U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Associate Administrator for
Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

April 13, 2012

Mr. Julius Knapp
Chief, Office of Engineering and Technology
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Dear Mr. Knapp:

In response to recent conversations between the FAA and FCC regarding the FCC's interest in the reentry risk posed by the upper stage of a Falcon 9 launch vehicle belonging to Space Exploration (SpaceX) Technologies, we are happy to share with you our assessment of that risk.

SpaceX is scheduled to launch to the International Space Station for NASA on April 30 under FAA license. The FAA has reviewed the SpaceX risk assessment performed by ACTA, Inc., which described a risk of 12.5 in 10,000. Additionally, the FAA conducted its own risk assessment last fall, and produced a very similar number: 12.0 in 10,000. More recently, NASA performed a more refined risk assessment based on better input data for the physical properties of the launch vehicle, and concluded that the risk for this mission does not exceed 3 in 10,000. The FAA considers this risk acceptable, and characterizes it as small relative to the random reentry risk associated with other large upper stages.

The FAA's method for assessing the risk of random reentry is similar to those applied by ACTA and NASA as follows. Like NASA's Object Reentry Survivability Analysis Tool (ORSAT) program, the FAA and ACTA methods are object oriented numerical models based on physics, such as Newton's laws of motion. The model treats the upper-stage as a container, which contains an assembly of geometric objects representing the fragments liberated at break-up. The idealized container matches the overall mass and ballistic coefficient of the upper-stage. High heating rates and aerodynamic forces produce break-up, where the container releases its content of objects (i.e., the debris list). Magnesium and aluminum structures have been observed to fail consistently at approximately 78 km (42 nm) altitude, causing a catastrophic break-up of the object. This major break-up phenomenon near 78 km altitude is remarkably independent of vehicle attitude and rates, diameter, shape, and entry flight path angles between –0.3° and –1.5°. The trajectories of the resulting fragments are modeled until ground impact or demise due to aero-thermal heating. In this type of model, the heating of the debris objects is conservatively modeled as starting after release at the break-up altitude. The risk to people on the ground is computed based on the probability of impacts in regions at latitudes within the orbital inclination, the population density in those regions, and the total "casualty area" associated with the fragments predicted to survive to impact. The casualty area for each fragment is defined as the area associated with the fragment's impact where a person occupying that area would be predicted to become a casualty. The casualty area accounts for the cross sectional area of a person and the average cross sectional area of any fragment predicted to impact with a kinetic energy of at least 11 ft-lb. The random re-entry risk analysis methods applied to the Falcon 9 upper stage comply with all NASA standards and the interagency consensus based requirements of the Range Commanders Council (RCC) 321 Standard and Supplement for launch and reentry risk assessments.

The initial results of both the SpaceX and FAA risk assessments differ from those reached by NASA. However, the FAA finds that the more recent NASA result is more accurate. Although the methodologies are the same, differences arise out of the different debris lists used. ACTA, on SpaceX's behalf, assumed a greater amount of fragmentation, which resulted in a greater casualty area. The ACTA random re-entry risk assessment used a debris list that was derived from previous analysis ACTA performed for a failure during launch, where the explosion of a propellant tank caused relatively extensive fragmentation. Under such a failure scenario, the fragments produced by the explosion would likely survive to impact. With a true random reentry from orbit, there would be no fuel on board, no explosion, fewer fragments at the outset, and fewer surviving fragments, and thus a smaller casualty area.

NASA's more recent calculations used a different debris list and accounted for the fact that there would be no propellant on board given a reentry from orbit. NASA computed the extent of the fragmentation (i.e. the debris list) using its methods, which produce results consistent with the available empirical data from past random reentries of upper-stages. NASA's analysis also had the advantage of using final engineering drawings at a component level. This meant that NASA had better information about shape, material and thickness of the components and was better able to determine the most likely fragmentation during a random reentry and the survivability of the debris fragments.

As is evident, ACTA's debris list provided a conservative surrogate for the more accurate debris list that was ultimately derived by NASA. The other conservative assumption in play during the initial analyses was that the casualty area reflected the explosion of a propellant tank, which, given regulations requiring propellant depletion on orbit, would not occur. For purposes of calibrating the results, it is important to note that the FAA ran the first debris list through NASA's ORSAT program last fall. The casualty area determined using the launch failure debris list with ORSAT was within 2% of the value computed by the FAA using a different software program. This demonstrates that the change in input was a determining factor in the different results.

I hope this is of assistance. Please let me know if you have any additional questions.

Sincerely,

Kenneth Wong

Kenneth Wong
Manager, Licensing and Evaluation Division