National Aeronautics and Space Administration

International Space Station Advisory Committee
and
Aerospace Safety Advisory Panel

September 9, 2011
NASA Headquarters
Washington, DC

OPEN MEETING REPORT

Lt. Gen. Thomas P. Stafford, USAF (Ret.)
Chairman
ISS Advisory Committee

VADM Joseph W. Dyer, USN (Ret.)
Chairman
Aerospace Safety Advisory Panel

J. Donald Miller
Executive Secretary
ISS Advisory Committee

Joint Meeting of the International Space Station Advisory Committee
and the Aerospace Safety Advisory Panel
NASA Headquarters
Washington, DC
September 9, 2011

Aerospace Safety Advisory Panel (ASAP) Members Participating via Telecon
VADM (Ret.) Joseph Dyer (Chair)
Dr. James Bagian
Mr. John Frost
Ms. Deborah Grubbe, P.E.
Mr. John Marshall
Ms. Joyce McDevitt, P.E.
Dr. Donald McErlean
Dr. George Nield

NASA (ISS) Advisory Committee Attendees
Mr. Wil Harkins

NASA International Space Station (ISS) Advisory Committee Members Participating via Telecon
Gen. Thomas P. Stafford (Chair)
Col. James Adamson
Mr. Percy Baynes
Mr. Joe Cuzzupoli
Mr. Charles Daniel
Dr. Dan Heimerdinger
Gen. Ralph Jacobson
Dr. Ron Merrell
Dr. Josef F. Schmid
Col. Jeffrey N. Williams
Gen. Joe Engle, Technical Advisor
Mr. Robert Maiberger, Technical Advisor

NASA Staff and Support Personnel Attendees
Dr. J. Donald Miller, ISS Advisory Committee Executive Secretary
Ms. Holly Stevens, ISS Advisory Committee Administrative Officer
Ms. Susan Burch, ASAP Administrative Officer
Ms. Paula Burnett Frankel, ASAP Reports Editor
Ms. Rebecca Sharek, NASA OIG
Mr. Ray Tolombo, NASA OIG
Mr. Eric Perritt, NASA OLIA
Ms. Meredith McKay, NASA OIIR
Ms. Diane Rausch, NASA OIIR

Other Attendees

Culbertson, Frank	Orbital
Hendrickson, Dan	AIA
Richards, Bob	Orbital

Other Telecon Participants

Atkinson, Loretta	IG
Bowersox, Ken	SpaceX
Braukus, Michael	NASA
Gertminter, Mark	NASA
Johnson, Paul	NASA
Jones, Derek	Booz Allen Hamilton
Leone, Dan	Space News
Mackey, William	Canadian Space Agency
Manrique, Lisa	O'Brien & Associates
Smith, Marcia	spacepolicyonline.com
Spencer, Scott	[private citizen]

Dr. J. Donald Miller, Executive Secretary for the NASA ISS Advisory Committee (ISS AC), called the meeting to order and welcomed attendees. He noted that on August 9, 2011, members from the NASA ISS AC and the ASAP met jointly in a fact-finding session at the NASA Johnson Space Center (JSC), Houston, Texas, to review the status of the two Commercial Resupply Services (CRS) contractors for the ISS--Orbital Sciences Corporation (Orbital) and Space Exploration Technologies Corporation (SpaceX). The purpose of this joint meeting, co-chaired by Gen. Thomas Stafford, Chair of the ISS AC, and VADM Joseph W. Dyer, Chair of the ASAP, was to review the findings of the JSC meeting in a public forum as required under the Federal Advisory Committee Act (FACA) guidelines and regulations. In the interest of time, Dr. Miller indicated that the discussion would be among the members only; he also noted that a transcript of this meeting would be presented to NASA in the near future and would be made publically available. After administrative announcements, Dr. Miller conducted roll call of attendees and then turned the meeting over to Gen. Stafford.

Gen. Stafford thanked everyone for participating in the public meeting. As outlined by Dr. Miller, at the request of the Associate Administrator for the Space Flight Operations Mission Directorate, working groups from the ISS AC and the ASAP (hereinafter referred to as the "Review Team") met at JSC to review the status of the SpaceX "Dragon" and the Orbital "Cygnus" logistics vehicles. The Team's review was limited to only one day, and therefore should not be considered thorough or complete. Gen. Stafford noted that the plan for this joint meeting would be to first briefly recap all of the comments submitted by Review Team members. Those items identified as warranting additional discussion, and those items that could result in other observations or suggestions to the Associate Administrator would be revisited for discussion and disposition (either as recommendations or as items requiring additional information). Members were invited to submit any other items, as appropriate.

VADM Dyer opened with some General Observations. He reiterated that this was a one-day exercise, and the observations were within that scope. Both SpaceX and Orbital launch schedules (respectively, November 2011 and February 2012) are very success oriented, but as a result of prepositioned spares and consumables, NASA is in a position to absorb up to a year's delay in either or both logistics delivery schedules. The Review Team strongly supports the ISS Program Office (ISSPO) plans to keep contingency options in place in the event of extended CRS delays. Six-crew operations aboard the ISS cannot be logistically sustained beyond January 2013 without CRS. There are some additional resupply options, but CRS is the baseline, and the ISSPO is currently dependent on its success.

The SpaceX schedule seems highly compressed. To go from System Readiness Review (SRR) to first flight in three months--with most of the systems engineering reviews taking place in one month--is not consistent with good practice and experience. What this suggests is that there is no time to discover, fix, test, or incorporate changes that are needed to assure mission success. As a general observation, both groups did address their respective safety efforts. While the time allotted in the discussions was not sufficient for the group to unequivocally endorse the safety efforts, the Review Team did not find any indications of significant systemic failings of their safety efforts. Specific safety concerns and areas of interest have been identified in subsequent sections of this summary.

Regarding the question of allocation of responsibility for mission success for the early flights, it is very likely that NASA cannot escape being seen (at least partially) as responsible for mission success. This is a concern; while it cannot likely be settled, it seemed somewhat casual in the current discussion, and some written ground-rules and assumptions need to be well documented.

There is a major difference in the design and verification approaches being taken by SpaceX and Orbital. SpaceX builds their computers up in house using commercial grade parts while Orbital purchases a computer using mil-spec, radiation-hardened parts. SpaceX has a one-size large thruster that is used for all operations (fine maneuvering is accomplished by millisecond pulsing of this large thruster), while Orbital has a more traditional approach with a large thruster for spacecraft transfer and small (7lb.) thrusters for fine maneuvering. SpaceX builds the majority of their components in house while Orbital procures a large number of their components from second sources. Both approaches, while different, can be made to work with a performance-based contract.

The Orbital team gave an excellent overview. They appear to be using very good, robust scenarios in their guidance, navigation and control (GNC) stress testing; they gave an excellent explanation of loads and how they were obtained as well as structures in general. They also presented a good discussion of the prior engine failure and corrective

action. SpaceX has a brief but impressive track record and appears to have a professional working relationship with their NASA counterparts.

Mr. Joe Cuzzupoli commented on the Management aspects. Regarding the management and engineering teams, the Orbital team appeared to be the more experienced. The SpaceX team is learning, but learning fast. Mr. Cuzzupoli recommended that both Orbital and SpaceX use their resident NASA personnel to obtain the lessons learned from other programs, e.g., Mercury, Gemini, Apollo, Soyuz, Skylab, Shuttle, and Space Station. It would be worthwhile for the company management to review the lessons learned that so that they don't make the mistakes that have been made in the past.

There is an acknowledgement by the primes of their responsibility to audit their Level 2 and Level 3 vendors. It has been our experience in the past that if there is going to be a problem, it most likely will be at those levels. The ISSPO is monitoring the Management Review Board (MRB) practices at the primes. The ISSPO is also initiating Flight Operations Review (FOR) early. This is very good—they are getting started, recognizing it's not complete, but now all participants know what is needed.

"Buy in" from the International Partners (IPs) on the commercial vehicle flights is accomplished via the membership and presence of IPs at Working Groups, Stage Operations Readiness Reviews (SORRs), and Flight Readiness Reviews (FRRs).

The ISSPO has resident personnel at both contractors' facilities. Mr. Cuzzupoli suggested that the Program Managers at both Orbital and SpaceX use these personnel to gather lessons learned from the past.

Mr. Chuck Daniel offered comments on Propulsion. Although not the focus of this review, propulsion is critical to meeting the launch schedules. Only in response to a direct question (and after the SpaceX presentation was completed) was there acknowledgement that "We had an engine shut down early on the previous launch, but that's OK." There was no explanation or root cause analysis or corrective action on this particular anomaly. This statement is troubling, i.e., not recognizing that premature engine shut down is a significant event. Orbital uses a rocket engine that is from the old Russian N1 rocket. It has experienced a recent firing failure at Stennis due to build up of stress fractures, and it has not had normal non destructive inspection (NDI) inspection or testing (it is now undergoing inspection and testing). The age of the engines (40 plus years) could present risks such as stress corrosion failure.

Dr. Donald McErlean commented on Hardware. There is a concern with the SpaceX design of the hatch and mechanism that opens on the Dragon capsule to expose the navigation instruments for operation. Failure to open or to close constitutes a point for loss of mission. SpaceX indicated that they've built redundancy into the mechanisms, but that is one area where more discussion (or insight) might be appropriate. In the briefing, the discussion of the failure, analysis of the root cause, determination of the affecting property, and the solution was relatively thin. The Review Team didn't know if SpaceX had performed a rigorous safety/correction analysis or not, but they didn't brief it at the review. When failures or weaknesses are detected by the contractor, a full insight into their process for investigation and risk mitigation is necessary.

Mr. John Frost discussed the Software findings. He noted that for autonomous rendezvous, software is critical for avoiding ISS collision. Orbital's concerns are focused on Engines and Software Development, and the Review Team agrees with that logic and prioritization. During the Orbital presentation, the comment was made that their software was obtained from different areas (presumably from other programs) and no single lead was identified. With no single software lead person identified (as in other successful programs), the possibility of an incompatibility or conflict could occur in the software process. One other issue that was brought up was the frequency response of one of the contractors. While the explanation was good, the 2 Hz cycle being used leaves open the question about latency in the Operational Flight Program (OFP) resulting in a "PIO" situation. Dr. McErlean noted that this was in the Orbital presentation. The concern was that the OFP updates itself on a 2 Hz cycle, and the question is: In a dynamic situation, is that fast enough to allow for the latency of position and distance measuring, and creation of a corrective action for the flight path? During the short discussion afterward, the Orbital team had a good explanation, but overall, the concern was that the vehicle could be outrunning its own control capability. The 2 Hz cycle is fairly slow—do we have a problem there? Dr. McErlean felt that this could require some additional discussion.

The SpaceX Software presentation was unsettling to the Review Team. There was no Capability Maturity Model Integration (CMMI) accredited capability or process, and the software chief said he didn't worry about errors because "there were no mistakes in the software." In the Review Team's experience, this is unlikely. Another comment was "we don't set requirements, we just do coding." The very essential part of software development is understanding the requirements so as to identify missed requirements, unexplained actions, and possible unsafe conditions.

Dr. Jim Bagian commented on Test and Verification. Some of the requirements in the Interface Requirements Document (IRD), such as leak checks, power quality, etc., are intended to be design requirements and are not performed on every mission unless there is a design change. Requirements are not normally re-verified each and every mission unless requirements change or a change is made which may impact a requirement. Re-opening requirements for verification can result from changes from NASA (mission support) or the commercial provider (supply chain/design/engineering). A question that was not asked but comes up is: What if the contractor changes vendors for components but does not change the design? When that occurs, could there be some change that affects the safety and reliability? Dr. Bagian felt that this probably should be addressed.

The briefings stated that SpaceX was going to apply additional NASA funding toward thermal testing which was not initially performed because of "testing priorities." This raised a question on other possible design trades made (or shortcuts taken) in overall technical and environmental testing. This is a somewhat risky approach. Components are tested only at the box level, not at the card or board level, and this is a concern. At the time of this presentation, SpaceX had yet to deliver their software, simulations, and computer to Sonny Carter for testing with the ISS interfacing systems. Given the amount of time such similar testing has taken in the past, the November launch date would appear questionable. The Orbital briefing included screening for radiation-hardened parts on components. This particular screening was not mentioned in the SpaceX briefing, and the Review Team is unclear where they stand. Orbital had a rigorous hazard tracking system which recognized 730 potential hazards and will track each one to closure. SpaceX reported a tracking system for Verification Completion Notices, but there was no evidence of one for hazards. The concern is the granularity of their understanding.

Mr. Wil Harkins commented on Safety and Mission Assurance. The comment that "NASA was responsible for Safety, and Mission Success was the responsibility of the Contractors", raised concern with some of the Review Team members. Realizing different guidelines and responsibilities exist for the COTS Space Act Agreements, there still is concern about the perceived responsibility in the event of a catastrophic failure. The ISSPO acknowledges this concern and is exercising insight and oversight to the extent possible under the Space Act Agreement and the Contract to make sure that it is well defined and covered.

The ISSPO is building success criteria into the Flight Rules so that if you fail a preparatory maneuver or check, you immediately go to a parking orbit for discussion rather than trying to resolve the failure in real-time. It appears there will be no confusion while still moving toward ISS. Within the so-called ISS box (Keep-Out Zone), the ISSPO emphatically emphasized that NASA has abort authority, which apparently has been acknowledged by both Space X and Orbital, but it was not confirmed that crystal-clear documentation on this exists. The ISS crew will monitor and have the capability to initiate an abort.

Dr. Josef Schmid commented on Atmosphere/Contamination. NASA systems personnel working with the two companies reassured the board that proper flight rules and hazard mitigation would be in place to include crew precautions for use of eye protection and proper use of telephoto lenses to prevent exposure to LASER and other radiation hazards. With regard to other hazards to the crew (electrical shock, sharp surfaces, inadequate lighting, poor ventilation locations), both companies delineated risk mitigations. NASA systems personnel also reassured the board that these mitigations would be tested and in place. The radiation environment while on orbit inside the vehicle will be similar to current cargo vehicles. Ventilation and air filtering systems of the new vehicles are similar to other cargo vehicles currently in use. Both vehicles will depend on ventilation from the ISS/node systems. Space X does not have a filter within its own ventilation ducting, while Orbital Sciences does have its own filter in its system. The NASA systems level personnel reassured the Review Team that the flight rules for first ingress, observation for foreign material, and off gassing specifications would be in place and comparable to current systems. However, there seems to be no atmosphere checks of the internal volume of the spacecraft prior to hatch opening. The ISS hatch has a sample port, but the question was not asked about the Space X and Orbital hatches. NASA has a standardized review process for contamination and hazards. Even with unique design assessments, each requirement has verification (analysis, test, and integrated test) done. Processing, cleanliness, and assembly have had NASA systems level

personnel present during these activities. Off-gassing requirements are similar to those of other vehicles such as the Multi-Purpose Logistics Module (MPLM), the Automated Transfer Vehicle (ATV), and the H-II Transfer Vehicle (HTV).

Col James Adamson offered comments on Operations. Combining the SpaceX C2/C3 mission with two Orbcom launches appears to be very aggressive mission planning. At the time of this review, the ISSPO had not approved this mission, and was carefully considering all aspects. The ISS is exclusively dependent on the Dragon for down mass and any failure of this system would leave the ISS with no back up. ISS has five options for up mass, but only one significant one (excluding Soyuz) for down mass. This would appear to be a significant risk to Station logistics. EMC/EMI was called an "open issue" by the ISSPO once the spacecraft is attached to the ISS and using Station power.

Dr. Dan Heimerdinger commented on Micro-Meteoroid and Orbital Debris (MMOD). The MMOD requirements and environmental models for commercial resupply vehicles were developed several years ago to provide consistent MMOD protection for all ISS resupply vehicles (ATV, HTV, SpaceX Dragon, and Orbital Cygnus). Damage to the Thermal Protection System (TPS) of SpaceX Dragon that causes loss of vehicle during entry is not included in these requirements. Also, damage causing vehicle functional failure of either the SpaceX Dragon or Orbital Cygnus vehicle is not included. The MMOD requirements are met by all unmanned IP and commercial cargo delivery visiting vehicles with the exception of Progress vehicles, which are provided by the Russian partner. MMOD requirements for crew return vehicles must recognize that damage to TPS can lead to loss of vehicle and crew during entry.

Ms. Deb Grubbe offered comments on Culture. Her remarks fell into three areas: a general understanding of what culture is, some positive observations, and some concerns. Experience has shown that an organization's culture can and does affect the decision-making processes and the level of risk the firm is ready to assume. One comment made during at least one of the briefings was "Culture eats strategy for breakfast." Culture also mutates and moves with personnel changes, external events, and changing business conditions. Being mindful of good cultural attributes is helpful, and when combined with solid engineering and good work processes, a successful outcome usually occurs.

There are a number of positives that were noted during the briefings. Identified differences in cultures can be a benefit, if the differences are recognized and used in a positive manner. SpaceX and NASA are aware that their cultures are vastly different. Orbital and NASA are aware that their cultures are somewhat different from each other. All three organizations' top leadership has direct insight into their respective Commercial Cargo projects. There appears to be good communication between all three organizations on technical detail. NASA has been studying, measuring, and working on opening up its culture and has made progress. SpaceX has an entrepreneurial mindset which is emphasized and encouraged throughout the entire design team. While this is a proven success process in many business fields, given the complexities of building and operating spacecraft there is a concern that too much streamlining of accepted "best practices" without an associated experience base could lead to unexpected challenges to mission success. SpaceX has addressed this issue by ensuring that some key personnel with NASA backgrounds are in place and charged with monitoring this tendency. Orbital has been conducting periodic employee surveys, although there was not enough time during the review to understand what has been done with that information. The Team encourages more work there. All three organizations have plans in place around how to best manage unexpected changes in personnel so as not to have serious lapses in tacit knowledge.

There are several items of concern with respect to safety culture. Both commercial cargo providers could pay more attention to the cultural differences in a more formal manner. NASA Commercial Cargo personnel who interface with the contractors/partners have an excellent opportunity to be alert to cultural issues that could harm the outcomes that all parties seek, and it is not clear that they are effectively trained to recognize their role and to execute against it. Unfortunately, the language contained in the Space Act Agreements is so obscure as to what is and is not allowed, it has blurred NASA's current oversight role. It will be beneficial to the program for executives of all three organizations to continue to recognize their roles in establishing a good "tone at the top." It is uncertain if mechanisms are in place to effectively handle "dissenting opinions" within each organization and across the interface. Is there an appeal process? Does everyone understand and know about it? How often is it being used? Do workers believe it is additive? NASA, acting as the ultimate client, recognizes the cultural differences, but it does not appear to have done anything proactively to address any potentially negative manifestations. If no one is actively monitoring or watching culture, then it will take its own course, which usually will not produce a positive outcome.

Gen. Stafford asked if there were any open questions or discussions.

In the General Observations area, Mr. Cuzzupoli reiterated that the Review Team felt that there needs to be something in writing regarding responsibility for mission success for the early flights.

Under Propulsion, Dr. McErlean noted that there are two contractors with considerably different approaches. Space X has a relatively new design; there is design consistency between engines, and they increase thrust by increasing the number of engines. This provides a lot of redundancy. Orbital is using a proven design, but the actual engine hardware has been in storage for a period of time and is undergoing inspection and refurbishment. They did experience an engine failure. In the case of Orbital, there was a detailed discussion on the failure and the corrective actions. In case of SpaceX's early engine shut down, the Team didn't see that kind of detailed discussion. It may have taken place at the contractor's facility, but it wasn't presented to the Review Team. The analysis and corrective action process is important, not just in propulsion, but across all systems. The ASAP, in particular, would like to see more explanation on how the process is being handled in both cases. Mr. Daniel added that the difference in culture is radical between the two organizations, e.g., SpaceX's comment that they didn't have failures in software. Not to recognize that there will be failures and not to have mechanisms in place to address them is rather short-sighted. Gen. Stafford added that in his experience, every program has had mistakes. "No mistakes" is highly unlikely.

Mr. Cuzzupoli returned to the general observation regarding lessons-learned. There is a tremendous business experience that NASA has had with contractors and things that have happened in the past, and they are all registered, both good and bad. If the contractors obtained this information, reviewed it, and looked at what applies to their programs, they would be better off. Lessons-learned are very important, especially in the space environment.

Col. Williams noted that he participated in a test simulation on tracking and capture. It appears that with implementations related to the large thruster size, it is more dynamic than experience with the HTV. With the current models, the vehicle when it approaches ISS and transitions from approach to hold mode, the damping is such that the vehicle will go about 1 m inside the capture volume, dampen out its rate, then go back inside the capture volume. It is probably something that is interesting, and the Team should continue to watch the process as the engineering teams converge on a solution.

There were no additional comments on Test and Verification.

In the area of Safety and Mission Assurance responsibilities, Mr. Harkins commented that one of the things that NASA needs ensure is that there is a clear, well-laid-out understanding of the responsibilities. There could be a lot of perception issues. This area needs to be well-defined so that everyone, including the public, can understand it. Mr. Frost added that we need to emphasize that for this mission, a unique acquisition approach is being taken by NASA in that they are not performing the detailed insight that they normally do for mission success. NASA is essentially relying on the contractors to do what is needed to ensure mission success and NASA will accept the result if the mission is not successful. Ms. McDevitt added that they need to keep in mind that the approach NASA is taking under the SAAs. In the area of hazard identification, analysis, and resolution, the Review Team did see that Orbital is very experienced. Also, the Team learned that SpaceX is in more of a learning mode which would be a concern, except that under the SSA, NASA is working very closely with Space X in this area to help them understand how to do the hazard analysis process and are providing examples from their database. Because NASA is responsible for the ISS, they are very much involved in assessing the risks in this area. Ms. McDevitt stated that she would be greatly concerned if she didn't see the close participation of the NASA people in guiding SpaceX. Mr. John Marshall made another comment related to General Observations and Safety. The one area where the SAA has not blurred responsibility is the docking and abort authority procedures. It is critical that it is crystal clear to all parties what the implementation procedures are and who has final control. While the Team is sure that those discussions have been held, the document with the hard-core requirements still remains to be identified.

Ms. McDevitt stated that one thing that provided her with some confidence is that during the mission profile, there are several points where they will have go/no go criteria for the various stages of the mission. NASA will have very specific go/no go criteria before moving into the next phase. There will be several maneuvers around the ISS to check out the vehicles and controls before entering the keep-out zone. This added to the feeling of confidence that it would work well. Mr. Cuzzupoli noted that during the FRR, NASA also has a go/no go position on deciding whether or not to put cargo on. It would be good to see this in writing, and how the whole process is expected to work.

General Stafford noted that since this is a concern of both groups, it should be forwarded to Mr. Gerstenmaier. Dr. McErlean added that we should make absolutely clear who has the go/no go authority when approaching the keep out box. Criteria is good and essential and the team has gone a long way to identify that. But eventually, as the vehicle approaches the box, there must be one clear, unquestionable authority on go/no go.

There were no additional comments on Atmosphere/Contamination.

With respect to Operations, Mr. Marshall focused on issue of the launch of two other satellites compatible or simultaneous to the demonstration. In SpaceX's presentation, one of the things that was repeatedly said was the need to "keep it simple" for mission success; however, by introducing the simultaneous launch, complexity would be added. The Review Team does not know what the final decision is or will be; if NASA has made a decision to allow this to happen, it seems to the Review Team that it added complexity and the potential to compromise focus on the demonstration.

There were no additional comments on MMOD.

With respect to Culture, Gen. Stafford commented on the management "go-go" syndrome. There are three examples: the tragic fire on Apollo 1, Challenger, and Columbia. On Challenger, quite a few people said "no go", and yet they launched. On Columbia, the foam issue was waived every time. He observed that Ms. Grubbe's comments on culture were very appropriate.

With respect to authority, Gen. Jacobson indicated that he was under the impression that NASA has "go-away" authority within a certain volume around the Station. Dr. McErlean noted that while this was accepted and acknowledged at the meeting by both contractors, there was no formal document signed by all parties that laid this out in detail. Mr. Marshall emphasized that this is the issue—it is not formally documented, with clarity of language that all parties have agreed to and signed. There was Review Team consensus on this issue.

In response to Gen. Stafford's call for any other comments, VADM Dyer noted that at this point in the ASAP meetings, he tries to pull back from the details and take a broad view. His first observation was on the importance of NASA as the keeper of the broad body of knowledge on space flight, and the importance of their role in shepherding commercial space forward. This is working well, but he strongly encouraged aggressive transparency between the companies and NASA Headquarters and NASA centers with regard to the issues and the challenges, calling upon that body of knowledge to move forward. Also, there is the importance of transparency internal to NASA. The NASA program office managing commercial space needs to be very upstanding in terms of their communication with the leadership and transparency internal to the organization. With regard to Orbital and SpaceX, Orbital generates the confidence of a company that has "been there, done that." They understand best practices. They also have the humility borne of experience; they understand how hard this is. SpaceX is entrepreneurial; their thinking is a fresh approach. They challenge conventional wisdom and have the potential to deliver at lower cost with innovations; they are aggressive by nature. However, their comments with regard to software were very disturbing and presented a lack of insight and sophistication on what can go wrong in this business. Schedule compression is also a concern. VADM Dyer remarked that if we could put these two companies in a blender, we probably would have it just right. Real transparency and engagement on behalf of NASA Headquarters will help get us to the right place.

VADM Dyer thanked Gen. Stafford for including the ASAP in this activity. Gen. Stafford felt that the two teams complemented each other and worked very well together. The Team's comments will be passed on to Mr. Gerstenmaier.

Dr. Miller thanked members of the ISS AC and the ASAP for their participation in and contribution to this review. He also thanked the people at JSC for their support, as well as Orbital and SpaceX for their contributions. The meeting was adjourned at 2:09 pm EDT.