National Aeronautics and Space Administration

International Space Station Advisory Committee

October 31, 2016
NASA Headquarters
Washington, DC

OPEN MEETING REPORT

Original signed by

Lt. General Thomas P. Stafford, USAF (Ret.)
Chairman

Original signed by

Mr. Patrick T. Finley
Executive Director

NASA INTERNATIONAL SPACE STATION ADVISORY COMMITTEE

October 31, 2016
NASA Headquarters
Washington, DC

TABLE OF CONTENTS

Meeting Report:		Page 1-11
Attachment A:	Advisory Committee Membership	Page 12
Attachment B:	Meeting Attendees	Page 13

NASA INTERNATIONAL SPACE STATION ADVISORY COMMITTEE

October 31, 2016
NASA Headquarters
Washington, DC

MEETING REPORT

Mr. Patrick Finley, Executive Director of the NASA ISSAC, opened the meeting, called the roll, and made the following remarks:

Patrick Finley:
From 25-29 July 2016, the ISS Advisory Committee met with the Roscosmos Advisory Expert Council as a Joint Commission and held a fact-finding session in Korolev, Russia, at the Central Institute of Machine Building, or TsNIIMash headquarters. The purpose of the Joint Commission is to gather information on the viability of the ISS, with a specific focus on crew safety and utilization issues.

The Joint Commission heard briefings by U.S. and Russian specialists covering a broad range of topics, including presentations on the status of the ISS Program, an update on the Medical and Human Research Status of the ISS, the potential for follow-on, long-duration missions, and a status update on the service life of the ISS modules. Additionally, the Joint Commission was updated on the upgraded Soyuz-MS launch vehicle, the elements of the Russian Federal Space Program 2016-2025 that pertain to human spaceflights, and the status of joint research being conducted onboard the ISS. Experts from RSC Energia, the Khrunichev Space Center, TsNIIMash, the Institute of Biomedical Problems, and NASA's ISS Program Office participated in the meeting and gave presentations.

I will now turn the meeting over to General Stafford to review the results of our recent fact-finding meeting in Russia.

General Stafford:
Good afternoon and thank you for participating in this open meeting of the NASA International Space Station Advisory Committee. For our meeting today, we will be discussing information we gathered from the July 2016 fact-finding meeting in Russia. I will summarize each of the main areas that we reviewed, and then allow time for Committee members to ask questions and discuss each topic.

ISS Program Overview
The meeting began with comprehensive International Space Station Program Overview presentations from Rocket and Space Corporation Energia (RSC-Energia) and the NASA ISS Program Office. The briefings were comprehensive and provided status updates on the full array of operations onboard the Station.

The Russian overview briefing reflected on a very busy operational schedule for the Station so far in 2016, including the Progress 63P cargo resupply mission in March, the successful new "digital" Soyuz MS crew vehicle launch in July, and the new digital Progress 64P cargo resupply vehicle launch in mid-July. The briefing described the status of space station

consumables, assuring us that levels of oxygen, water, and propellant are sufficient to at least September 2016 – even when accounting for a reduction in cargo missions. No outstanding issues were mentioned during Increment 47, with all systems (including environmental controls) functioning nominally.

Future plans for the Russian segment were briefed, including three new modules to be developed and launched in the coming years – the Multipurpose Laboratory Module (MLM), the Node Module, and the Science Power Module (SPM). A contract between RSC-Energia and Roscosmos was signed to complete the MLM and transport it to the Baikonur Cosmodrome in preparation for launch. Shipment to Baikonur is expected in April 2017, and launch is targeted for December 2017. The Node Module and Science Power Module remain under development.

The briefing also described a number of off-nominal situations that occurred between December 2015 and July 2016. In December 2015, during the automatic docking of Soyuz 45S, the computer saw a failure message that resulted in the crew manually docking. The root cause for the initial problem was the failure of a sensor. After further testing, the system was determined to be working nominally.

In June 2016, there were anomalies related to the Progress 62P vehicle, which was docked to the space station. It was determined the issues were related to the software. Mission Control Center - Moscow conducted an analysis of the software and sent commands the vehicle, successfully resolving the issue. The cosmonauts further performed a manual docking test on the Progress 62P vehicle by undocking, backing out 200 meters and docking in manual mode.

It is our understanding that simulator fidelity issues prevented full testing before flight. We believe these issues with the new software are indicative of a couple of lessons that are worth noting. First, there is a learning curve associated with the new software, and it is expected that flight and ground crews will correct this deficiency in the future as training progresses. Second, it appears that the ground software testing simulator lacks fidelity with the flight hardware which causes reduced confidence in test results.

We were also presented with a report on an anomaly associated with the Progress 62P vehicle tank. A mitigation strategy was identified, and a new testing methodology was introduced. Additionally, corrective measures have been implemented on all subsequent Progress vehicles (including the vehicle that flew in July 2016). RSC-Energia believes the issue is well understood and these mitigation strategies will provide a permanent solution.

We also heard a report on the Soyuz 47S launch delay, which was originally scheduled for 24 June and ultimately launched on 7 July 2016. The Joint Commission noted that there were two reasons for the delay. The first was due to a software error during software compilation. This was resolved by compiling and testing a new version of the software, then reloading the software. The second, longer, delay was due to a bad test result on a "Backup Circuit Control Unit" LRU, which affected the sensors used to achieve vehicle attitude control. After de-orbit burn, vehicle stabilization needs to be maintained, so the senor function was critical. This was resolved by removing, replacing, and retesting a unit removed from Soyuz 49S.

The US overview briefing reviewed the space station flight plan and discussed recent and future operations. The SpaceX CRS-9 cargo resupply vehicle successfully launched in July 2016 and included the International Docking Adapter. The Orbital-ATK CRS-5 "return to flight" mission

of the upgraded Antares rocket following the launch failure in 2014 is scheduled for the fall and will include a new set of Russian engines. The Japanese HTV-6 cargo vehicle is also scheduled to fly in the near future and will bring new lithium-ion batteries to the station.

The overview also included a review of accomplishments of Increment 47 and a look-ahead to Increment 48. During Increment 48, two extravehicular activities were performed to install a docking adapter and retract a radiator related to past attempts to locate an ammonia leak. So far in 2016, the US Operational Segment exceeded a target utilization rate of crew-tended research equaling 35 hours per week. Additionally, 38 hours of joint U.S.-Russia utilization was achieved. It was reported that since the beginning of the space station program, close to 2,200 individual science investigations have been performed on orbit.

The International Space Station Program Office also presented about anomalies that took place on the US operational segment. In January 2016, a spacewalk, EVA 35, was terminated because of reports of water in the helmet. NASA has been focused on finding the cause of water entering EVA suits since EVA 23, which was believed to be a result of contaminated water that was used on the ground and transferred to the station. NASA replaced all hardware believed to be affected, and even though the water was significantly less than water present in EVA 23, the presence of water in the suit during EVA 35 was a surprise. U.S. astronauts tested the suit once inside the station and could not reproduce the anomaly, and the suit worked without issue. The suit was returned to earth aboard the SpaceX CRS-8 Dragon and tested extensively on the ground without any negative results. This has been puzzling, and it's possible that a combination of factors between the crew member and spacewalk profile led to the presence of water in the helmet.

Additionally, there was an issue with the waste processor conductivity, but the processor is still functioning, although taking longer than usual to complete its task. The USOS Water Processing Facility is also experiencing an issue believed to be related to chemical components present in the water. Component levels are too low to affect crew health, but it could be a concern for machinery in the future. If this issue continues, the crew will change out the multi-filtration beds. The Air Conditioner on the USOS has seen an increased electric current in one fan, which may be a precursor to a future failure, and the fan may need to be replaced. Finally, while conducting a part replacement on an external power module, some loads were exceeded, and while the module was not damaged, it is possible some of the rails associated with the module were bent.

The ISS program office also provided an update about cargo resupply missions. The Orbital-ATK CRS-6 mission was the second successful flight following the failure in 2014. Cygnus launched on an Atlas V launch vehicle and all main objectives of the mission were completed, including a fire experiment that took place after vehicle undock from the station. The experiment was a purposely lit fire to learn more about the behavior of fire in micro-gravity environments. The OA-5 mission is scheduled for launch this fall on the Antares launch vehicle, equipped with new RD-181 engines. That Cygnus spacecraft will also deploy cubesats at a distance of at least 45 kilometers above the station.

The ISS program office presented about the successful launch of SpaceX CRS-8, which included the Bigelow Expandable Activity Module (BEAM) as part of its payload. The deployment took roughly seven hours. Since the module was packed and stored for more than a year, the materials of the module resisted expansion more than anticipated. A slow, low pressure

expansion was the preferred method to avoid a rapid deployment of the module, which would put load stress on the module. The expansion took more time than anticipated, but the proper configuration was ultimately achieved.

The space station Program Overview presentations were of the highest quality and included detailed descriptions of all technical and operational aspects on station. Given the reduction of Progress cargo resupply missions from four to three per year, the Joint Commission was pleased to note that both Programs report consumable levels are robust. According to the reports delivered at this meeting, the Joint Commission believes the space station is technically sound, and the Program is meeting its objective to expand station capability. Generally, the status of the program appears to be robust and is achieving its targeted science utilization rate. The Joint Commission is pleased to observe that the space station is not only technically sound but expanding functional and operational capability.

I will now open up the floor for Committee questions or discussion regarding the ISS Program overview. There were no questions or discussion**.**

Medical Update and Human Research Status

A representative from the Institute of Biomedical Problems (IBMP) gave a presentation on the status of medical issues and human research underway on station. The presentation focused on events since the last meeting (December 2015) and noted that over the last six months or so, the medical situation on station was nominal or uneventful. Elevated CO-2 levels on both the Russian and U.S. segments were observed over the last six months. In May, on a NASA initiative, a decision was made to "separate" the ventilation systems of the USOS and Russian segments so the CO-2 levels did not affect crew members. Despite higher CO-2 levels, Russian crew members did not have any health complaints. At the same time, U.S. crew members noted better conditions on the USOS segment – in terms of the environment and the quality of sleep. In June, ventilation between the two segments was combined again, and there was no change to the cabin environment. Air contamination levels increased during periods of cargo vehicles visiting the station, but at no time was the crew negatively impacted. U.S. and Russian medical professionals set standards for air quality impacts of the BEAM module on station. Crew members took air samples within BEAM that were analyzed by IBMP. There was concern over off-gassing of the BEAM materials or possible microbial growth that could have taken place during storage, launch, installation, and deployment. After testing, IMBP determined the BEAM module presented no risk. Four more air quality tests will be conducted during the two-year mission of BEAM.

The focus of the last year was the one-year mission. It was noted that not only Scott Kelly and Mikhail Kornienko participated in the mission, but that other crew members supported their work. Preliminary data from Kornienko's 11- month flight compared with data from his previous six-month flight did not reveal any negative changes to his condition. The condition and health of both Kelly and Kornienko upon deorbit was satisfactory, and both passed the "Field Test" with positive results. Both the U.S. and Russian medical communities have agreed to share results from the experiments of the one-year mission. In the early post-flight period, there were some issues with exchanging scientific data because there is very little time for cosmonauts to be assessed for research post-flight. Additionally, some post-flight evaluations were not completed due to standard post-flight rehabilitation rules.

There are many risks to the human body in space exploration, all accentuated by long-duration missions. Some examples are musculoskeletal, sensorimotor, behavioral health and performance, nutrition, radiation. The experiments for the one-year mission were designed with these risks in mind. The objective of one-year mission was to exceed six-month missions and see if there are any "brick walls" or big problems encountered by astronauts. While long-duration missions were conducted on the Russian MIR station, there are now better technological tools to evaluate the experiment. NASA will also compare data from the one-year crew to previous data from shorter-duration flights.

While data from the one-year mission is still being processed, it appears it will help increase understanding the effects of flight beyond low-Earth orbit on the human body. A major benefit of the joint experiments is the invaluable experience of U.S. and Russian communities working together and sharing equipment during the mission. So far, the teams have concluded that no barriers to a long-duration mission manifested, as long as crew sticks to program of exercise and countermeasures. The communities also learned that for future long-duration missions, there is a need to outline detailed plans for joint research and plans for post-flight evaluation and research. At a meeting between NASA and Roscosmos in April 2016, both medical communities supported proposals by the Multilateral Human Research Panel for Exploration (MHRPE) to continue cooperation on long-duration missions to study risks of such missions and study effects on human body. The long-duration missions helped forge better working relationships between Russian organizations and between Russian and international organizations.

From NASA's perspective, the one-year mission was a new experience for the U.S. side. It provided a unique opportunity to study the Kelly twins, an opportunity which may not come again. A brand-new set of experiments are being used to study these twins, with a focus on genetics and protein transcription as well as the expression of those genes. NASA will also study the microbiome (bacteria that live on and around the human body).

Visual impairment is identified as one of NASA's highest priority medical problems. Historically, roughly 50% of crew members have experienced some level of impaired vision after several months in microgravity. The cause of this phenomenon is still unknown, and therefore the potential treatment is still unknown. The Fluid Shifts experiment was designed to target this issue. The goal was to assess the expansion of blood vessels due to fluid shifting upward toward the head. The one-year mission gives NASA the possibility of determining whether this continues to advance over time or if it plateaus after a certain time period. The Field Test is an ambulation and coordination test immediately after landing. This is important to determine when an astronaut could step out and begin work on the surface of a planetary body after a long-duration space journey and is also important to identifying which countermeasures may be employed to counteract the effects of the long-duration journey. NASA believes the one-year mission utilized the station to reduce risks to human space exploration.

I will now open up the floor for Committee questions or discussion regarding the medical update or human research status. There were no questions or discussion.

Potential for Follow-on Long-duration Missions

Following the medical update, which included presentations on the recent one-year mission, there was discussion about the potential for follow-on long-duration missions to the station. We commend the medical and research communities for collaboration on the recent one-year

mission of Mikhail Kornienko and Scott Kelly. This mission supported research on future exploration and significantly improved the integration of Russian and U.S. crews and program resources. We further understand the U.S. and Russian Program Managers have an action to report to their respective human spaceflight directors on the status of planning for another one-year mission in the future, and we have asked for an update on planning efforts at a future meeting. Our group thought it was important to obtain as many one-year missions as possible.

I will now open up the floor for Committee questions or discussion regarding follow-on long-duration missions. There were no questions or discussion.

ISS Module Service Life Status

The Joint Commission also received an update from the U.S. and Russian sides about the status of the service of the station modules. The Russian side reminded the group that most modules have already been in operation beyond factory service life. The modules have been reviewed for extending service life beyond factory numbers, and all have been certified to continue flying to at least 2020. In 2010, RSC-Energia began reviewing Russian segment modules for certification beyond original service life, and in 2013, the certification extension to at least 2020 was approved. The Russian segment modules undergo a continuous review process, and each year a review panel must confirm the validity of extension to 2020. The 2016 Russian resolution confirming 2020 certification will take place in August and, at the moment, there are no outstanding problems that prevent safe operation off Russian modules to 2020. According to the Institute of Biomedical Problems, station service life is approaching the service life of the MIR station. Based on comparison of the two, life support systems have performed well onboard. Microbial erosion on station structures is always important to consider. On MIR, biologically infused corrosion of the internal metal structure was observed, but has not been observed on station – this improves expectations for its service life compared to MIR.

While Roscosmos has not yet formally requested RSC-Energia perform all required analysis to extend the life of Russian Segment to 2024, RSC-Energia has begun reviewing engineering plans internally. The Functional Cargo Block (FGB) is the oldest module on station. Currently, the module is in good shape, and there are no outstanding issues with its operation. The Functional Cargo Block is now being refitted with new hardware, because some technologies in the original module have been phased out since its deployment. The issue of sustaining support for the Functional Cargo Block remains an open question after mid-2016. Negotiations are underway between NASA and Roscosmos to determine the future of its sustainment.

The ISS program office explained that NASA and its international partners have spent considerable resources on considering service life issues, but that there is more work to do. NASA and Roscosmos have had eight meetings about space station service life, including the most recent in April 2016 in Houston. At the meeting, NASA and Roscosmos developed a strategy document for contingency action planning. It covers issues such as final perigee, allowable footprint, propellant usage strategy, etc. The goal is to develop a generic strategy that can be applied to specific contingencies should one arise. NASA and RSC-Energia are working to complete this document. There is still a need to refine total attitude control cost estimates for the entire de-orbit sequence, a need to understand how much propellant the whole activity would require (this is especially important as Progress flights have been reduced from four to three a year). There is a lot of work to be done to determine paths to de-orbit in a variety of contingency situations.

The goal is to try to maintain systems that would be needed for de-orbit for 180 days – this would allow another Progress vehicle to be involved (potentially), which would make for a more efficient de-orbit burn.

The Joint Commission notes that it appears there is much more organization and structure to these discussions between NASA and Roscosmos since previous briefings and encourages the two sides to continue the important work remaining on this issue.

I will now open up the floor for Committee questions or discussion regarding the ISS module service life status. There were no questions and no discussion.

Russian Federal Space Program 2016-2025

TsNIIMash presented on the human spaceflight elements of the Russian Federal Space Program 2016-2025, which was approved in March 2016. As described in the Federal Space Program, Russia will allocate roughly 1.4 trillion rubles during the 10-year period to continue space station utilization to 2024, deliver three new modules, develop a next generation crew transport vehicle, and create a technical capability to create a Russian orbital station after the International Space Station. Some missions were moved beyond 2025, but one of the program tasks is to develop some basic elements of technology for future missions. A large priority in the Federal Space Program is ensuring fiscal security and safety of the space program, another is science experimentation, and also to expand the crewed missions. Funding for crewed space missions represent the largest portion of overall funding.

During the next decade, Russia intends to increase the functionality of the station's Russian segment. Roscosmos will increase the research and experiments by a total of 32 investigations. Another goal is to become autonomous for power and electricity needs by 2025. Russia will alter the station configuration, including adding four additional docking ports.

I will now open up the floor for Committee questions or discussion regarding the Russian Federal Space Program. There were no questions and no discussion.

ISS Joint Research Status

The U.S. and Russian program management teams also presented about the status of joint research aboard station. Until recently, Roscosmos was striving to pursue its own national science and research program (much like the other international partners). Experience, however, has shown it is much more beneficial to perform complex and expensive research internationally. Roscosmos believes there are three benefits of joint research: reducing the overall costs of experiments, strengthening the scientific team and value of results, and fostering increased international coordination between organizations. In 2013, NASA and Russia signed a joint protocol to conduct about 45 experiments jointly. Initially, five hours of crew time was devoted to joint research time per week. In 2016, NASA and Russia signed a new protocol removing the five-hour limit on joint research, and now there is no specific limit.

TsNIIMash is responsible for working with NASA to coordinate joint station research. TsNIIMash uses a joint research matrix, which currently includes 45 different experiments. So far, nine have been completed, 10 are currently aboard the station, eight are short-term experiments (these are experiments that scientists on earth are already working to prepare), and 16 are long-term experiments. Integration of the research programs promises valuable results beneficial for all participants, but issues do exist, such as the different planning and management

systems partners utilize, which makes it difficult to schedule. The Institute of Biomedical Problems noted the main problem of human research in space is that there is not a common understanding of how to certify experiments. Both sides certify experiments in their own way and believe a common understanding is needed. TsNIIMash noted that Roscosmos is currently trying to clarify and simplify this process so it is more transparent.

I will now open up the floor for Committee questions or discussion regarding the status of ISS Joint Research. There were no questions and no discussion.

Conclusion

In conclusion, the Committee once again commends the International Space Station Program and the International Partners for the continued successful operation of the station and for maintaining an international crew with the existing flight vehicle assets. We also stress that continued vigilance is necessary to maintain safe and productive operations of the space station.

Given the information we discussed today, do any Committee members have any final questions or comments? Do the Committee members have any objections to the findings of this report?

Joseph Cuzzupoli:

I didn't hear anything about the commercial crew program and I have a question or two: I recall that in the latter part of 2015, our committee wrote a letter to NASA about the commercial contractors who proposed to do a "load and go" concept where you load fuel when the crew is onboard. Our charter is to look over the crew training and crew safety, that is what our committee is designed for and we wrote a letter to NASA from our committee. NASA organized a meeting down at Kennedy Space Center with the NASA Advisory Council and Aerospace Safety Assessment Panel along with some of us (from the ISS Advisory Committee). We brought this issue up and told them about our concern in, I believe, February of 2016. Just recently we had an accident while they were loading fuel onboard with a payload installed. It blew up the pad and destroyed the payload. My question: have we received anything from NASA about this issue? Are we in the dark on this? With all our experience on this committee – people who have 50 to 60 years of experience with building and launching vehicles – we want to know what has NASA done with this item.

Thomas Stafford: *We were briefed by (Kathryn) Lueders in 2015 and she said SpaceX would have the crew strapped in and they would load the fuel 30 minutes before launch. We said nobody is ever near the pad when fuel is being loaded. That is international. It was a December 9 letter to Gerstenmaier, and I said nobody ever approaches the pad if it's fueled. We brought that up to Lueders and she said she would get back to us, but in August I still hadn't heard anything. I called Gerstenmaier about a week before the explosion.*

Early on someone from SpaceX, the Chair or COO, talked about a sniper or disgruntled employee (causing the anomaly). We brought up to Kathy (Lueders) about a cryo recirc and they said SpaceX didn't want to put a recirc valve. Bill Parsons said that the tank was about ¾ full when it happened and I haven't heard anything from NASA. Our letter to Gerstenmaier in December of last year hit the nail on the head that this is a hazardous operation. I was talking to our counterpart, Gorshkov, about this and he was surprised there was a payload onboard during a static fire. We never heard anything about what stage the fueling was at on the pad when the fire started.

(McDonnell) Douglas was firing the third stage of the Saturn V and had an external helium bottle and it exploded and damaged the pad. They were surprised that SpaceX has high-pressure helium tanks inside the tanks. Gerstenmaier has promised us that we will have a briefing. I assume we will have one when we meeting in Houston in December.

Joseph Cuzzupoli: *We don't have any info on the accident except what we read in NASAWatch or the newspaper. I haven't talked to our committee members, but what you mentioned: helium tanks installed in fuel tanks is very unusual in my experience There are wirings, tubing, etc., since Apollo 13 when we had a fan issue on cooling the fuel and we had a thermostat that shorted out during ground testing. The crew blew out the side of the service module when they flipped that switch. I haven't talked to Chuck Daniel about his experience with doing that.*

Thomas Stafford: *Thanks for your input. You have had great experience in Apollo and Shuttle. From my experience, the helium tanks are always on the outside.*
Any other questions? There were no other questions or discussion.

Thomas Stafford: *Based on the recent fact-finding meeting in Russia and this discussion, the ISS Advisory Committee concurs with the assessment outlined here today.*
Thank you all again for the expertise you bring to our Committee. Now, I'll turn this over to the Executive Director to wrap things up.

CLOSING
Patrick Finley: *Thanks again for all your hard work on this assessment. We have started planning for our next meeting in Houston, scheduled for December 2016. I look forward to seeing you and our Russian counterparts in Houston this winter. This meeting is adjourned at 2:57pm.*

Attachment A

NASA International Space Station Advisory Committee

NASA Headquarters
Washington, DC
October 31, 2016

ADVISORY COMMITTEE MEMBERSHIP

Chairman

Lt. Gen. Thomas Stafford, USAF (Ret.)

Members

Col. James Adamson, U.S. Army (Ret.)
Mr. Hal Bell
Mr. Joseph Cuzzupoli
Dr. Charles Daniel
Dr. Michael Foale
Dr. Daniel Heimerdinger
Dr. Ronald Merrell
Capt. William Readdy, USN (Ret.)
Dr. Josef Schmid
Col. Jeff Williams, U.S. Army (Ret.)

Technical Advisors

Maj. Gen. Joe Engle, USAF (Ret.)
Maj. Bob Maiberger, U.S. Army (Ret.)

Executive Director

Mr. Patrick Finley

Dep. Executive Director

Ms. Holly Stevens

Attachment B

NASA International Space Station Advisory Committee

NASA Headquarters
Washington, DC
October 31, 2016

Members Participating

NASA International Space Station Advisory Committee

Chairman Thomas P. Stafford (via telecon)
James Adamson (via telecon)
Harold Bell
Charles Daniel (via telecon)
Michael Foale (via telecon)
Daniel Heimerdinger (via telecon)
Ronald Merrell (via telecon)
William Readdy
Josef Schmid (via telecon)

Executive Director

Mr. Patrick Finley
Ms. Holly Stevens (via telecon)

Technical Advisers

Gen. Joe Engle (via telecon)
Mr. Robert Maiberger (via telecon)

NASA Attendees

Tabitha Thompson, Office of Communications
Patrick Forrester, Astronaut, JSC (via telecon)
Diane Rausch, Office of International and Interagency Relations
Rebecca Gilchrest, Office of the General Counsel
Meredith McKay, Office of International and Interagency Relations

Other Attendees

Irene Klotz (via telecon)
Marcia Smith (via telecon)
Andy Pasztor (via telecon)