or mounting solid rocket motors on the vehicle. To be specific, the definition of "hazardous materials" should also make clear that quantities greater than those allowed on cargo aircraft are intended. These activities should still be "preparatory to launch", excluding activities such as proof-loading of tanks.

By defining the beginning of 'launch" in this way, the manufacture of an RLV becomes distinct from its operation; and the *operation* of an RLV is really the activity being licensed.

The proposed ending of "launch" is also problematic. The NPRM proposes "launch" to end after the licensee's last exercise of control over the vehicle. For a suborbital trajectory, this makes sense. However, consider a piloted vehicle which will be used for resupply of an orbiting asset, such as the International Space Station. Surely the launch license does not cover orbital operations, which are

beyond the responsibility of the FAA at this time. The NPRM itself recognizes this problem, as p. 23 of the draft requests comments on the circumstances under which is "may be appropriate to separately assess the reentry risks of a reentry vehicle from those presented by the entire mission."

B-G believes that the extended definition of "launch" is the source of this confusion. We recommend that a "launch" terminate at the earlier of two events; the licensee's last exercise of control over its launch vehicle, or the launch vehicle is in an orbit with a lifetime under worst-case atmospheric conditions of 30 days or more.

Methods for calculating orbital lifetime are known to the industry (see, for example, Wertz and Larson, _Space Mission Analysis and Design, second edition_, p. 206ff). There should therefore be little ambiguity in computing orbital lifetime. Once a vehicle is in a long-lived orbit, launch is over, whether or not it is the *intent* of the operator to perform a deorbit burn and reenter quickly.

To summarize, the definition of "launch" in §401.5 should be modified. Amend the definition to read "Launch means to place or try to place a launch vehicle or reentry vehicle and any payload from Earth in a suborbital trajectory, in Earth orbit in outer space, or otherwise in outer space. The term launch includes the flight of a launch vehicle and pre-flight ground operations beginning with the loading of hazardous materials in preparation for flight. Launch ends after the vehicle is in an orbit with an orbital lifetime of 30 days or more, or after the licensee's last exercise of control over its launch vehicle, whichever comes first."

B-G believes this revised definition of launch to be appropriate for both expendable and reusable vehicles; expendable vehicles are viewed as hazardous earlier in their life cycle due to the earlier integration of hazardous materials. However, if the FAA does not wish to amend the definition of launch for both expendable and reusable launch vehicles, it would be acceptable if the modified definition of launch applied only to launch of a reusable launch vehicle, as defined in the proposed §401.5

Definition of Hazardous Materials, §401.5

As discussed in the comments on defining "launch", this

should be modified to make clear that the applicable standard is that applied to cargo aircraft. One possible wording would be "Hazardous materials means hazardous materials as defined in 49 CFR 172.101 as applied to cargo aircraft".

Applicability to Passenger Transport, §431.23

The comments attached to the NRPM, particulary those on page 9, are of concern. B-G is pursuing an RLV intended to provide passenger transport on suborbital trajectories. We fully recognize that the licensing of such a vehicle will be the subject of considerable cooperative work between B-G and the FAA. However, we do not wish potential investors to be under the impression that the FAA's lack of regulation in this area implies that passenger transport is forbidden. The fact is simply that it is too early to envision what regulations or certification procedures may be appropriate to passenger carrying vehicles. As the NPRM states on page 9, "The FAA envisions that future use of RLV operations may include passenger transport . . . to and from space". B-G would like this demonstration of the FAA's intent to be embodied in the text of the regulations, and 5431.23 would seem an appropriate place.

B-G would suggest that a section (d) be added to this section, reading:

(d) While specific regulations for passenger transport RLV missions do not yet exist, passenger operations are envisioned by the FAA. Policy approval will be extended to passenger transport mission proposals as long as the other requirements of this section are met.

This language would encourage the industry to develop a passenger-carrying industry, consistent with the FAA's mission. By placing the language in the policy review section, it will be made clear that the issue of passenger safety is distinct from the safety of the general public being protected by the safety review.

Launch and Reentry Ec Criterion, 5431.35 b.

B-G applauds the use of an expected casualty criterion as a quantitative assessment of flight risk. The procedures for calculating Ec as discussed in Advisory Circular AC 431.35-1 are clear and unambiguous. However, the confused definition of "launch" as originally proposed has reduced this clarity of how the Ec

criteria applies to a RLV. Especially for RLVs with the potential for a long orbital life, the use of "mission" (a term not defined) confuses matters. The explanatory notes make FAA's intent clear -- that the combined risk of launch and reentry shall not exceed Ec of 30 per million flights. The regulations should reflect that intent. We would suggest rewriting sections (1) and deleting section (2) to say:

(1) For public risk, the risk level associated with a proposed mission does not exceed an expected average number of 0.00003 casualties per mission (or Ec criterion of 30 x 10-6) to members of the public from the applicant's proposed activity (launch and reentry combined)

The reason for this modification is to implement the FAA's intent of licensing RLV's on a "per mission" basis, with a uniform Ec criterion applying to the mission as a whole. There is therefore no need to impose more stringent criteria on reentry than on other parts of the mission. Only for reentry vehicles launched by an ELV could a separate criteria be needed, as ELV licenses do not require the risk of payload reentry to be considered -- that is properly addressed elsewhere in the regulations, however (as part of the payload review for an ELV license). There is no justification for the Ec limit of reentry vehicles to be as low as 1 per million flights -- this places all the safety burden on the reentry operator, allowing the launch operator to "use up" all the risk allotment. B-G therefore suggests that this separate limitation on entry be scrapped, and the sole criterion for safety be that the combined risk of launch and reentry not exceed an Ec of 30 per million flights.

Dwell Time Limits: §431.43 c (2)

This section is very objectionable, as the lack of definition of key terms "substantial dwell time" and "densely populated" renders the meaning of the section completely obscure. As stated above, B-G believes a primary purpose of Congress' authorization of RLV regulation was to bring predictability to the regulatory environment so that business ventures did not face undue regulatory risk. This clause defeats that purpose.

If "substantial dwell time" was 0.01 second, and "densely populated" was 50 people per square mile, there is no credible ground track which meets these criteria. If

"substantial dwell time" is 1 minute, and "densely populated" was 5000 people per square mile, there is no reasonable trajectory which fails. The devil is in the details -- which are deliberately not defined. This is a recipe for uncertainty, and for "licensing by lobbying" rather than on grounds of public safety.

Why is this regulation here at all? What public interest is being served by a restriction above and beyond the Ec limits which B-G enthusiastically supports? The explanatory notes in the NPRM, pages 42ff, make the rationale clear; "because of the costs and disadvantages of flight testing, the FAA expects that many RLV and reentry vehicle operators will propose to validate vehicle design through the use of sophisticated computer simulations . . . For these reasons, the FAA proposes to impose operational restrictions..."

Stripping away the diplomatic language, this implies that the FAA does not believe that Ec calculations without supporting flight test will be sufficiently reliable to ensure public safety. B-G does not necessarily disagree with that assessment, although assuming the FAA's advisory circular AC 431.35-1 is followed, it is unlikely that the Ec calculation will be grossly off, some error is certainly present until validated by flight test.

The apparent intent of the language in §431.43.c.2 is therefore to ensure that in addition to Ec calculations, flights are planned in a way which minimizes the consequences of a failure. However, the present language is so vague as to be completely unacceptable -- no RLV business venture could proceed with a reasonable assurance of a license under this language.

However, elsewhere, in §431.43 d, the NPRM places additional operational restriction on "unproven" RLVs. This makes sense, as long as the limits are clear and quantifiable (see the discussion in that section). Consider an analogy to experimental aircraft. Experimental aircraft are not certificated -- neither will RLVs be, since standards for certification do not exist. Therefore experimental aircraft are required to operated over unpopulated areas (airport airspace) until they have demonstrated by flight time that they do not pose an undue threat to the general public. We recommend a similar approach.

B-G therefore requests that subsection (2) of §431.43 c be deleted and replaced by operational restrictions in 5431.43 d.

Fundamentally -- if you don't believe the Ec calculations, the vehicle isn't proven. If you do believe the Ec calculations, no further restrictions are required to ensure the safety of the public.

Work Rest Standards: §431.43 c (4)

These work rest standards are clearly written with a view towards remotely operated vehicles. In B-G's view, there is no credible way to operate a piloted RLV under these regulations as drafted. Consider a typical mission profile -- the crew boards the vehicle 3 hours prior to launch, conducts checkouts, and launches the vehicle. They then stay on-orbit for 24-72 hours performing their mission, and then initiate reentry, fly to the landing location, and land the vehicle.

Clearly, the crew constitute "Vehicle safety operations personnel"; in fact, in past spacecraft such as the Gemini

spacecraft, the critical operations can only be controlled by the crew -- a model we believe will be more common in the future. B-G believes that the safety of the general public and the reliable operation of the vehicle are greatly enhanced by placing critical decisions in the hands of the pilots aboard the vehicle rather than ground controllers, and the regulations should foster this mode of operation. At the same time, crew rest requirements do enhance safety.

B-G would not object to this rule if it were made clear that "rest" can take place aboard the RLV, during the mission. In other words, being "off-duty", but on board the RLV, counts towards crew rest requirements. We believe that crewed RLV operations would then be compatible with the requirements of this section. Proposed language would add a subsection (v) to §431.43.c.4, such as:

(v) rest periods to comply with the requirements of this section can take place on-orbit, aboard the RLV, so long as the resting crewmember performs no flight tasks during the rest period.

Additional Restrictions on Unproven RLV: §431.43 d

This is the section of the greatest concern to B-G. It is our opinion that the rules in this section, as written, would prevent any RLV company from basing their business strategy on U.S. operation of their vehicle. This section requires major revision if there is to be a U.S. RLV industry.

Subsection (1) suffers from the same defects as proposed §431.43.c.2, discussed above. The same remedies are required here. B-G recognizes that unproven vehicles need to operate with even greater attention to public safety than a proven vehicle. However, in addition to the lack of clarity in §431.43.c.2, we have added "unproven", an additional undefined term.

We point out that under a strict interpretation of this section, NO EXISTING EXPENDABLE OR PROPOSED REUSABLE LAUNCH VEHICLE COULD BE LICENSED, EVEN IF LAUNCHED OVER THE OCEAN FROM A GOVERNMENT LAUNCH RANGE. The lack of definition of terms in subsection (1) means that any limit, no matter how stringent, might be applied. Even worse is subsection (2), proposing a concrete means of establishing acceptable risk. By assuming probability of "failure" of 1, and not defining failure, we must assume a worst-case failure, such as breakup of the vehicle from aerodynamic forces. If there is one person in a yacht, 500 miles downrange from the Florida Spaceport, and an easterly vehicle is assumed to fail, in the *worst possible way, at the worst possible time, there will be at least one casualty. Under section (2), that launch should not be licensed. Therefore, the only hope is to appeal to section (1), with none of the terms defined, and hope that a license may be allowed -- a factor entirely dependent on the persons involved and the political climate of the time.

Subsection (2) must be deleted; there doesn't seem to be any way to fix this which would be superior to the Ec calculation but still be possible to meet.

Subsection (1) must become clear and quantifiable. In order to do this, the FAA must take the additional step of defining terms. B-G would suggest the following language in this section:

(1) The projected instantaneous impact point (IIP) of the vehicle shall not dwell for more than 10 seconds over any area of population density greater

than 200 people per square mile.

If that language is unacceptable, we would suggest an alternative criterion involving a new concept "time-weighted density". Some example language:

(1) The time-weighted population density (TWPD) beneath the vehicle is the product of the dwell time of the projected instantaneous impact point (IIP) of the vehicle in a given area and the population density in that area. In order to limit the likely consequences of a vehicle failure, the TWPD of the vehicle shall not exceed 2,000 person-seconds per square mile over any segment of the trajectory.

This alternative language, while more complicated, allows a realistic trade off between ground tracks with

long dwells over suburban areas and ground tracks with

very short dwells over urban areas.

In this proposal, the operational restrictions are only levied on unproven vehicles. For this to be meaningful, some definition of "proven" must be made. Since the stated rationale for limits on "unproven" vehicles is the uncertainty in the Ec calculations, the best means of "proving" the vehicle would be to demonstrate, in flight, sufficient capability to demonstrate Ec below 30 per million flights. For example, once the vehicle has flown through maximum aerodynamic stress conditions without breakup, the assumption that the vehicle will not break up can be considered "proven". Or if the Ec calculations rely on abort modes to contain the effects of system failures, once those abort modes have been demonstrated, they may be regarded as "proven". Therefore, if a modified subsection (1) is retained, we should add a new subsection, similar to:

(2) Once the assumptions in the Ec calculation have been demonstrated by flight test sufficient to validate Ec less than 30 per million flights, the requirements of subsection (d) will no longer apply.

Reentry Operational Restrictions: §431.43 e

Again, as written, this section cannot be reasonably complied with. Subsection (1), requires that the operator "monitor the status of safety-critical systems immediately

before enabling reentry flight and verify that the vehicle can reenter safely to Earth". NO MANNED OR UNMANNED SPACECRAFT HAS EVER MET THIS STANDARD. Some examples: the Space Shuttle cannot verify the integrity of its heatshield prior to entry, the Apollo 13 and Mercury-Atlas 1 missions both had serious grounds for concern of heatshield integrity but could not verify those concerns, the Apollo 12 mission was concerned that the pyro actuators for the parachutes had been damaged by lightning, but had no way to verify their integrity prior to reentry.

However, reentry vehicles have an excellent operational record in spite of these limitations. Eventually, the art will be sufficiently well developed to meet this standard, but not today. The good operational record of reentry vehicles makes it doubtful that this regulation is necessary; economics requires RLV companies to make their best efforts not to risk the hardware on reentry. One alternative is therefore to delete subsection (1).

Another alternative would be to accept the limitations of the current art, which will evolve, with language like:

(1) For those safety-critical systems where practical monitoring techniques have been demonstrated in other vehicles, monitor the status of safety-critical systems immediately before enabling reentry flight and verify that the vehicle can reenter safely to Earth; and

Note that B-G has no objections to subsection (2) as written.

Reporting Requirements: §431.79 b

The proposed requirements are far too onerous to be practical. We believe the intent of the 15-day notification is to allow the FAA to perform collision avoidance analysis with other space objects. For flight test operations of a new RLV, launch windows will *not* be hit precisely (nor are they in experimental aircraft testing). Expendable launch vehicles also seldom meet this standard as written. This rule needs to be improved in two ways:

* Shorten the notification to 3 business days

* Allow a given license to include several launch windows within the same license; for example, launch along

the same track could take place between 0900 and 1100 GMT on July 18, 2000, or between 0815 and 1015 GMT on July 19, 2000, or between 1445 and 1645 GMT on July 20, 2000. This would allow for repeated launch attempts for the same mission – similar to current ELV practice.

B-G would suggest language such as:
(b) Not later than 3 business days before each licensed RLV mission, a licensee must notify the FAA, in writing, of the range of times and dates of launch attempt opportunities for the intended launch and reentry or other landing on Earth of the RLV.

Costs of Compliance: page 98 of NPRM

In the attached notes, on page 98-99, the FAA assumes that application for a policy review will consume eight hours of time for each application, and that compliance with the safety application requirements will consume the equivalent of one full time staff position. These requirements are used to evaluate the cost burden of the regulations.
In the opinion of Bertram Greason, Inc. these assumptions greatly understate the regulatory burden placed on RLV companies. Our own assessment based on time spent

evaluating the regulations is that each policy application will require roughly one month's work by a skilled

employee, for a cost estimate of $8583 per application. The eight-hour estimate is more appropriate for the application of subsequent flights of a given type of payload. B-G contemplates operation of two different types of vehicle. One vehicle would fly roughly one sortie per week, with 5-6 different types of missions per year; for this vehicle, the burden would be on the order of $72,300 per year. Another vehicle would fly mostly similar missions on suborbital flights at a high mission rate of one per day -- implying a burden of roughly $104,000 per year. We believe these are more realistic estimates for the burden of the policy review.

Revenues used in assessing burden: Page 115 of NPRM

The revenue projections the FAA use in determining the regulatory burden are unrealistic. They assume that RLV operations will be fundamentally similar to the operations of existing ELVs -- few missions per year at high revenue

per mission. Neither of the vehicles B-G is pursuing fit this model. Both will fly a large number of missions per year (50-400) at relatively low revenue per flight. For the suborbital vehicle, revenue per flight is expected to be in the neighborhood of $90,000, while profits per flight (available to pay for regulatory costs) may be as low as $10,000 per flight. That vehicle would produce annualized profits of $2 million to $3 million. Even the orbital vehicle is expected to generate profits above costs of only $50 million to $100 million per year. The discrepancy is that once RLVs are operating in a competitive environment, the market-supported price of launch is expected to drop significantly.

Against that, the expected annualized costs of compliance are given at $700,000 on p. 115 of the NPRM. That does not apply to the first year of operation, but is "smoothed" out over many years. In the first year, the FAA estimates the cost of compliance for determining safety risks alone to be $757,000, and there are many other burdens.

Therefore, it appears that the regulatory burden is in fact very significant. For a developer and operator of a purely suborbital vehicle (a reusable sounding rocket or tourism vehicle, for example), the costs of compliance in the first year could equal or exceed the total potential profit of the venture. Therefore, Bertram Greason, Inc disputes the conclusions of p. 115-116, where it is asserted:

* A regulatory flexibility analysis is not required

* The proposed rule is not likely to cause small business failures or adversely impact their position relative to larger businesses.

In particular, B-G wishes to draw attention to the entire market segment of suborbital or very small payload launch, which is inherently a niche market with revenues, profits, and margins much lower than the space launch business. The current regulations are tailored to very large vehicles for space launch, and so many regulatory steps required for orbital launch (driven by compliance with the Outer Space Treaty of 1967) are being needlessly imposed on suborbital ventures. While these requirements (such as the 15-day notification for each flight) may be merely onerous to a space launch venture, they would likely

be crippling to a venture focused on suborbital flight. B-G strongly suggests that a distinction be made between orbital and suborbital flight, with the presumption that the regulatory burden can be relaxed for suborbital applications.