Commercial Space Transportation Advisory Committee (COMSTAC)
Systems Working Group Teleconference Minutes
December 18, 2012, 1:00-2:00 pm EDT

I. Introduction

a. Henry Lampazzi, FAA, introduced himself as facilitator for the telecon.
b. He reminded everyone that the FAA will not propose new regulations until October of 2015, and so the telecons are not about soliciting proposals, but background research to narrow the focus on specific topics. The telecons are held about once a month with the help of COMSTAC as industry advisor.
c. Minutes for each telecon are posted on the FAA-AST website, and speakers are encouraged to identify themselves.
d. The next telecon, on Fault Tolerance, will be held January 15th at 1pm Eastern.
e. Last month's topic was key terms and definitions for Commercial Space Flight. He thanked Dr. Dave Klaus for leading the telecom, and everyone that participated.
f. The current topic is Abort and Abort Systems. Henry Lampazzi described them as an element in Government Human Space Flight in the past, and this telecon will discuss them moving forward in Commercial Human Space Flight, utilizing lessons learned from previous US missions, and others.
g. He then outlined the six questions to be addressed during the telecon (slides 8-9), and the objectives he hopes to reach at the end (slide 10).

II. Presentation

a. Working Definition – Launch Abort System

i. Henry Lampazzi read to the participants the current working definition aborts: "an escape system used on large vehicles, primarily vertical systems, used to separate occupants from the launch rocket state or stages in the case of imminent catastrophic events."
ii. Livingston Holder, COMSTAC Working Group Chair, asked where the definition comes from. Henry Lampazzi answered it comes from COMSTAC.
iii. Derek Webber asked whether the definition of abort is a semantic issue or legal issue, and what the consequences are of calling something an abort that is not. Henry Lampazzi responded the discussion will be about how the community's thoughts on abort fit into the conversation moving forward.
iv. Mark Sundahl asked if the definition should be limited to launch vehicles, or expanded to other space vehicles. Henry Lampazzi responded that it will be addressed later in the discussion.
v. Pam Melroy, FAA, also responded, in part to Derek Webber's question, that the discussion is about what best practices and good guidance is, and what approach can be taken. There may be too many vehicle and flight unique scenarios to justify a best practice discussion. But for the type of system in the working definition, there are a lot of lessons learned.
vi. Derek Webber responded with an example of failure to dock with a space hotel, not due to catastrophic failure, or an "imminent catastrophic event" as in the working definition. This separate scenario may need another definition, like failure to dock and need to return to Earth. Pam Melroy said they were comfortable commercial

operators may use terms however they choose, but backing away from a space hotel is a less useful scenario for developing shared language for best practices.

vii. Randy Raley noted the lack of language in the working definition regarding safety of people and community in the area during launch, and said it needs to be included. Randy Repcheck, FAA, responded that this telecon focuses on aborts for occupant safety as opposed to public safety.

viii. Livingston Holder also responded, in part to Derek Webber's question, that his example may be a dock abort, but this discussion is about trying to narrow the scope. However, this discussion may have legal ramifications, in that it will create expectations about the meaning of abort terms.

ix. Greg Kennedy asked about including air launched horizontal vehicles in the working definition. Pam Melroy responded it will be addressed later in the discussion.

x. Dave Klaus asked whether the working definition should be broadened beyond the launch abort system, to the abort concept, to which Pam Melroy responded the discussion will initially focus on systems.

b. First Question: "Does an abort apply to the launch/ascent phase only, or does it apply to other flight phases as well?"

i. Randy Raley suggested the scope be limited to powered flight, and not unpowered descent or on-orbit thrusters; scenarios of powered flight where you need to get away from a large expenditure of energy.

ii. Derek Webber suggested for commercial space flight the scope be redefined as something like escape from life-threatening circumstances, since passengers are still onboard even after the launch phase.

iii. Pam Melroy responded again, saying the team has previously discussed his question, but found it difficult to discuss best practices for other phases across different vehicle designs. Livingston Holder also responded that this was a potentially branching discussion. Each flight mode has another series of questions, and should all be explored, but in a short telecon, focus should be devoted, and the launch phase is a very dangerous period of light with broad-reaching consequences.

iv. Aaron Oesterle also noted that under the applicable regulatory authority, the launch and reentry phases are the most important to focus on.

v. Greg Kennedy noted the X15 program had quite a bit of experience with landing at alternate sites because of overcoming flight issues and other considerations.

vi. Dave Pitre challenged the term "imminent catastrophic event" because it did not cover abort for non-catastrophic events, like a loss of redundancy. The limit to powered flight also does not cover Return to Launch Site (RTLS) procedures. Pam Melroy responded that the definition was limited to "imminent catastrophic event" to cover scenarios exposing occupants to greater risk in order to avoid a more extreme hazard. She clarified that the definition of risk would be addressed later in the discussion.

vii. Mark Sundahl followed up on the issue of different needs for multiple vehicles, and stated the ultimate goal of passenger and crew safety will be achieved through a

combination of design features and abort capabilities that operators will be able to pick and choose from that may apply to their spacecraft.

c. Second Question: "Is an abort system a part of fault tolerance?"

   i. Henry Lampazzi further asked whether single fault tolerance would be one IMU and an abort system, or two IMU's and an abort system.
   ii. George Tyson compared it to two abort systems currently used in aviation. Ejection seats for the military, and ballistic parachutes as used in Cirrus aircraft. The ejection seat is the last thing a fight jock would want to do (use), and is not part of their fault tolerance. And the ballistic parachute is also the absolute last thing you do (want to use), and not part of the fault tolerance.
   iii. Janet Karika responded in the context of the Atlas 5, where the goal is to keep as much as you can at the interface and the capsule, without including anything that would require changes to the rocket. Having abort as something additional before reaching into the rocket would make sense.
   iv. Geoff McCarthy disagreed with the previous comment on ejection seats and parachutes. In the military, the ejection seat is the first resort when anything goes wrong in a fighter airplane, like the engine quitting, because there is no other impact protection in the vehicle. The rules are clear: eject if out of control at 10,000 feet, eject if engine failure at 2000 feet. The ballistic parachutes on Cirrus planes are not used often enough, and there are perverse incentives forcing owners to pay for the plane or negotiate with the insurance company for choosing to use their parachute. The telecon group should keep these things in mind when considering the wisdom or need or functionality of escape systems. Ejection seats are at least 4-sigma if not 5-sigma reliable. They come from the factory 6-sigma reliable, but there is a possibility of deterioration of maintenance or reinstallation.
   v. Pam Melroy noted that reliability of abort systems will be addressed later in the discussion.

d. Third Question: "For what types of vehicle designs should launch abort systems be recommended?"

   i. Randy Raley stated that if you have stored enough energy to cause a cataclysmic event that would affect the riders then you need an abort system. Henry Lampazzi clarified this as vehicle design dependent.
   ii. Derek Webber asked if another variable should be the duration of the burn, when the explosive force is liable to be used, and an abort system may not make sense. Randy Raley agreed, saying we should move in the direction of requiring full disclosure to occupants of the time period when there is no help. He compared it to the shuttle, during the time period when you couldn't do transatlantic and you couldn't really do a return to launch site.
   iii. George Tyson described it as an acceptable level of risk. Certain vehicles will have higher risk, and abort systems should be evaluated by how much they reduce the level of risk.

iv. Russ McMurray asked how the risk would be at best. George Tyson responded that it's very vehicle dependent, and within the operator's and occupant's purview. Occupants can make their own decisions, if the risk and risk reduction is explained to them in a way they can understand.
v. Russ McMurray suggested categorizing abort systems that might be appropriate for various kinds of vehicles, or categorize the types of vehicles the FAA will eventually regulate, and tailor the conversation.
vi. Livingston Holder agreed, and considered a suborbital winged vehicle that takes off from a runway. While under power, if you have the option to turn off the rocket engine, you still have an aerodynamic recovery period. If the hazard goes above a certain threshold, you may need an abort capability that is something more than simply turning the engine off. It could be very vehicle and mission dependent.
vii. Russ McMurray agreed, again contrasting an aircraft design where a manual system might be good enough, with a rocket design that may require an automatic system because there isn't enough time, or because the vehicle has reached a certain, unrecoverable pitch.
viii. Bill Khourie followed up with the example of an air launch system, with a winged vehicle separation that can land if the range hopefully has supporting landing facilities.
ix. George Tyson restated that the abort system has to be considered in relation to each vehicle, as far as level of risk and how much it reduces that level of risk.
x. Pam Melroy restated that the concern is for the safety of the occupants when you have to choose whether to make a hazardous maneuver to avoid something that is even more hazardous. The current scope focuses on maneuvers that are going to result in some kind of hazard. For winged vehicles, air drop abort looks like a return in the normal reentry profile, and not likely to increase risk to the occupants. A discussion of best practices should focus on the more hazardous environment.
xi. It was commented that for air-drop vehicles, the abort may occur above its safe landing weight, while it is storing fuel on board that would have been burned off faster if the engine hadn't been turned off.
xii. Adam Dershowitz noted the discussion was getting into very specific vehicles, and the issue was becoming high levels of risk, rather than picking out practices for those specific vehicles. For example, X vehicles in the 1950's could not land after air-drop without serious problems unless you could dump all the fuel. It's more important to look at overall risk, rather than specific needs of particular vehicles.
xiii. Someone asked whether there should be general guidelines or a measuring stick, for the crew, or astronaut, or someone, to make the decision whether to abort or whether the risk is acceptable.

e. Fourth Question: "What should the reliability be for an abort system?"

i. Henry Lampazzi used the last comment to segue.
ii. Randy Raley said it may be up to the designers, whether they want to trade a more reliable abort system for a reduction in redundancies.
iii. Livingston Holder further asked whether abort systems should accommodate the entire flight profile, or a percentage.

iv. Randy Raley linked it to the safety of people on the ground. The operator should be forced to identify how they will bring down a vehicle if the occupants will be safe guarded separately.
v. Geoff McCarthy clarified that aborts can happen either with the entire vehicle, or part of the vehicle as in a designed escape capsule, or individual occupants exit separately. Someone else noted that when you leave the rest of the vehicle powered, it can reenter and cause a different type of hazard, of even collide with your escape.
vi. Janet Karika stepped back and noted that the discussion was developing into a sort of acquisition guide, getting into how one must design their system, instead of developing a requirement for the operator to show that they are protecting the safety of the occupant. Some systems are so unique, abort is going to be designed on a case by case basis. The discussion should stay more at the requirements level.
vii. Mark Sundahl suggested an approach based on a legal standard like duty of care, requiring operators to show they are taking every possible cost-effective measure to ensure the safety of their passengers.

f. Fifth Question: "Should operators have a different level of care for occupants during an abort?"

i. Henry Lampazzi used the previous comment to segue.
ii. Pam Melroy emphasized Janet Karika's comment on asking the operator how they are protecting the occupant. The question is what levels of care should be expected in an emergency, like an abort.
iii. Russ McMurray noted that under a hopeful extension of CSLA indemnification, we would not want to put the government on the hook to pay third party damages for an abort system that protects occupants but not the uninvolved public.
iv. David Allen noted that in commercial space flight, the occupant is much like a passenger on an airline. Protecting the passenger is essential to protecting the industry, and should be the top priority.
v. Janet Karika commented that space flight participants would have to understand the risk, and a catastrophic event would be part of that known risk.
vi. Randy Raley disagreed with prioritizing the passenger to protect the industry, because catastrophic damage to the uninvolved public can also kill the industry. Janet Karika agreed.
vii. Mark Sundahl commented that design liability or defective product law requires operators to design a spacecraft that is safe to the extent that it's cost effective, feasible.

g. Sixth Question: "Which of these abort initiations would you recommend for a minimum level of safety?"

i. Henry Lampazzi moved to the final question in the interest of time.
ii. David Allen stated that crew on board should be able to make the first level of decision, since they will be hands on in any situation. But have a second tier where crew on the ground can override in certain situations.

iii. Janet Karika stated that they took a different approach, opting for automatic procedures. For instance, with health monitoring systems, even if pilots want to feel in charge, you may need to eject participants quickly, without time to sit and think about it or vote. If other systems do not trigger automatic procedures, then crew can make the call.

iv. Henry Lampazzi summarized it as a potential mixture of manual and automatic systems depending on design. Livingston Holder described this as a tiered level of protection. In situations where the crew has time to observe something happenings, they can take action, as opposed to something that progresses rapidly before the crew can react or displaces them from the controls.

III. Conclusion

a. Henry Lampazzi deferred to Pam Melroy to close the call. She thanked everyone for an exceptionally robust discussion, including those who already began sending her e-mails, and she encouraged anyone with further thoughts to also contact her.

Teleconference Participants:

Chuck Abernethy (Aerojet), David Allen (Black Sky Training), Sirisha Bandla (Commercial Spaceflight Federation), Chris Burns (Cutting Edge Communications), Giugi Carminati (Weil, Gotshal & Manges LLP), Adam Dershowitz (Exponent Failure Analysis Associates), John Dicks (L-3 Communications), Phil Engelauf (NASA), Peter Fahrenthold (Northrop Grumman), Christine Fanchiang (Colorado), Robert Frize (Carrick Consulting Limited), Richard Gavin (NASA), Matthew E. Granger (Lockheed Martin), Livingston Holder (Holder Aerospace), Harry van Hulten (Space Expedition Corporation), Ruth Hunter (USDOT/Volpe Center), Patricia Hynes (New Mexico Space Grant Consortium, NASA EPSCoR), Angelo Karavolos (NTB Technologies and Associates), Janet Karika (NASA), Greg Kennedy (NASTAR Center), Bill Khourie (OSIDA), David Klaus (Colorado), Charles Larsen (FAA-retired), Raymond Leung (George Washington University), Michael Lopez-Alegria (Commercial Spaceflight Federation), Geoffrey W. McCarthy (Aerospace Medical Association), Mike Murray (ULA), Aaron Oesterle (PoliSpace), Brad Owen (USAIG), Michelle Peters (Zero-G), Richard Rankin (Brandywinecreek Associates LLC), James Russ McMurry (Boeing Law Department), Alex Saltman (Commercial Spaceflight Federation), Milton Skip Smith (Sherman & Howard LLC), Mike Snead (Spacefaring Institute LLC), Mark. J. Sundahl (Cleveland-Marshall College of Law), George Tyson (Orbital Commerce Project, Inc.), Michelle Voelker (Aerospace Corporation), Derek Webber (Spaceport Associates), Thomas Wiener (private practice)

Participants from the FAA Office of Commercial Space Transportation (AST) included: Paul Eckert, Henry Lampazzi, Jeff Sugar, Dave Gerlach, Stewart Jackson, Pam Melroy, Ken Wong, Rene Rey, Randy Repcheck, Brian Meade, Mike Kelley