Federal Aviation Administration

Commercial Space Transportation Advisory Committee (COMSTAC)
Systems Working Group Teleconference Minutes
August 14, 2012, 1:00 am EDT

COMSTAC DFO, Sue Lender, welcomed teleconference participants as they joined the meeting. She also activated the recording feature and took attendance.

Sue reviewed the ground rules for the teleconference. She also noted the minutes will be posted to AST website as soon as possible. She then turned the meeting over to Livingston Holder, who welcomed the participants. Livingston noted that the FAA is not in a position to conduct a rulemaking at this time. The FAA is interested in listening to an industry discussion on topics that could be important to rulemaking. This will be very valuable to the FAA when and if it begins to craft a rule. This is the method of interaction in these teleconferences. He then introduced Pam Melroy of the FAA/AST, who had prepared charts to guide the teleconference discussion. These were emailed to potential participants before the teleconference. Pam expressed her appreciation for the Systems Working Group supporting this teleconference.

Pam asked participants to limit their remarks to five minutes. She also invited participants to send additional comments by email or by calling her on the phone.

The first question that the FAA had on the Human Spaceflight topic was level of safety. Pam clarified that when AST refers to level of safety, it is talking about threshold requirements. Should crew and spaceflight participants have different thresholds of safety? This does not refer to qualifications or training, but the targeted human protection. She invited comment on this question.

Participants expressed a number of viewpoints. These included:

- I think the standard should be different for participants and for those who are just passengers. Safety of flight obviously is the number one rule no matter what medium you're in. You want to insure that those who are commanding and controlling the vehicle have a different standard and health status than do passengers.
- I agree that basically the crew and the participants have a different level of performance that we have to maintain. I don't know that that will lead to there being different systems for the two of them. Obviously the crew has to stay functional. The participants just have to stay alive. It would be unwise to say we won't allow their standards to be different. Their standards may have to be different for reasons we can't see right now.
- Perhaps there's an analogy that could be taken from the aviation industry in that we have certain passengers who are responsible for emergency exits. Then we have other crew members who have other responsibilities. I'm sure that the

aviation side of the FAA has different standards for those. Maybe we could look to them for that bifurcation and use that as an analogy going forward into commercial human spaceflight.

- There's also an issue of perceived risk, which is a potentially very different from the reality of the risk. I would expect that the crew would have a real understanding of the risk involved. I think there's a real question of how passengers would perceive that risk, whether they think they're just getting onto an airplane or whether they really understand what's going on.
- I have a thought about radiation. The crew is going up and down multiple times, hundreds of times or more, where the participant just goes up once. Again iterated over a period, they will receive more radiation and it's necessary to have perhaps more protection for radiation for the crew than for the rest of the people on the spacecraft.
- We're definitely in support of the crew having a higher standard of safety than do the spaceflight participants. Obviously they're the key factor in our manned vehicle. Some of the folks that don't have a manned vehicle, obviously it's a different consideration. For us crew safety is superior to passenger safety.
- I have a concern that we're tending to be more hardware centric in our safety as opposed to people centric. This may be a serious issue. Being hardware centric only gains a little bit of safety where if we're people centric, it gives us lots of options. It wasn't hardware that belly flopped a plane into the Atlantic. I think we need to be more people centric when we're talking safety.

Pam asked for comment on whether the threshold of safety should vary based on the type of flight profile, such as whether it is orbital or suborbital, the complexity of the vehicle, or the purpose of the flight, whether it's for research, tourism, or extreme support. Is there a different threshold of safety if you have a spaceflight participant who is not paying for the flight, so the flight is not for compensation or hire?

The viewpoints expressed included:

- One of the issues that certainly NASA and JSC have been dealing with is the visual impairment and inter-cranium hypertension problems that have occurred in some of the astronauts. This is currently being researched. I am concerned with long duration missions and in particular with space tourist missions because those participants are going to be less vetted medically and theoretically at a higher risk. Long duration and space tourism may be at higher risk for these problems
  Pam asked if that was acceptable.
  It's not yet acceptable as far as the safety of a space tourist. For a long duration mission and for space tourism in particular may involve structures that are spinning, in other words artificial gravity.
- With diverse industries, unique designs, totally different flight profiles, the idea that we can have a one size fits all rule is just not appropriate.
- I think one of the things we should consider in our thought process is what is the scenario and a little more definition of the environment and exposure to help answer these types of questions.

- I find it incredulous that we're talking about different levels of safety for a crew member versus a spaceflight participant in the same enclosed volume.
- About those two other comments about different systems, different flight profiles, all that stuff. This gets back to the earlier comment about being hardware centric as opposed to human centric. Human centric is about options. It's not about the hardware. This means you could have different flight profiles, different hardware, different whatever. It's about what your people have as options.
- Pam asked for amplification about the comment that the appropriate way to regulate is to have a definition of the flight profile or exposure and then target the threshold of safety to that.
- There are so many variables that are playing at the same time. I also agree that there is a way of approaching things differently between hardware prospective versus a human centric. You're talking about human engineering ergonomics and how the human interface use of that would be the centerpiece and that's how you build your system. Sometimes, gaming it, playing it through from the simulation point of view. Understanding it helps derive the kind of questions that might be more pertinent to define rules and regulations that would support this venture.
- In the April 2011 issue of Aviation Space and Environmental Medicine, there are two papers that correspondents on this call might wish to review. One is the History of Suborbital Space Flight by Mark Campbell and Alejandro Garbino. Following that is suborbital commercial space flight crew member medical issues that are essentially physician papers of the state of the scientific knowledge about suborbital and commercial space flight.
- There are in many military airplanes differing levels of safety for the crew. I would cite examples of the B2 bomber that has two ejection seats, but occasionally has three crew persons. The B52, for example, has ejection seats that function in different positions. There are multiple examples of that particular problem that not all crew members have an opportunity to get out of an airplane. That might serve as an example of different levels of safety in the same vehicle risk.

  A question was asked about the example of multiple safety levels within the same vehicle. Is there a threshold that must be achieved that other crew members exceed because of their position in the vehicle?

  Yes there is. It's mostly a design problem of older aircraft. The threshold is, of course, that everyone would have an opportunity. Everyone gets a parachute. They want to have a reasonable chance to get out of the airplane in a reasonable emergency. My intention was to illustrate that in some circumstances governmental organizations have accepted differing levels of safety for crew members.
- About B52s, personally being part of that at one time of my life, the design characteristics for B52 were definitely altitude dependent. You had two downstairs that would just be a free fall gravity and then the chute would deploy. Then on the upper deck you had little rocket motors that would separate you from the aircraft and then the chute would deploy.

  One of the common things that we all had to carry onboard was oxygen. We don't know if it's going to be a low altitude ejection or a high altitude ejection.

- Basically we're talking about levels of safety and training. Obviously, the level of safety is increased with the level of training whether it be for crew members or space flight participants. I'm curious how everybody feels that that should be regulated? You need to protect the human.
  Pam stated that the topic of training was not part of the discussion for this teleconference. When we talk about thresholds of safety, we're talking about personal care and the human protection elements and not things like training. This could be a future topic.

Pam steered the discussion to the next question. That was whether we should be using or considering a quantitative versus a qualitative measure of safety. As she pointed out in the chart, there is a method where you can compute the quantitative prediction for loss of crew or loss of mission. You set a threshold where you can't fly unless you achieve a certain number. She invited comment on whether a quantitative approach is appropriate for the commercial space industry. What quantitative methods might work? What should the FAA and industry be measuring?

Comments included the following:

- This is a new industry. There just won't be enough data for statistical purposes for quite a while.
- First, there are only two ways that you can do a quantitative measure. One of them is analytical and one of them is empirical.
  The analytical way of doing it is loss of crew, loss of mission, and place a heavy emphasis on the systems that are like the systems we have flown before. The only way to do it without biasing towards trying to change as few things as possible is to do the system more or less that we have today. This is where we assess the flight safety of a given system based on its demonstrated flight history. That's the system that's in the current regulatory regime. That's the system that's embedded into the inform consent regime. I think it's the only credible system.
  If the FAA attempts to set a threshold quantitative requirement saying, "You must be at least this demonstrated safe level," this would be catastrophically unwise for the development of the industry. Two things can happen: That level of safety, whatever it is and however you derive it, will be set at a low level removing much of the incentive for operators to continuously drive to a higher level of safety as a competitive weapon, as a competitive drive to gain their customers.
  Or two, you set it to a high level of safety and that high level of safety cannot be met in the foreseeable future of the industry based on demonstrated flight history. You get into a situation where the only way to prove it is to back up expert opinions and paper analyses, which do not lead people to trying new things to improve their safety. What they lead to is trying new things to improve the analysis. I think we have 40 years of space flight history that shows us that going down that road may maintain, or fail to maintain, our past practice levels of safety.
  The thing we all have to bear in mind is that the past practice of safety in spaceflight will not work. We cannot develop a successful commercial industry by maintaining our past practices in safety. We have to do something better.

Doing something better means doing something different and allowing people to do something different means we're going to have to structure a system in which they are allowed to do so.

Given that belief I think the question that was asked previously about different thresholds of safety. Once you realize the threshold of safety is not a number that you have to meet, threshold of safety is are there certain risks that we as an industry have a sufficient record to indicate our serious risks. We need to spread best practices through the industry to mitigate those risks. It's not obvious to me that the mitigation of those risks does vary, depending on the type of mission that you're doing, nor that it doesn't.

If we maintain the informed consent regime, which I believe strongly we must, it's really up to the customer to determine whether their particular mission tolerates a different level or a different character of risk than someone else's type of mission. The FAA's province should be where are the risks? Are they sufficiently serious that they need to be mitigated? If they need to be mitigated how do we foster the development of industry standards? If industry standards fail to be developed what regulations are required to insure that best practices are used? Or that an alternative means of compliance to eliminate those risks that are found.

Trying to put in a number would be the kiss of death.

- Several participants agreed with this comment.
- Another participant asked if there are similar loss of crew and loss of mission type requirements in commercial aviation. Commercial space transportation is at a higher altitude, but there are similarities to flying across the Pacific Ocean at night. There's not much chance of a successful landing if something goes wrong. The FAA noted that there is a reliability requirement for elements, such as engines, avionics, etc. But not an overall loss of crew, loss of mission type requirement.
- One of the things that we have to recall in our history is that aviation was largely unregulated in its infancy. As we got smarter, we regulated and sometimes overregulated. Now what we have is we have a strong structural regulatory environment with an immature industry as opposed to an immature industry and an immature regulatory environment.

  The risk that the new industry runs is being stopped by the regulatory environment, which is more robust today than the industry is. Striking the balance of the regulatory environment and the industries maturity is going to be the challenge to assuring that the industry actually can take off. Elsewise, we can stop it in its infancy.
- A topic for a future teleconference might be to look at risk from a legal point of view, particularly as it would apply to passengers.

  It was noted that the FAA already has an informed consent requirement.

  There was a suggestion that we might need a risk management regime that benefits the operators, so that they have a clear understanding of the risk of carrying spaceflight participants.

- People are confusing the terms ‘participant’ and ‘passenger.’ Legally, there are different requirements for how they are treated. Informed consent deals with ‘participants.’ ‘Passengers’ fall within a regulated safety environment.

Pam moved to the next question. What is the expected level of safety in a failure situation? In aviation, a single level at fault tolerance for a critical hazard is a generally accepted standard of safety. On take-off you’ve got to be able to lose an engine and safely either stop or continue to take-off. There’s take-off data based around that.

A single malfunction shouldn’t result in harm to the occupants. What happens after a single failure in human spaceflight? Is it the same thing that there should be no harm to the occupants after a single failure? Is the expectation that the launch operator will terminate the mission or the flight and bring everybody back right away? What kind of safety should we be thinking about for a second failure if that should occur?

- Obviously, you don’t have spares for everything. Generally, aviation can tolerate the loss of an engine perhaps but not the loss of a wing or the loss of an elevator. It really means that you have to be able to tolerate any single reasonable probable failure. There are some systems where it’s much more practical to design the system to make that failure improbable than it is to figure out how to how to put on redundancy or something to contain parts of that failure.
- The ultimate endgame is what is acceptable enough to insure the survival of the passengers or crew members onboard to return safely in any regime whether you’re taxiing on the ground or you’re in a take-off mode, ascent mode, or reentry.
- The first thing I would think of is can I still breathe and can I still control the vessel? I mean controllability and sustainability of the environment, life support. To me that’s the bottom line and do I have an egress – a way out if you can’t do both of those things or one of those things.
- We like to look at options. If you have a failure what are your options at that point? Each progressive failure limits your options. At what point are your options so limited that you call it quits. We look at what the crew, passenger, or whoever, have as remaining options after the failure. You could have two failures and still have plenty of options. You choose from those options on what needs to be done.
- It’s important to look at it overall as a system reliability, which is to try and get the analogy with aircraft. With aircraft you’re talking about the liability of ten to the minus nine. With spacecraft the technology doesn’t exist and it’s not going to for a long time. If you try to regulate from the outside, you really force designs to have particular systems. Instead we ought to be looking at a big picture and overall reliability, which we then can meet either with redundancy or improving particular designs and things of that nature.
- A shuttle flew for decades with zero fault tolerance ability in selected systems as the two disasters showed. I don’t think that any regulations of commercial space vehicles should hold them to a higher standard than the shuttle displayed during its history. There are going to be systems for which there are no back-ups. The

participants that will be the revenue source for the early years of this industry. If the risks are disclosed to them that should be sufficient. I don't think the FAA can come up with a strict standard of one fault tolerance for everything because no spacecraft has flown with one fault tolerance in our history.

- I'm not sure how a normal person is able to assess the risk in the manner that we're talking about. I'm not sure what that means to them. Either they have a great desire to be a spaceflight participant like climb a mountain or go swimming underwater or something, swim with the sharks. That's their choice. I don't see how you can give them information that would help them make an informed decision for a typical member of the public.
- I think there are ways for people to understand their environment before they get involved with it. Again that goes back to levels of training. I guess that's for another discussion, but there are ways for people to understand their environment.
- I think there is some reasonable level. If the FAA was to say no single malfunction should result in harm to occupants, I think that's reasonable. Now if you're talking about a wing falling off. Well a wing falling off is usually a result of one or more other malfunctions in the structure. They're designed for minimal risk considerations to be made for things like that.
  I would think a statement no single malfunction should result in harm to the occupant is fairly reasonable. You may even say no two malfunctions shall result in harm to occupants, but then it's up to the industry to make the design to prevent that. When you start going deeper into detail, then each different spacecraft or suborbital vehicle will be a varied design. The FAA just can't spend the time and money necessary to go over each type of failure that there could be. I think industry there will have to fairly regulate itself. I think one broad generic statement like single malfunction that might be something.
- Does the FAA want to start shaping what it is to be "spacecraft worthiness" just like we do aircraft their worthiness. Is there a certain level between industry and government agree that's considered minimum and acceptable worthiness point of view because if periodic inspection for paying passengers versus a participant? That's another topic that you might want to socialize down the road.

Pam noted that there was one last question to ask. What is the level of care, short of a fatality, that we need to be worried about? Earlier in the meeting someone pointed out that as long as the passenger survives that's fine. In the charts that she sent around there are a couple of scales of injury. There's a scale used by the Association for Advancement of Automotive Medicine, but even more importantly, we also list the definition of a serious injury. This is the definition that we use if we classify the event as a mishap or an accident. Obviously, you want to make sure that everybody does a little better than survive because if they're all seriously injured you have to report a mishap on every flight. That's clearly not reasonable.

What we're trying to get is what are people's thoughts about what level of care should we be targeting? What's appropriate in those extreme ranges?
There was a request for clarification. Are we stating that on a nominal flight what the level of care should be, either the participant or the passenger, or are we talking about a

nominal situation?
Pam stated that she was interested in the answer to both of those questions.

The responses included:

- In general aviation today, the FAA is primarily concerned with fatalities. That's not the only regulatory force on the industry. You also have insurance and insurance is worried about everything from plane damage to injuries that require hospitalization. If you're asking what the FAA should be worried about – fatalities. The industry through insurance will take care of the other stuff.
- I can give you a bit of background on injuries from escape systems. Early ejection seats had a 40 percent incident of spinal or compression fractures. That was down to well less than four percent when I reviewed this subject about 15 years ago. When we evaluate the injuries from ejections we consider the whole process from initiation through the parachute landing fall. There's a significant percentage of minor, I guess one, two, or three injuries even in a parachute landing fall. That philosophy and that categorization may be of use in this discussion.
- There was a question on statistics for a capsule ejection mechanism.
- Well it's a difficult question because there have been so few airplanes built with capsules and so, few ejections. The F-111 had a capsule system that was quite reliable. Ejection systems overall are 80 to 85 percent lives saved. The 10 to 15 to 18 percent fatalities can usually be traced to a late delayed ejection decision. Malfunction of the ejection system is simply unknown. I only know of one in 20 or 30 or 40 years of history of use of the ejection systems in airplanes.
- I would just put forward a suggestion and try to answer this question of making comparisons with the extreme sports industry, mountaineering, and bungee jumping, stuff like that, how they handle insurance and categorization for this purpose.
- Are you also asking what is the reasonable level of when you need to report an incident? Pam responded No. That's really something that the NTSB and the FAA work out in terms of reporting. We're thinking about acceptable levels of safety for a flight.
- Just a question, do you also have to think in terms of any long expiration issues? All these address short term kinds of injuries. If you're thinking long term with the possibility of long duration missions, then you get into a bunch of other issues that really are not addressed in terms of the FAA or cars or other kinds of regimes.
- I also wanted to make sure that we understand that the types of flight profile that we fly will also impact this significantly. In Virgin's case,where our plan is to let people float around there's a chance for minor injuries just from the process of floating around in a zero microgravity environment as opposed to other competitors who will have their people strapped in seats. The level care of minor injury reporting is going to have to be pretty much a case-by-case basis. It's going to be very difficult I believe to set an equitable standard across the industry.

Pam thanked everybody who participated and reminded everyone that the FAA/AST has a docket open. If anyone would like to make a public comment they can do so. If someone would like to make a confidential comment they are welcome to send Pam an email or give her a phone call.

She asked for suggestions for topics that might be good for these telecons or ways that we could do this better. With that she turned the meeting over to Livingston to wrap things up.

Livingston thanked the participants and asked everyone to keep in mind that this is an on-going discussion. If at all possible, we as an industry can form consensus that will let the FAA know strongly our opinion. The FAA will listen to all inputs from all the industry participants and take that into consideration when and if they start building a regulatory environment for the industry.

He noted the next teleconference has been advertised and expressed his hope that everyone would join the next discussion. Livingston adjourned the meeting at approximately 2:20 p.m. EDT Sue noted that the recording was being turned off.

Teleconference Participants

Livingston Holder (Holder Aerospace), Chair, Brett Alexander (Blue Origin), Art Anismob (Space University), Melchor Antunano (CAMI), Lee Archambault (NASA JSC), Herb Bachner (Aerospace Consulting), Lindsey Bagley (Tauri Group), Sirisha Bandia (Commercial Spaceflight Federation), Therese Brewster (Zero-G), Michael Chandler (NASA), Mark Campbell (Aerospace Medical Association), John Coleman (CSSI), Dan Collins (United Launch Alliance), Paul Deason (STAT LLC), Adam Dershowitz (Exponent Failure Analysis Associates), Lee Engelauf (NASA JSC), Christine Fanchiang (University of Colorado), Chris Ferguson (Boeing), Bob Floyd (NASA JSC), Marshall Gardner (DII Aerospace Laboratories), Stevan Gilmore (NASA), Javier Gomez (Tauri Group), Lou Gomez (New Mexico Spaceport Authority), Jeff Greason (XCOR), David Gump (CircumSpace), Mike Holguin (ULA), Ruth Hunter (DOT), Sri Iyengar (United Launch Alliance), Robert Johnson (CAMI), Melissa Jones (NASA), Chuck Larsen, Michael Lopez- Alegria (Commercial Spaceflight Federation), Mike Machula (NASA JSC), Gaspare Maggio (SpaceX), Kate Maliga (Tauri Group), Akane McCarthy (Space Adventures Ltd.), Jeff McCarthy, Gini McDevitt (TASC), Peter McGrath (The Boeing Company), Stokes McMillan (Sierra Nevada Corporation), Doug Messier (Parabolic Arc), Robert Millman (Blue Origin), Michael Murray (United Launch Alliance), Bradley Owen (United States Aviation Underwriters), Nigel Packham (NASA JSC), Robert Patlach (NASA/JSC Human Performance & Engineering Division Wyle), Michelle Peters (Zero-G), Sein Roden (FAA), Alex Saltman (Commercial Spaceflight Federation), Robert Seibold (The Aerospace Corp), Tom Shelley (Space Adventures), Patti Grace Smith (Consultant), Phil Smith (Tauri Group), Mike Snead (Spacefaring Institute LLC), Philip Stepaniak (NASA), Ken Stroud (Sierra Nevada Corporation), Rick Svetkoff (Spacefighters), Jon Turnipseed (Virgin Galactic), George R.Tyson (Orbital Commerce Project Inc.), David Valentine (Department of Anthropology University of Minnesota), Erika Wagner (Blue Origin), Derek Webber (Spaceport Associates), Thomas Wiener, Lauren Worley (NASA), and H. R. Zucker (TASC).

Participants from the FAA Office of Commercial Space Transportation (AST) included: Kelvin Coleman, Dave Gerlach, Ken Gidlow, John Howell, Stewart Jackson, Ray Jenkins, Eugene Kadar, Mike Kelly, Susan Lender, Thomas Martin, Brian Meade, Pam Melroy, Randy Repcheck, Rene Rey, Jeff Sugar, Pam Underwood, Jim Van Laak, Al Wassel, and Ken Wong.