

National Aeronautics and Space Administration
Commercial Space Committee
of the
NASA Advisory Council

July 30, 2013
NASA Headquarters

Washington, DC

Meeting Minutes

David M. Lengyel
Executive Secretary
Commercial Space Committee

Patti Grace Smith
Chair
Commercial Space Committee

*Meeting report prepared by
Jill Hacker
Zantech IT*

CONTENTS

Proceedings	3
New Member Introductions.....	3
Commercial Cargo and Crew Update.....	3
Aeronautics Research Mission Directorate Lessons Learned.....	7
International Space Station Commercial Utilization Update.....	9
Prizes and Crowdsourci	11
Commercial Market Study	13
Deliberations.....	19
Appendix A, Attendees.....	25
Appendix B, Meeting Agenda	26
Appendix C, Committee Membership.....	27

Proceedings

New Member Introductions

Ms. Patricia Grace Smith, Committee Chair, and Mr. David Lengyel, Committee Executive Secretary, welcomed participants. All committee members were present except Lon Levin.

Jennifer Wiles and Stefanie Payne were present to support the use of audio-visual equipment. Shawanda Robinson was present for part of the meeting.

Ms. Smith introduced the new committee members, Col. Joseph F. Boyle USAF (Ret) and Mr. Hoyt Davidson.

Col. Boyle served 28 years in the U.S. Air Force, mainly in acquisition, and then moved on to a consulting career.

Mr. Davidson has had an interest in space since the Apollo era. After college, he was an engineer at Lockheed, writing proposals for contracts. After that he worked on Wall Street and then for the commercial satellite industry in the mid-1990s. Mr. Davidson founded the company Near Earth LLC in 2002 to help aerospace and commercial space companies raise money.

Ms. Smith welcomed both new members.

For the day's meeting, Ms. Smith asked members to consider the question of when down selection of commercial crew and cargo companies should occur. She said the full NASA Advisory Council (NAC) would address this issue at their upcoming meeting.

While the Committee awaited the first speaker, Mr. Trafton thanked Mr. Lengyel for the e-mail updates Mr. Lengyel had been sending to the Committee daily. Other Committee members agreed that these updates were very helpful.

Commercial Cargo and Crew Update

Philip McAlister

Mr. McAlister gave an overview of the status of the Commercial Cargo Program and its accomplishments. He also discussed the status of Boeing's and Sierra Nevada's, and SpaceX's work under the Commercial Crew integrated Capability Program (CCiCAP), certification products contracts, the Commercial Crew Transportation

Capability Program (CCtCAP), Commercial Crew Program risks, and a synopsis of collaborations for commercial space capabilities.

Ms. Smith asked how NASA is resolving differences among companies in the way things are done. Mr. McAlister replied that if there are anomalies, the partners are required to provide NASA with a post-flight report, but they are not required to go into great detail. As long as a partner meets the exit requirements of its Space Act agreement (SAA) with NASA, it will be paid.

In discussing plans for SpaceX and Orbital flights, Mr. McAlister stated that any failure that might occur in the future would not diminish what the Commercial Orbital Transportation Services (COTS) Cargo Program had accomplished. He compared the program with the Evolved Expendable Launch Vehicle Program (EELV). EELV was very successful even if later it did not work out well because the large market for which the program was geared never materialized. Mr. Oswald said that in the EELV case, the U.S. Air Force created a lot of cost growth after development by imposing more requirements. He suggested that NASA should simply declare victory on the COTS Cargo Program; it could very easily be messed up from this point forward. He asked whether the Committee should try to figure out what the Air Force had done wrong. Mr. McAlister said the intent had been for Government just to ride company's coattails. But after the Government became the main customer and then only customer, it imposed many requirements. Mr. Oswald added that then there was no competition. Mr. McAlister said they had reflected on EELV lessons-learned and that it was very enlightening.

Ms. Smith asked Mr. McAlister to comment on follow-on contracts after 2015, for COTS Cargo. Mr. McAlister replied that that was a sensitive area, currently under review.

Mr. McAlister said the request for proposals (RFP) for the TCAP (transportation capability) had been issued recently. The contract will contain options for International Space Station (ISS) missions. He said there would be overlap between COTS and the Commercial Resupply Services (CRS) Program, to mitigate financial risk. Mr. McAlister replied that there would be two firm fixed price contracts, based on Federal Acquisition Regulation (FAR) Part 15. There would be deviations and waivers to minimize burdens on the partners. NASA is looking for a good balance between what NASA would like to see in a contract and what the contractors would like to see.

When Mr. McAlister discussed Sierra Nevada's progress – it was doing well, having met five of its nine milestones to date – Ms. Smith whether Sierra Nevada was planning to continue to use helicopters for drop tests; she said there was concern about the use of helicopters. Mr. McAlister said he believed they were planning to use autonomous, non-piloted helicopters. He explained that the SAA requirement was for tests; it did not specify aircraft, so Sierra Nevada had discretion about what kind to use. He added that it is a challenging set of tests.

Mr. McAlister went on to discuss Certification Products Contracts (CPC), for which companies propose their own standards, which NASA will evaluate to see if they meet the contract's intent. In the past, companies had to meet NASA's standards, which were harder to meet but not necessarily better. Now partners have to think about how the design will meet NASA's requirements. Getting that done early has turned out to be better for both partners and NASA; it mitigates risk for both parties. Mr. Oswald asked whether NASA will eventually require a failure modes and effects analysis (FMEA) from the partners as part of the system safety package. Mr. McAlister replied that he was not sure; for the most part NASA lets the partners propose and demonstrate how they will close the requirements. He said he would get back to the Committee with an answer.

In reference to a presentation viewgraph that said, "Our progress over the next month will inform us on our ability to hold to the schedules," Ms. Smith asked whether "the next month" referred to August. Mr. McAlister said it did; the CPC partners had delivered at the end of May and the beginning of June and NASA had 90 days to evaluate. At present, signs were encouraging that NASA would be able to do its part in time.

Referring to Mr. Oswald's earlier comment that NASA could mess up the program by adding more requirements for the commercial partners. Mr. McAlister said mechanisms, all run by different people, wanting data that is similar but not the same. William H. Gerstenmaier, Associate Administrator for the Human Exploration and Operations Directorate, is making sure that NASA is not asking for the same data multiple times. NASA's engineers are not there to give oversight or direction, just to gain insight; direction, when it is given, must be given through the program. In SAAs, data NASA receives from partners can be used only in evaluation of milestones. Partners like such limitations; NASA has to be sure to maintain that kind of confidentiality.

Continuing, Mr. McAlister said the biggest risk is eliminating competition prematurely. The goals of the commercial crew program are safety, reliability, and cost effectiveness. Competition supports all of those goals. The partners know how important safety and reliability are, so they are battling to achieve those. Because there are still uncertainties about these systems, it would not be good for NASA to be dependent on a sole provider.

In response to a question from Ms. Smith about the budget and its effects, and Mr. McAlister gave his opinion, with the disclaimer that he was not speaking for NASA, that the chance to a develop human space flight system does not come often and NASA will use the products of the CCP Program for a generation. NASA must take care in the way it makes short-term decisions in these matters, because these decisions affect long-term goals.

With COTS coming to a close, NASA would like to have better knowledge of what the commercial sector is planning to do, so that NASA can leverage that rather than build it themselves. Some companies do not know the right entry points to get an agreement with NASA; that might lead NASA to enter into an SAA with a company that is not the best for what NASA wants. NASA wants to make announcements for agreements that entail no exchange of funds.

Ms. Smith asked Mr. McAlister if technical interchanges can happen under a FAR-based contract; and if so whether they are not as robust as those under an SAA. Mr. McAlister replied that that would depend on the contract's terms. Under a fixed price contract, there is the risk that a partner will reply to NASA's request to a technical interchange with "We didn't budget for that." He explained that NASA will follow its collaborations synopsis with an RFP only if they get a good response from industry. They are looking for integrative capabilities that NASA could potentially buy in the future. This action does not preclude any other partnering between NASA and industry; it is just another way to partner.

Mr. McAlister said the selection criteria have not yet been written. Those criteria will include some benefit to NASA. He explained that SAAs are not grants; partners get paid incrementally and in response to performance.

Mr. McAlister discussed NASA's sentiment about COTS and SAAs. To the extent that COTS is successful, that is a knock against NASA's traditional approach. The traditional approach is appropriate in some cases. For example, cost plus contracts are needed for new things. But NASA has been working with low-Earth orbit (LEO) for decades, with ISS as an anchor tenant. On the other hand, an SAA would not be appropriate for something new and huge like a heavy-lift launch vehicle, when the only customer will be the Federal Government. The culture is changing, and that is difficult. Over the years, NASA has developed a command mentality; cost plus contracts, which allow NASA to dictate rules, are where NASA is comfortable. Mr. Trafton asked whether there was a feeling at NASA that a command mentality is appropriate for something new and challenging but not for something old and known like LEO. Mr. McAlister replied that he thought there was progress but it was difficult to gauge. He did not see a great demand for many more funded SAAs. Mr. McAlister replied that there is not much argument against using SAAs now that success has been proven. Going forward, however, supporting SAAs means fighting against the hypothetical that NASA may not be as safe with an SAA as with a contract that puts NASA in command mode. It is a process. Many people just want to keep the way NASA has always done business.

Ms. Smith complimented Mr. McAlister for having weathered challenges exceptionally well, given the enormous walls over which he had had to climb. She cautioned Mr. McAlister that there may be pressure to stop using SAAs when the program becomes operational. Mr. Oswald cautioned that it is possible for well-meaning civil servants over the next 10 years to snatch defeat from the jaws of victory.

Mr. McAlister left the meeting to brief another committee.

Mr. Oswald suggested that it might be better to organize committees by launch vehicle, rather than by program. He noted that the Committee never discusses SLS or Orion, which are \$2.8B programs. Dr. Harris asked if a briefing would be possible. Ms. Smith said such a briefing would be a possibility.

*Aeronautics Research Mission Directorate
Lessons Learned
Robert Pearce*

Mr. Pearce explained that Aeronautics Research Mission Directorate (ARMD) partners with industry to set future direction and provide value. As Boeing says, the DNA of aviation is with NASA. For much aviation, basic research was done at NASA. Mr. Pearce's presentation addressed ARMD's missions and strategies, as well as how ARMD carries out its programs.

Mr. Pearce quoted Marion Blakey, Chair of the NAC Aeronautics Committee, to sum up what ARMD does:

ARMD provides critical support to our Nation's aeronautics research efforts. They have a strong track record of leading complex, collaborative research with multiple Federal agencies, academia, government labs, and industry.

Dr. Harris asked about transfer of technology. ARMD deals in tangible, visible things. Does NASA get financial benefit from technology transfer? How is it carried out? Mr. Pearce replied that for the most part NASA does not see financial benefit from ARMD's work. Technology is transferred through collaboration. From the early stages of research, NASA publishes information in journals and at conferences. By the time a technology is ready to be commercialized, companies have the information they need to carry it out. It is generally a fairly smooth process. The hiccup is the decision about what can move forward. Because of funding constraints, ARMD must be selective in deciding what to bring to full-scale testing.

Mr. Oswald asked whether Boeing was considering the Pratt engine for the 737 Max. Mr. Pearce replied that he understood that Boeing had commercial agreements with General Electric that would prevent them from adopting it.

Mr. Pearce explained that ARMD uses SAAs as well as contracts to create partnerships.

Ms. Smith asked whether ARMD's work was tied in to the NextGen plan. Mr. Pearce replied that ARMD has been part of NextGen since its inception. ARMD is

systematically taking research up to high technology readiness levels. They have formalized the transition to make sure the Federal Aviation Administration (FAA) is putting resources forward on the planning and program side and NASA is putting resources forward on the research and development side. The parties are setting things down in writing to avoid later misunderstanding.

Mr. Davidson commented that Mr. Pearce's list of benefits (a viewgraph) seemed to include no benefits to NASA. Mr. Pearce replied that ARMD's mission is purely research; the benefits of that research are for the Nation, not for NASA. But NASA does get benefits, like the building up of expertise. ARMD is looking to work with the Space Technology Mission Directorate to find synergies between technologies that either commercial space or direct NASA missions need, and the kinds of technologies that ARMD is working on.

Ms. Smith asked Mr. Pearce what he saw as the principal challenges to bringing unmanned aerial systems (UAS) into the National Airspace System. Mr. Pearce replied that rules needed to be created. ARMD stepped into the impasse and made agreements with Requirements and Technical Concepts for Aviation (RTCA). They are working on required "command and control" communications. They are working with the World Radio Conference to get agreement to test certain aspects of the spectrum. They are working to develop standards for UAS; three years remain on that project. They work with academia, with other agencies, and with other nations.

Mr. Oswald asked if ARMD was working the requirements for hardening the command and control links for unmanned aerial vehicles (UAV). Mr. Pearce replied that cyber security was being handled by other parts of the community.

When Mr. Pearce discussed safety, Mr. Oswald asked whether ARMD gets involved after major accidents. Mr. Pearce replied that they do get involved after a specific accident if they are asked. More generally, in partnership with the community, they help analyze causal factors of accidents and what can be done to mitigate them. FAA is in process of updating a study done in the mid-1990s about human factors in automated systems. It comes down to choices made decades ago: Rather than build mitigations in the automation, the system leaves it to the pilot to be the mitigator. That mostly works, but pilots sometimes fail. The pilot, then, is the hero but sometimes ends up being the villain. The question becomes what to do at the beginning of the design, of the life cycle.

Mr. Pearce explained that ARMD is an external-facing mission directorate. It is a continual challenge to keep everything lined up and working efficiently. He said ARMD should have a relationship with the Committee similar to what they do in aeronautics. Col. Boyle suggested that ARMD was doing that already with the Efficient Descent Advisor (EDA). Mr. Pearce explained that the optimized profile descent – the most efficient kind of descent – is something that air traffic controllers can do when traffic is light; EDA makes it possible in high traffic.

Ms. Schroeder asked about the possibility of applying the space tourist model to the commercial space industry. Mr. Pearce replied that ARMD has been approached by organizations with concepts for hypersonic point-to-point transportation. ARMD has done a few systems studies. There is a high risk and a lot of technologies are in their infancies; ARMD has not invested a lot of money in it. ARMD does have some SAAs with various companies, but there may not be an integrated community that can speak with one voice. ARMD does its work through four research centers. They try to put these things together creatively. Industry as a whole has not been knocking on the door looking for help, although some small companies have.

Mr. Pearce explained that NextGen is focused on commercial airlines. ARMD is looking at smaller-scale UAS and other on-demand aviation. They have not done much in that area, but there is some investment in looking at how they would operate a system that is much more diverse than the one they have today. From a technical perspective, ARMD looks across the Agency to see that they are sharing as appropriate. It would be difficult for ARMD to change the perspective with which they look at industry, but the Agency could do it. Ms. Smith said this issue is important because one area called out in Congress's consideration of the NASA Reauthorization Act is air and space traffic management. That challenges agencies that are charged with those responsibilities to start knitting the issue together more.

Mr. Lengyel thanked Mr. Pearce for an excellent presentation.

International Space Station Commercial Utilization Update
Mike Read and George Nelson

ISS managers began the presentation by explaining that commercialization comes in at the ISS in two ways: from NASA and from the Center for the Advancement of Science in Space (CASIS). Resources are generally divided in half between NASA and CASIS. Research with commercial support is for areas that look like they will contribute to exploration.

Mr. Read, said NanoRacks was one of the first companies to come to NASA seeing an opportunity to sell services to the ISS. NanoRacks has developed some capabilities that NASA needed, all with outside funds. There has been a two-pronged approach: 1) Industry sees an opportunity to exploit ISS capabilities and turns that opportunity into a business model; and 2) NASA is able to get some capabilities that they could not have procured via a traditional contract. Another company, Teledyne Brown, has also invested in an instrument at the ISS.

Mr. Nelson said technologies NASA invests in are those for which NASA potentially has future needs. The Bigelow Expandable Activity Module (BEAM) uses a fixed price cost-sharing method. The Sabatier system is strictly performance based; it is a good example of the alignment of NASA's interest and commercial interest.

Mr. Read said there is a research announcement for which proposers may propose other uses of ISS that no one else may have realized are needed. They are putting things out as problems for industry to propose solutions to, in the form of business models. NASA encourages industry to think outside the box and come up with some capabilities NASA needs but cannot provide in a traditional way.

Mr. Read said the greatest impediment is the absence of an exemption for intellectual property (IP) rights for non-NASA grant users. That is, the Government keeps the rights to results of research performed at the ISS. But NASA wants companies – especially big pharmaceutical companies – to do research, so they must have an incentive to make that investment. An IP exemption for ISS users would be a big help to fostering the commercial use of ISS. Ms. Smith asked if it was possible to get rid of the rights reservation. Mr. Nelson said NASA was working with Congress to do that, but only for non-traditional users.

Mr. Nelson said ISS has to continue to evolve on-board capabilities. Better capabilities will in turn create an incentive for people work in microgravity. The capability of getting results on orbit rather than waiting for materials to be returned to Earth and analyzed will make it possible for experiments to be completed more quickly.

NASA is trying to build payloads smartly with the best opportunity for success; therefore NASA continues to try to cut out extraneous requirements. NASA must look for opportunities to get people to invest in ISS and must reward those that invest private dollars for things NASA requires.

Ms. Schroeder asked whether the ISS Office was working with the Legislative Affairs Office at NASA Headquarters on the IP issue. Mr. Read replied that that was a question for Headquarters; his office was supportive of the issue but had not been working with Congress.

Duane Ratliff, CASIS CEO, said CASIS had not been working directly with NSBRI but with the Human Research Program (HRP) to understand how to leverage the use of crew as potential human subjects for research proposals. He said he thought the relationship with NSBRI might grow, not necessarily in funding but collaborating in research that may have value in the NASA exploration missions as well as in contractual benefits. Dr. Harris said the Committee's observation was that NSBRI was looking just from the standpoint of health care and research around that. The Committee was simply recommending that the two organizations collaborate more.

Mr. Ratliff explained that in the past two years, CASIS had focused on understanding the National Laboratory research environment. Understanding opportunities that the ISS National Laboratory environment provides, they asked what interests and needs back on the ground can be put into the marketplace. They came up with a focus on material science and space flight hardware as well as industrial products,

benefits to climate change science, and mining (through Earth observation). To date CASIS has issued grant opportunities that are similar to NASA research opportunities. CASIS incentivizes with funding that may cover just costs or may cover everything. The CASIS selection process looks at both scientific and economic merit. The CASIS operational review is a high-level feasibility review. CASIS just issued a call for stem cell research, which closed Thursday, July 25. CASIS received 51 proposals. That is a milestone, given that CASIS' three solicitations before that brought in only about 21 proposals.

Mr. Ratliff noted that as a result of having the National Laboratory open for use by others, CASIS can consider research that they would never have thought about. CASIS relies on unsolicited proposals as well as on formal grant opportunities; they have developed this as a way to receive white papers. In sum, Mr. Ratliff said that in less than 2 years, CASIS has allocated more than \$15M to research on 40 projects. They have demonstrated the ability to raise non-NASA funds. They have established formalized commercial partnerships. They have reached out to business start-ups.

Mr. Lengyel asked Mr. Ratliff to comment on lessons learned to date on processing science down mass with commercial partners such as SpaceX. Mr. Ratliff replied that down mass return is very limited. Many customers would like to have organisms returned alive and intact, but that capability does not exist. Perhaps instead of specimens being returned, their final data can be returned. At present there is a backlog of human-based tissue awaiting return. Once that backlog is handled, the rest of the specimens can be returned quickly.

Ms. Smith thanked all participants, especially the presenters.

*Prizes and Crowdsourcing
Jenn Gustetic*

Ms. Gustetic, NASA's Prizes and Challenges Program Executive, shared advancements NASA has made in philosophy in prizes and crowdsourcing: where and how these methods are working. These methods, she said, are being embraced. In its 2012 Report to Congress on Government Prize Use, the White House Office of Science and Technology Policy said

From the Centennial Challenges Program, to the NASA Open Innovation Pavilion, to the NASA Tournament Lab, NASA leads the public sector in the breadth and depth of experience and experimentation with prizes and challenges.

Crowdsourcing is used for a variety of problems including coding, methods, and ideas.

One advantage to using prizes is that NASA awards a prize – that is, NASA pays – only for a result that meets the criteria stipulated in the rules. (But NASA has to pay the cost to run the project in any case.) Another advantage is that prizes do not entail the administrative work of contracts or grants. And they are open to the general public. They can bring value from unexpected places. For example, glaciologists, through their knowledge of edges, have helped in problems of dark matter.

Mr. Trafton asked about the program's annual budget. How is it possible, he asked, to establish an annual budget for something for which you pay only for success? Ms. Gustetic explained that some of the budget money is no-year money, getting preserved for as long as the prize is around. Some of it comes from the budgets of the programs that stand to benefit from it – and whose managers choose to use prizes – rather than the budget of the prizes and crowdsourcing program. The cost of running a contest is about equal to the prize money.

Mr. Davidson asked whether a prize of \$20M in a program would be ruled out for lack of no-year dollars. Ms. Gustetic replied that the program might have to work with the Office of Management and Budget, the Office of Science and Technology Policy, and Congress to make that work, and it could take a few years.

The Obama Administration has been supportive of prizes. There are provisions for prizes in the America Competes Act. NASA has had the authority to use prizes since 2005. In that time, NASA has experimented with a variety of prizes.

Examples of NASA's successful use of prizes:

- NASA has run seven pilots on the Innocentive website, at which inventors can register communities can seek solutions. NASA ran seven pilots there. Through Innocentive and the work of Bruce Cragin, NASA found an algorithm to predict solar flares, which are a danger to astronauts.
- Using a prize, NASA found a way to measure inter-cranial pressure (which may account for vision problems on station) non-invasively and using hardware that is easily available on station.
- Strain on webbing was being measured with a photographic method. But because of the nature of the webbing fabric, the pixels in the photographs twisted, making accurate measurement impossible. NASA Langley issued a challenge for solution. Three respondents proposed a simple method of adding a strap and measuring the strain on the strap. The solution was immediately usable.

NASA can write into the rules that it will get a no-cost, royalty free license to the solution, or that all the code will be turned over to NASA and NASA will open source it. Seeing their work open sourced is an added benefit to prize competitors. Other

incentives for competitors include marketing and the opportunity to compete with big business on a level playing field.

In the Green Flight Challenge of 2011, NASA sought aircraft that could fly 200 miles in less than 2 hours using less than 1 gallon of fuel. Two teams succeeded. For this contest, Allied organizations raised money. The Comparative Aircraft Flight Efficiency (CAFE) Foundation worked with Google; Google provided \$1M.

The Lunar Lander challenge, run in 2008 and 2009, had two winners: Masten Space Systems and Armadillo Aerospace. Masten stated that their business grew as a result of attention from this competition.

Currently there is an ISS challenge to position the solar collectors to generate as much power as possible.

Mr. Lengyel asked what laws are relevant to prizes and crowdsourcing. Ms. Gustetic replied that her office, the Office of the Chief Technologist, is working on that question and will get back to the Committee about it. The Office is also formalizing policy internally; that should be done by the end of this calendar year.

Mr. Lengyel asked how participants will arrange to get to the Moon for a project to be done there. Ms. Gustetic replied that there is a prize of \$30M and there may be milestone prizes (\$750K to \$7M) to help teams get to the point where they can land on the Moon. Some teams have arrangements with private providers to get to the Moon.

Mr. Davidson said he wished there could be larger prizes, for bigger and better things. In response to a question from Ms. Smith, Ms. Gustetic said the biggest available purse to date was Green Flight, with a prize of \$1.65M and \$1.47M awarded.

The Commercial Crew Program has not used big prizes, but the Office of the Chief Technologist (which administers the prize program) would be open to conversations with Commercial Crew people.

Mr. Lengyel thanked Ms. Gustetic for a great presentation.

Commercial Market Study
Rebecca Spyke-Keiser

It is within NASA's mandate to consider the commercial use of space to fullest extent possible. The Commercial Market Study was done to find areas in which NASA might pursue public-private partnerships. For each of 10 areas of space capability, the study looks at the market situation, the supply side, and the demand side. It focuses on the economic data and the potential for partnership and provides this

information to the programs and to their leadership, for potential use in decision making, and to the public.

The purpose of this study is to provide economic intelligence on public-private partnership areas for space capability development that could meet NASA's mission objectives as well as strengthen US global competitiveness and promote the economic vitality of the Nation.

Public-Private Partnerships for Space Capability Development
Driving Economic Growth and NASA's Mission
Interim Report

Each of the 10 areas is a strong candidate for economic stimulation with increased NASA partnerships and, potentially, resources. Dr. Keiser asked the Committee for the following things regarding the Commercial Market Study: feedback, additional data the Committee thinks would be helpful, additional areas the Committee thinks should be covered, and any suggestions for how the analysis may be used.

The study areas are:

1. Satellite servicing;
2. Interplanetary small satellites;
3. Robotic mining;
4. Cargo transportation beyond LEO;
5. Crew transportation beyond LEO;
6. Microgravity research for biomedical applications;
7. Liquid rocket engines;
8. Wireless power;
9. Space communications; and
10. Earth observation data visualization.

Mr. Oswald asked whether space-based solar power is out of consideration. Dr. Keiser replied that it is not; it falls under the broad category of wireless power on the list. There is a whole array of NASA applications for wireless power.

Satellite Servicing

In satellite servicing, the challenge for the private sector has been in raising capital and proving that there is a market. But there have been 86 potential servicing opportunities from 1990 to 2010. The potential is there.

Mr. Oswald asked if the market is real, given that providers get 14 to 18 years on some big GEO-birds. Dr. Keiser replied that if the satellite-servicing capability existed, developers might build satellites to last, for repair and upgrade. Developers do not do that now because the capability is not there. Another aspect of the market is risk mitigation. For example, if a satellite gets into the wrong orbit, servicing can help.

Col. Boyle asked about the retrieval of “space junk.” Dr. Keiser replied that the military’s Defense Advanced Research Projects Agency (DARPA) mission in Phoenix is looking at retrieval of debris and recycling of existing satellite parts.

Mr. Davidson said he understood that there had been commercial attempts. IntelSat had said they did not want to be the only customer; everyone has been looking to the government to be the second customer. He asked if there was a counterpart at the Department of Defense (DoD) that was willing to be a customer in a public-private partnership. Dr. Keiser replied that there had been discussions with DARPA; NASA has an Ames office that is partnering with DARPA and working with them on their Phoenix mission. At higher levels at DoD, there is much more potential to talk about partnering. The discussion to date at the Secretary of Defense level has mostly been about orbital debris.

Ms. Smith asked what the advantage would be in having a satellite last less time. Dr. Keiser explained that the main idea of satellite servicing would be to help extend a satellite’s life. Replacement – say, of a malfunctioning satellite – is just one aspect of satellite servicing.

If a 20-year satellite can be extended longer, Ms. Smith asked, what does that do to the market for new satellites? Dr. Keiser suggested that it might lead to more specialization.

Mr. Oswald asked how many GEO-birds get taken offline because they lack fuel. Dr. Keiser replied that there were 50. Mr. Oswald said those satellites just drift. If there were very successful refueling NASA’s bill per launch would go up; in that case it would make more sense to send up a new satellite than to service an old one. Dr. Keiser replied that there has to be a balance.

Interplanetary small satellites

Small satellites are those that can conduct missions beyond LEO and that have mass less than 500 kg. The use of small satellites could help NASA through lower cost. Small satellites are becoming a larger part of the commercial satellite market. With small satellites there is potential for public-private partnerships.

Robotic mining

This area is ripe for partnerships. Several companies already use autonomous equipment to mine. Two companies have secured funding for mining the Moon and asteroids.

Mr. Oswald asked whether space debris is getting worse. Dr. Keiser replied that Dr. Nick Johnson, NASA’s chief scientist for orbital debris, believes the amount of space debris is increasing, but it may not yet be time for a mitigation program. Still, he

would like to see an agreement worked out soon so that if the situation becomes critical an agreement will not have to be worked out under difficult circumstances.

In response to a question about whether companies had shown interest in working with NASA, Dr. Keiser said there have been discussions with Caterpillar. She thought it would be a good thing to have discussions with mining companies on potential sharing of technology.

Alex MacDonald explained that there are two automated mining sites, in Australia and South Africa. There is shared interest for economic development. It is clear where these vectors are going. It behooves NASA to pay attention to this.

Mr. Oswald noted that planetary defense was not on Dr. Keiser's list of study areas. Dr. Keiser replied that planetary defense is important and NASA's Office of Strategy Formulation is looking for ideas for asteroid identification and mitigation. They are doing an asteroid retrieval mission and would love to do more partnerships in this area.

In response to a question from Ms. Smith, Dr. Keiser commented on legal issues and rights of private companies under the Outer Space Treaty. She said the State Department has said it will make its interpretation when something is planned to fly. She expressed hope that groups like Planetary Resources would continue the dialogue. Ms. Smith said Planetary Resources had checked with their lawyers and had found no problem.

Cargo transportation beyond LEO

Ten private companies and non-profit organizations are planning activities beyond LEO.

Crew transportation beyond LEO

Partnerships are ripe in this area. China has announced plans to send humans to the Moon by 2025. No other country has invested significant resources beyond LEO.

Microgravity research for biomedical applications

There is a potential to develop drugs to treat diseases.

Human health technology is 57% of the biotech industry, totaling \$93B. If there is a way to utilize space to develop this market, even a small percentage of the market would have high potential for private industry as well as for NASA.

Liquid rocket engines

NASA is helping the United States regain some of the rocket industry. There are U.S. companies developing less expensive liquid rocket engines. There is great potential

for partnering. In 2011, the United States had none of the launch market. But the United States' share is growing now, thanks to SpaceX and Orbital.

Wireless power

Wireless power is the capability to transmit power short and long distance without wires. This is how rovers are powered and energy is beamed to launch systems. It is an area ripe for public-private partnerships, with a huge world market for energy. There is ongoing research in this area. With the number of UAVs growing, there will be increasing demand for wireless power. A number of wireless charging technologies are being developed by industry.

Mr. Oswald asked why NASA is not developing microwave and laser capabilities. Mr. MacDonald replied that the demand is not there.

Mr. Oswald pointed out that there must be huge energy losses with wireless energy transfer. He asked what it was needed for. Mr. MacDonald replied that wireless power would be useful for powering rovers and is a powerful force for consumer goods. It behooves NASA to pay attention and potentially develop partnerships. Mr. Oswald commented that if the business case could be made for using wireless power terrestrially, that would have an effect on launch costs. Mr. MacDonald replied that the economic case did not close presently.

Space communications

Ms. Smith said there would be strong support from the Government in this area. Tom Wheeler, Chairman of the Federal Communications Commission FCC, had said he was very much in favor of development in space.

Commercial applications include GEO and LEO activities. There is a huge amount of global satellite industry revenue. Dr. Keiser believes that with the number of communication satellite operators, with the huge amount of industry, and with the new technology being developed, this is an area ripe for enhanced public-private partnership.

Earth observation data visualization

Government collects a lot of data and needs to make that data accessible and usable to people. As a result, there is an explosion of commercial applications in this area. There is a huge potential market, a huge number of satellite remote sensing companies, NASA applications and commercial applications.

Climate change data is expected to reach 150 petabytes. NASA has to understand how to use this data.

Summary

Dr. Keiser expressed hope that NASA can start using tools like the market survey in decision making. Before a program is even formulated, NASA should think about public-private partnerships, so that the program has the best benefit for everybody. NASA needs to develop a strategy and architecture for doing this. Dr. Keiser has sent the preliminary report to all the mission directorates in the hope of working with them.

Col. Boyle asked about weather. Dr. Keiser replied that that is another huge area for public-private partnership.

Col Boyle asked whether there is synergy between ARMD (which had made a presentation that morning) and the Office of Strategy Formulation, where things seem to have revenue or profit associated with them. He asked Dr. Keiser how she had decided on the 10 study areas on the list.

Mr. MacDonald replied that the list was meant to include not necessarily the 10 most important areas, but rather areas that are interesting. These are the market signals, the overall trends that are worth paying attention to as NASA tries to understand the Solar System. Dr. Keiser added that on the supply side, NASA does combine commercial space ventures with private non-space ventures that can utilize those same technologies. There are a number of kinds of public-private partnerships that NASA can do for different reasons. Mr. Davidson commented that a public-private partnership may create a whole new industry, one that will serve everyone.

Mr. Trafton thanked Dr. Keiser for a good presentation. Ms. Schroeder agreed and asked what the plan was. She suggested that weather be added to the list of study areas. Some of the areas on the list of 10, on the other hand, might turn out not to be worth pursuing. Dr. Keiser said there would be more briefings at NASA as well as briefings for Congress and industry.

Mr. Oswald thanked Dr. Keiser for a great presentation. He commented that weather is a basic question. In other parts of the world, governments that do not have their own space programs buy commercial weather products. In the United States, weather forecasting is seen as the Government's job. He asked whether the National Oceanic and Atmospheric Administration (NOAA, which does weather forecasting) should be buying services. He said it is a visualization problem – how do you handle the data? There is another problem: There are not enough sensors, or the sensors are being poorly managed. Dr. Keiser said it was encouraging that in Congressional hearings it was being asked why NASA is not obtaining weather satellites, or their parts, more commercially.

Mike Bevin, from NOAA Office of Space Commercialization, commented that in a way NOAA in fact is buying commercially: they buy images from Canada. Lightning data is from a commercial system. NOAA Administrator Dr. Kathryn Sullivan is looking at

using commercial data in national weather prediction models even further. A Government system gets better as it gets augmented by commercial parts.

Mr. Bevin and Dr. Keiser agreed that they should talk about how they could work together.

Mr. Bevin asked about commercial involvement in the Commercial Market Study. Mr. MacDonald replied that NASA has functions that do talk to industry. But it was important that NASA employees go through the process of doing the research. Dr. Keiser noted that only publicly available data was used in the study. For the next stage, they may ask industry's permission to use additional data. Mr. MacDonald said NASA wants to share information; if information from private industry is included, there may be limits to sharing. Dr. Harris said it would still be useful to get general input from the private sector, even if that input does not include data.

Committee Deliberations

Ms. Smith asked the Committee to develop pithy statements, key takeaways to present to the NAC. The Committee agreed on the substance of its observations and recommendations, with wording to be fine-tuned later.

Commercial Crew Update

Ms. Schroeder said she had been struck by the amount of investment by the private sector. She asked whether that is something NASA wants to promote. It could help reinvigorate the U.S. commercial space industry. Mr. Lengyel suggested the wording "surprised by the amount of investment by commercial providers." Ms. Schroeder suggested "surprised by the larger investment by private partners than anticipated."

Referring to EELV, Mr. Davidson warned that it was still possible to snatch defeat from the jaws of victory. Mr. Lengyel commented that EELV providers put in a significant amount of funding on their own. Col. Boyle said it was important how those companies recouped their investment. They planned on launching forty times per year, but went to six times per year. Once NASA had control of the process, it added constraints and requirements. What happened in the COTS regime was in anticipation of what was expected.

Mr. Davidson pointed out that a big gain from COTS was the creation of an industry that the United States had lost to the Europeans. With two great launch vehicles the United States now has a commercial launch industry again. Col. Boyle commented that that may even be seen as a threat. Mr. Davidson said the United States is leading again; Ms. Smith questioned that. Mr. Oswald said Orbital has a steep hill to climb and SpaceX may not be able to maintain its price.

Mr. Trafton asked whether the Committee wanted to tell the NAC that the Committee liked what COTS did. Ms. Smith and Mr. Lengyel said the Committee wanted NASA to affirm the use of funded SAAs when appropriate and when there are mixed-end users. Mr. Oswald questioned the relevance of mixed-end users to COTS. The proposed statement was:

Affirm the use of funded Space Act agreements when appropriate.

Ms. Smith commented that public-private partnerships do work. For example in the COTS program, industry is contributing substantially. Ms. Schroeder agreed. Ms. Smith added that COTS yields benefits for both NASA and the Nation. Dr. Harris asked whether the COTS program's success with cargo should be used to bolster the same model for crew. Mr. Oswald cautioned against declaring victory for COTS too soon. If Orbital has one accident, they could withdraw from the program and it would not be nearly so successful. Ms. Smith replied that even if that should happen, the project would still be a success, because it is a demonstration project. Ms. Schroeder suggested the words "the good use of public-private partnerships" instead of "success." Mr. Trafton suggested adding "thus far."

COTS is an example of the good use of public/private partnership efforts to date, yielding benefits for both NASA and the Nation.

Referring to the Commercial Crew Update, Ms. Schroeder said Mr. McAlister had given the impression that NASA was not contemplating SAAs for the crew part, but instead was planning on using fixed price contracts. She wondered if it was too late to recommend SAAs. Col. Boyle explained that it was only in reference to certifications that Mr. McAlister had indicated moving toward fixed price contracts.

Mr. Davidson noted that the program had resulted in two providers. Several people suggested saying "systems" instead of "providers."

Developed two launch systems, with the potential to revitalize the commercial launch industry.

Aeronautics Research Mission Directorate Lessons Learned

Ms. Smith suggested that the lessons learned need to be documented and integrated going forward.

Dr. Harris said EELV had seemed to work at the beginning but broke down as years went on. He suggested that the problem might have been mission creep. Mr. Trafton commented that NASA had given FAR contracts to the EELV companies before there was a successful flight. That created the impression that it was going to happen.

Document lessons learned and integrate into future programs.

Mr. Davidson and Ms. Schroeder suggested that including potential service contracts up front reduced risk. Mr. Davidson added that NASA had learned that it could give up some of its control and still get a good result. Ms. Smith suggested emphasizing that it is for investors that up-front service contracts reduce risk.

Including potential service contracts up front creates confidence and provides risk reduction for investors.

Mr. Lengyel said he would send the draft observations and recommendations to committee members that evening for discussion.

Dr. Harris suggested that the Committee state support for Mr. McAlister's warning that competition not be eliminated prematurely. He said the Committee supports continued competition during this phase of the program, so that short-term budget issues will not derail a long-term project. Mr. Trafton suggested using Mr. McAlister's wording.

A risk to NASA is prematurely eliminating competition that can satisfy the goals and objectives of the program.

Hate to see us make a short-term decision on something of long-term consequence.

Mr. Oswald suggested that Mr. McAlister's warning was about resisting the temptation by well-meaning people to try to improve the system. With two full up-and-running systems, NASA's tweaking things will drive up costs. He projected that 10 years from now those vehicles will cost much more than they do now, largely because of new Government requirements. Mr. Oswald suggested a standalone statement: Resist requirement creep during operational phase. The Committee agreed.

Resist requirements creep during the operations phase.

Ms. Smith asked whether NASA should encourage insight into a company's finances. Mr. Davidson said he thought so: A company's ability to do its part must be a key in choosing that company in the first place. Mr. Oswald cautioned that even a company that can afford to invest may choose not to do so.

Ms. Schroeder commented about competition. There is competition not only among the launch system developers, but also among the spaceports [?] A launch facility will want to serve more than one customer. NASA should not limit competition among launch systems.

Ms. Schroeder asked about cargo transport post 2015. Mr. McAlister had said it was a sensitive issue and asked whether the Committee should address it. Ms. Smith said the Committee should.

Ms. Smith suggested "In planning for the future, NASA should decide follow-on contracts after 2015." Mr. Oswald added that NASA can extend the existing contracts. Ms. Schroeder commented that there would be risk in eliminating competition to satisfy the program's goals. Mr. Lengyel suggested discussing the issue further the next day.

Col. Boyle suggested an observation supporting continued use of collaboration.

We support continued use of collaboration.

Ms. Schroeder suggested that ARMD should reach out to the burgeoning space tourism industry to explore point-to-point transportation. Mr. Davidson agreed about reaching out to space tourism industry but objected to the reference to suborbital point to point.

ARMD should reach out to the burgeoning commercial space tourism industry.

Ms. Smith commented that NASA can provide greater leadership in development of next generation airspace by recommending a more integrated approach.

NASA should take a leadership role in the development of next-generation airspace by adopting an integrated approach to air and space.

International Space Station Commercial Utilization Update

Mr. Oswald proposed a recommendation to expedite the extension of ISS's life to 2028.

Expedite the extension of the International Space Station to 2028.

Ms. Smith suggested a recommendation to exploit outreach to pharmaceutical companies for the use of ISS for biomedical experiments, because many high-risk disease categories need to be solved.

Ms. Schroeder suggested that there should be an exemption for the ISS for IP rights.

Secure ISS exemption for IP rights.

Col. Boyle commented that most experiments at the ISS seemed to be about microgravity. But there are other aspects of exposure to the long-term space environment that could be explored.

Explore the possibility of research on exposure to the long-term space environment.

Mr. Oswald referred to the presentation's statement that CASIS had \$2M in outside funds committed to flight opportunities. He said this amount was so small that it made CASIS look like it was failing. Ms. Smith agreed, saying CASIS' progress to date was underwhelming.

CASIS progress is underwhelming in terms of revenue generated by committed flight opportunities to date.

Use of Prizes and Crowdsourcing

The Committee agreed that the people organizing the prize effort were doing good work. Ms. Smith suggested that they look for a way to budget at least one larger prize in the next 3 years.

Look for ways to budget at least one larger prize over the next 3 years.

As Mr. Davidson pointed out, the largest prize to date was \$1.5 M. Ms. Smith proposed wording: "applaud an aggressive and smart approach."

Applaud a smart and aggressive approach.

Commercial Market Study

Col. Boyle suggested that the ARMD process for strategic analysis be applied to the Commercial Market Study.

Market study/benchmark the ARMD strategic analysis process.

There was a suggestion that the market study be validated by commercial industry. Mr. Oswald suggested that it might be enough to validate a few of the study's 10 elements, for a check.

Dr. Harris said Dr. Keiser had said she *would* validate the study. Mr. Lengyel commented that the market study is an inherently governmental activity, but having it validated outside is a good idea.

Recommend validating study with independent private contractor. [The notes from the meeting say “independent private sector.”]

Ms. Smith suggested that the study be renamed, as it is not a market study.

Ask market study people to rename their study to better reflect its nature.

At Ms. Smith’s request, Mr. Lengyel said he would bring the list of draft observations and recommendations to dinner that evening.

Mr. Lengyel invited comments from the public. Alan Keisner, connected by telephone, thanked the Committee and presenters, especially Dr. Keiser.

Ms. Smith reminded the Committee that it would meet the next morning at from 8 to 10 am to work on briefing charts, which Ms. Smith would use in her presentation to the NAC on Thursday, August 1.

Mr. Lengyel said the Human Exploration and Operations Committee were considering recommending that the 2.5 contractors be decreased to two. Ms. Smith asked whether it was important to maintain 2.5. Ms. Schroeder and Mr. Trafton said NASA was not ready to down select. Mr. Oswald said the NAC should not be telling NASA how to build a watch; the NAC should just tell NASA to include competition. Ms. Smith suggested telling them to keep it as it was.

The meeting adjourned at 5 pm.

Appendix A, Attendees

Committee Members

Ms. Patricia Grace Smith, Chair
Col. Joseph F. Boyle USAF (Ret)
Mr. Hoyt Davidson
Dr. Bernard A. Harris, Jr.
Mr. Stephen S. Oswald
Ms. Franceska O. Schroeder
Mr. Wilbur C. Trafton

NASA Attendees

Stefanie Payne
Shawanda Robinson
Jennifer Wiles

Non-NASA Attendees

WebEx

David Ladler
Andrew Culbertson
James Dean
Alan DeLuna
Mary Lynne Dittmar
Jeff Foust
Jonathan Geldof
Yves Grondin
Brian Harris
Kevin Ingoldsby
Alan Keisner
Allen Li
John Limperis
George Nelson
Duane Ratliff
Andrea Riley
Kris Romig
Catherine Sham
Nigel Simmons
P. Whitney

Appendix B, Meeting Agenda

8:00 am

New Member Introductions

8:15

Annual Ethics Training

Commercial Crew Update and Collaborations for Commercial

9:15

Space Capabilities

10:30

Aeronautics Research Mission Directorate Lessons Learned

11:30

International Space Station Commercial Utilization Update

1:15 pm

Use of Prizes

2:15

Commercial Market Study

4:30

Public Comments

4:45

Adjourn

Appendix C, Committee Membership

Ms. Patricia Grace Smith, Chair
Patti Grace Smith Consulting

Col. Joseph F. Boyle USAF (Ret)

Mr. Hoyt Davidson

Dr. Bernard A. Harris, Jr.
CEO, Vasalius Ventures

Mr. Lon C. Levin
Cofounder, XM Satellite Radio and other satellite businesses

Mr. Stephen S. Oswald
Founder and president, Syzygy Enterprises, LLC

Ms. Franceska O. Schroeder
Principal attorney, Fish & Richardson

Mr. Wilbur C. Trafton
President, Will Trafton and Associates