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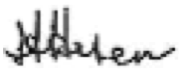
MEETING MINUTES

4/27/14

B. Scott Gaudi, Vice-Chair



4/27/14

Hashima Hasan, Executive Secretary

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Wednesday, March 26, 2014

Introductions and Announcements

Dr. B. Scott Gaudi, Vice-Chair of the NASA Advisory Council (NAC) Astrophysics Subcommittee (APS), opened the meeting and welcomed the Subcommittee members. He explained that a public comment session was scheduled for each day of the two-day meeting; otherwise, only Subcommittee members were to participate.

Astrophysics Division Update

Dr. Paul Hertz, Director of NASA's Astrophysics Division (APD), began his presentation by focusing on strategic and budget issues. The U.S. science community is privileged to be able to do publicly funded astrophysics. To continue, however, the science community must continuously articulate why it is important and exciting. The three core science questions NASA asks – How did our universe begin and evolve? How did planets, stars, and galaxies come to be? Are we alone? – underpin the Agency's research and space missions.

APD has benefitted from following the Decadal Surveys (DSs), which have identified the large missions that are best suited to be done by NASA. The James Webb Space Telescope (JWST) will launch in 2018, and the Wide-Field Infrared Space Telescope (WFIRST) would be transformative as well. APD articulated how the Division is following "New Worlds, New Horizons" (NWNH), the 2010 DS, in an implementation plan and has made some decisions that will lead to the next steps. The 30-year Roadmap that APS developed lays out some of what is possible over the upcoming decades. It has already been valuable in articulating why astrophysics should be supported, funded, and executed by the United States.

Scientifically, APD is still in good position. The astrophysics budget including JWST is relatively large. For Fiscal Year 2014 (FY14), the Division has a budget of $1.33 billion. The President's proposed budget for astrophysics in FY15 is lower, at $1.25 billion. The difference is in the Stratospheric Observatory for Infrared Astronomy (SOFIA) mission, which is deleted in FY15. The proposed budget is not adequate to extend all of the missions APD is currently operating. If the upcoming Senior Review says to extend them all, something else will have to go, as the money is just not available.

JWST remains on schedule with a fully supported replan in the FY14 budget appropriation and FY15 budget request. The team is doing a great job and will continue to do so. APD is also reinvigorating the Explorer program. New Explorer missions include the Transiting Exoplanet Survey Satellite (TESS) and the Neutron Star Interior Composition Explorer (NICER). There will be a Small Explorer (SMEX) Announcement of Opportunity (AO) later in 2014, which also solicits for a Mission of Opportunity (MoO). The planning budget is adequate to have four Explorer AOs per decade as recommended in the DS. If the cost cap were to be increased, however, APD would have to lower the cadence of AOs. The investment in Research Opportunities in Space and Earth Science (ROSES) has been increased. NASA is actively planning the Astrophysics-Focused Telescope Assets (AFTA) version of WFIRST, which uses the 2.4-meter telescope assets that the National Reconnaissance Organization (NRO) provided to NASA and which includes a coronagraph.

The budget future remains uncertain. Dr. Hertz noted that while he has had this job, the final budget has yet to match the plans he submitted. The thing that is hardest for APD is not the level of funding, but rather the lack of planning numbers to count on from year to year. The President's budget request for FY15 includes a 10 percent reduction from FY14, which is why SOFIA was eliminated.

Dr. Gary Melnick asked if the WFIRST Design Reference Missions (DRMs) 1 and 2 are still viable. Dr. Hertz replied that they are, though they are not under active development. There is nothing that would

prevent APD from picking them up again beyond the cost of doing so. The Division is much further along on AFTA, and the DRMs have nowhere near the same level of understanding of the technical challenges.

Dr. Kenneth Sembach asked if the budget decrease that led to the cancellation of SOFIA was a surprise to NASA. Dr. Hertz explained that when a budget is created, APD puts together a budget that fits the guidelines that the Division has been given; this budget extends through the 5 outlying years. APD submits that budget to the Science Mission Directorate (SMD). Any unsolvable problems go to Dr. John Grunsfeld, the SMD Associate Administrator. Next, Dr. Grunsfeld creates a budget for SMD and sends it to the NASA Administrator, Charles Bolden. NASA then develops an Agency budget that goes to the White House, which puts together a government-wide budget that is presented to Congress. Last year, the White House and Congress agreed on discretionary spending for FY14 and FY15. However, the guidelines for the various Federal agencies had gone out before that, and the submitted budgets were larger than what the agreement would allow. Therefore, the White House had to excise part of APD's budget, and it took out SOFIA. This is the budget that Dr. Hertz has been directed to use. Congress can accept or modify that budget. When Congress gives NASA an appropriation, the Agency will return with an operating plan.

APD is addressing all of the DS priorities. WFIRST is moving ahead as AFTA. There is a cadence of an AO every 2 or 3 years, alternating SMEXes with standard-sized Explorer (EX) AOs. The European Space Agency (ESA) is moving forward on two DS priorities, a Laser Interferometer Space Antenna (LISA) and an International X-ray Observatory (IXO); NASA is pursuing partnerships on both of these missions. The Division is investing in exoplanet technology, doing exoplanet probe studies, and advancing cornagraph technology to see if a coronagraph could go onto WFIRST. The mid-decade review will look at activities related to a possible inflation probe. APD has also augmented the Research and Analysis (R&A) program.

The FY14 budget appropriation for JWST was $658 million. This is the most expensive year of the mission, the peak year, as the major pieces come forward to be assembled. The rest of APD is receiving $668 million, which is $26 million more than requested. However, the Division has been directed to spend $56 million on WFIRST-AFTA, after planning on only $13 million for that activity. The final budget requires that APD rephase about $20 million. There was a similar need for rephasing in FY13 due to sequestration. APD received no funds for Education and Public Outreach (E/PO) in the FY14 appropriation. All funding for E/PO in FY14 is carryover and a bit of reprogramming.

Missions

Dr. Hertz next discussed APD missions. ASTRO-H is going well and the U.S. contributions are on schedule. NASA is providing detector assemblies for ESA's Euclid mission; beginning production of flight models is currently on hold while ESA catches up on the engineering. The science from Kepler is still outstanding, and the spacecraft is going through engineering test runs of the two-wheel mission "K2."

SOFIA has been successful at implementing its program and has completed all of the technical requirements for full operational capability. NASA is now validating that, declaring development complete, and putting it into operation. This is the equivalent of a launch for a space mission. Development was completed ahead of schedule and under budget for the replan. However, the FY15 budget proposes to end funding and put the observatory in storage, with a budget of zero after FY15. With the German Aerospace Center (DLR), NASA's partner in SOFIA, the Agency established a working group to lay out a plan forward that can be accommodated within the FY14 budget of $84 million, plus $12 million for FY15 and nothing thereafter. DLR has said that it cannot take over the mission, increase its funding, or operate as the primary partner. Therefore, NASA is seeking other prospective partners that could take over the funding and science of SOFIA. This must be done quickly, as it will take time to put SOFIA into storage. The SOFIA working group will report back to Dr. Hertz and his DLR counterpart on April 7 to identify any necessary near-term actions.

Dr. Hertz was not at liberty to discuss how SOFIA came to be on the chopping block. He did say that it is a standard budget activity to talk about what a division would do with more money and what it would do with less. APD was told to take a 10 percent reduction, which meant removing SOFIA, the Hubble Space Telescope (HST), or the R&A program. Dr. John Nousek was concerned that this presents a risk that affects APD's future. The Division's missions depend on collaboration, and NASA now looks like an unreliable partner. Dr. Hertz noted that this was discussed during the budget process. Dr. Gabriela Gonzalez wondered if APS should examine budget scenarios.

Dr. Hertz said that NASA will be reaching out to other potential partners immediately. Activities like this are more efficient and effective when planned in advance, but APD was given a budget proposal and is now developing a plan reflecting that budget. He noted that SOFIA has commissioned four instruments. The only Level 1 requirement not yet met is 960 science hours per year, and that is something for which the mission has 4 years to reach. DLR maintains that NASA should be the one to find a new partner, and he agrees.

Dr. Melnick observed that in ramping down this rapidly, the contractors, who provide the majority of support for SOFIA, will be defunded, and NASA will lose decades of experience as these people lose their jobs. Institutional memory will be gone within weeks or months. Dr. Hertz agreed, saying that the technological and scientific expertise in the excellent civil servant/contractor group of about 150 has taken time to build. That will be lost, and it will be difficult to reconstitute that group. Many people are trying to figure out how to operate at a reduced cost, which might make it easier to pull in a partner.

Dr. Joel Bregman said that the economy is doing better and the gross domestic product (GDP) is growing, and yet the nation is not all that committed to long-term programs. NASA does not have the planning that ESA does; ESA will choose a mission and can have confidence that they will do it. NASA built a $1 billion asset and is now turning it off. Partners wonder why. It shows a lack of appreciation of science and technology development. He wondered if the White House and Congress can be brought to understand the issues about teams going away, partnerships, and timelines.

Dr. Hertz replied that this country funds government activities one year at a time, which has always been challenging for NASA. Whether people see the commitments as a problem depends who they are and where they work. The budget proposal and approval process goes to the Office of Management and Budget (OMB) and Congress, and they all have different viewpoints. He agreed that this leads to a loss of leadership in prime science. The United States must choose where to lead. Saying the budget is too small does not help. Dr. Bregman said that Dr. Hertz leads well, but APD is being pushed around. Dr. Hertz reminded APS that their advice goes to the Administrator, and they can think about whether there is useful advice to send to him.

APS Discussion

Dr. Nousek said that APS must do its part to ensure that science interests are accommodated. Dr. Karl Stapelfeldt noted that Dr. Hertz did not seem to have an interim solution for SOFIA. He wondered if just shopping the existing structure to other partners is the best way to go. If Congress were to restore some funding to APD on this, it might enable development of a contingency plan to be done differently. Dr. Hertz is charged to implement the budget that is laid out; he is not on a path for a contingency budget plan. APS should ask for that.

Dr. Chryssa Kouveliotou said that it would not be appropriate for the APS to write a letter to the OMB, and an intermediate path might not be realistic. Dr. Bregman agreed that the funds are gone, and asking

Congress to restore it will not work. However, it might be possible to seek 2 years of a budget to develop an alternative to turning it off.

Dr. Melnick was concerned about the process by which this decision was made. He thought that Dr. Hertz effectively conducted a senior review. In a senior review, missions are given target goals and a sense of the likely funding reduction, allowing the mission teams to develop a plan for operating under that reduction. He suggested that APS voice a strong objection to this similar process, which is outside the norm.

Dr. Gaudi saw the process as more like the sequestration cuts that Dr. Hertz had to make. It was not possible for Dr. Hertz to keep pushing things into another timeframe. This time, however, the cut has a very different flavor from across-the-board reductions or delays. Dr. Melnick thought that that made the case as to how outside of the norm this was. In sequestration, things that had not started were cancelled or delayed. Historically, launched missions are protected and extended missions receive greater scrutiny. However, in this case, the process was inverted. Dr. Gaudi thought that the process did not seem that different, but the gravity of the outcome was very different. APS is not part of the budget decision process, but perhaps that could change.

Dr. Sembach agreed that it is unfortunate that SOFIA has not been in a senior review. He urged caution in making assumptions about Dr. Hertz's decisions. APS did not know what happened, and it was not useful for the Subcommittee to second-guess Dr. Hertz. Dr. Melnick replied that OMB said it was a lower priority, so someone somewhere made that determination. Dr. Sembach said that this happens elsewhere, and the decisions are made by people who do not know what is going on with the project.

Dr. Gaudi said that APS could ask Dr. Hertz for more explanation, though he might not provide it. APS could also ask if the members can influence this. Dr. Kouveliotou agreed with Dr. Sembach. APS was trying to identify a decision point. However, there is always a question with OMB. She wondered what program discontinuation APS saw as hurting APD most. Dr. Melnick asserted that the issue was the process and how the decision was finalized. Dr. Kouveliotou thought that Dr. Hertz had told the Subcommittee as much as he could. Dr. Melnick maintained that APS could say what they wanted in a report and could note that they found the process troubling. Dr. Gaudi suggested that they also ask if APS can influence these decisions.

Dr. Gonzalez advised proposing concrete actions, like saying that APS was surprised or hurt by the lack of consultation on this decision. This has happened for two years in a row, and she thought the Subcommittee should be proactive in proposing a preferred process. Dr. Paul Ray explained that Dr. Hertz cannot consult with APS because developing the President's budget request is an embargoed process. APS could make suggestions, but Dr. Hertz is not bound by that advice, nor are those above him, so there could still be surprises.

Dr. Nousek said that this was not a unique event, as there had been cuts in each of the last 3 years. APS could talk about the process, but this happens. Dr. Melnick countered that he was unaware of any mission that has been cut after being up for only 2 weeks. He thought there was an imperative to comment strongly on SOFIA. It went back to the mission team evaporating. The Congressional staffers would see this, and the prime contractor would make sure that they see it. If APS wanted to see Congress amend the decision, the Subcommittee had to provide additional help. APS should be explicit with its displeasure.

Dr. Kouveliotou asked where else OMB would go in the APD budget to cut $84 million. Dr. Giovanni Fazio said it was clear that Dr. Hertz had to send OMB a scenario for a 10 percent cut. APS should strongly object while also proposing an alternative, possibly by delaying new starts. Dr. Ray said that at that point, APS was not advising Dr. Hertz but was instead advising Congress, which does not have to

listen. Dr. Kouveliotou pointed out that the APS advice was meant for Dr. Hertz and not for OMB. She wondered what APS could do that would be practical. Dr. Melnick said that the Subcommittee could remind people that this was unprecedented, remind them of the funds invested, and remind them of the collaborations. He was not proposing that APS do its own cuts. That is not the Subcommittee's job or area of expertise. However, APS could state that it regarded this as a dangerous situation.

Dr. Gaudi pointed out that if another U.S. agency took over the collaboration, that agency would have to find $84 million for the mission. Dr. Ray agreed, stating that any funds for continued SOFIA operations must come from somewhere else, even from another agency. The Budget Control Act sets the total discretionary budget, however. Dr. Nousek said that OMB decided to change the balance within NASA and moved $200 million from SMD to other parts of NASA. Dr. Melnick added that Congress adjusts budget numbers as it sees fit. A letter from APS would provide support for those on Capitol Hill who are sympathetic. Dr. Sembach proposed that the science case should drive the support. He would hope that there is some focus on the science potential and science loss, and that the thinking goes beyond the redistribution of funds. It is important to not lose sight of that.

Dr. Gaudi said that he was hearing that APS would like more insight on the process, especially if the DS was used in making the decisions. He also heard that APS wanted to know if and how it might be able to provide input. Dr. Hertz should be able to delineate the process. Dr. Sembach noted that Dr. Hertz is legally bound by what he can and cannot say. Dr. Fazio thought Dr. Hertz indicated that this was one of the options he presented to those above him. Dr. Melnick said that Dr. Hertz was forced into this, but APS can state its disapproval of the process by which newly launched missions are terminated. Dr. Gaudi added that APS should note that the decision was not made via the usual external review process. Dr. Kouveliotou noted that in her opinion, those who lead a large division must have to have some freedom to make decisions, especially when turn around times are extremely short.

Dr. Bregman observed that it seems strange to make cuts like this in a growing economy. Dr. Karl Stapelfeldt thought that APS should say that in its letter, and note what they thought the process should be. The Subcommittee's charge is limited. Dr. Nousek said that they should think about what can be done now. APS cannot comment on OMB, but it can list the terrible effects of the SOFIA shutdown. Dr. Stapelfeldt suggested advising Dr. Hertz to expand the charter of the working group. It could be that other organizations might have a different approach. Institutional interests may have been placed above science, which concerned him.

Dr. Gaudi said that APS should ask Dr. Hertz if there were a way for the Subcommittee to have input on these decisions. This could go into the letter. Dr. Melnick identified three components of the letter. The first dealt with process and the identification of SOFIA as a lower priority. APS needs to understand how that came about. Second, the letter should have a statement in support of SOFIA, both as a large investment and as a scientific need. Third, the clock is ticking on the path forward to find a way to have the United States retain more than a small fraction of SOFIA.

Astrophysics Division Update continued

Dr. Hertz resumed his presentation. The President's FY15 budget explicitly calls out funding for preformulation work on WFIRST-AFTA. This is the first time WFIRST has had a budget line, and the funds allow planning and technology development. Congress appropriated $56 million for WFIRST in FY14. The FY15 request is much less, but APD can carry over some funds. This will help mature technology for the wide-field imager and the coronagraph. At the same time, the Division will try to retire risks associated with the 2.4-meter telescope assets made available by the National Reconnaissance Organization (NRO). From six possible architectures for the coronagraph, NASA has now selected the two that it will continue maturing toward Technology Readiness Level (TRL) 5 by FY17. Those are an

occulting mask coronagraph and the phased induced amplitude apodization (PIAA) complex mask coronagraph. The science definition team (SDT) is doing a DRM and draft science requirements, while the study office is continuing to assess the telescopes. The wide-field detector work would be useful to whatever version of WFIRST is implemented. It is not possible to have the coronagraph on DRM1 or DRM2. The coronagraph is not a requirement for WFIRST, and if it throws off the schedule or cost, NASA will move forward without it. At this point, however, APD is working to include it. The Division is also looking at probes.

Dr. Fiona Harrison led a National Research Council (NRC) group that looked at WFIRST-AFTA. The study found that AFTA advances the science beyond the requirements set by the Survey, but there are two categories of risk. The first involves using the NRO hardware as opposed to building to specifications. The APD response is that the Division is using its upfront funds to drive that risk down. The other risk is that of disrupting the program balance by developing an observatory whose cost is incommensurate with the overall astrophysics budget, which APD recognizes. APD will respond formally to the NRC report within 90 days.

APD is working with ESA on the mission concept proposal for an x-ray observatory as ESA's L2 mission. At this point, ESA has no mission architecture, so NASA cannot formally determine what the Agency could add. Dr. Nousek noted that U.S. scientists are participating in this effort on an ad hoc basis with the Athena proposal. He wondered about U.S. formal participation. Dr. Hertz said that he has no basis for picking people to join a specific proposal writing team. He will work with whatever mission ESA selects.

Over the last 7 years, APD has increased R&A funding by about 20 percent, though it has not been applied exactly as recommended in the DS. Despite the budget increases, the selection rate is down due to a 75 percent increase in the number of proposals. In answer to a question, Dr. Hertz explained that most missions have their own Guest Observer line. The Senior Review advises the Division on this. There is not enough money to fund all of the data time that is desired. Dr. Hertz will discuss the outcome of the current Senior Review at the next APS meeting, and at that time will address the balance between the Guest Observer program and the Astrophysics Data Analysis Program (ADAP).

The current Senior Review has three panels. The Hubble Space Telescope (HST) panel was completed before the meeting, the Chandra mission's panel was meeting the week of the meeting, and all other missions were to be addressed in a panel meeting the following week. HST and Chandra will continue, while the remaining missions will compete for a funding wedge to cover the next two fiscal years, possibly extending to FY18 in some cases.

A draft Explorer AO will be completed soon, with the goal of issuing the AO before the end of FY14. Following a prior discussion by APS of the cost cap versus the number of AOs, Dr. Hertz sought further input from the NRC Committee on Astronomy and Astrophysics and determined that APD will not change the cost cap.

The FY14 budget has no funding for E/PO except for HST, which was restored by Congress. Dr. Hertz found $1.2 million for the rest of the program. New rules are likely in FY15, along with an eventual consolidation that has yet to be determined. In advance of this, he consolidated astrophysics E/PO at the astrophysics program level. SMD places high priority on E/PO, but that funding was taken from the budget. He expects that eventually E/PO will no longer be part of every mission.

Dr. Edna DeVore asked if there had been any further discussion about consolidation of E/PO with the Department of Education (DoEd). Dr. Hertz replied that SMD has $15 million for E/PO, compared to $42 million in FY13, and the Directorate will decide how to apply those funds. The related DoEd budget is

down by 50 percent, and the funds NASA formerly allocated to E/PO did not go there despite the President's request that it do so in FY14.

The mission study for ESA's x-ray observatory begins in May. NASA participation involves putting U.S. scientists on the study team, and discussions with ESA, which will select the scientists. Dr. Hertz encouraged APS members to publicize this via their science networks. NASA will participate in every step and is discussing who to put on the mission study. There is no architecture yet.

Discussion with SMD AA

Dr. Grunsfeld described how funded science can sometimes go in unanticipated directions that provoke additional Congressional scrutiny, as recently occurred with an Earth Science Division (ESD) study. His stance is that NASA funds the research, and the conclusions are those of the scientists. SMD does not want to control how scientists present the data in terms of conclusions.

When SMD began preparing for the FY15 budget year, expectations were that the President's budget request could be ugly. The actual number is a good budget, and there are additional funds in an opportunity growth and security initiative fund. However, the budget environment remains difficult, and APD took a disproportionate hit this year. This is the budget proposal, not a final appropriation. The APS role is to give advice. The members are part of the science community and represent that community, and SMD appreciates the advice. He encouraged the members to make their voices heard more broadly. It is important to communicate that NASA is unequalled in turning taxpayer dollars into great science. There are data to support this assertion. For example, when Greg Davidson tracked worldwide science stories, he found that SMD accounted for 15 percent of worldwide science in 2013, with half of that being archival research from missions.

SMD still has substantial budget and is actively partnering with ESA. The Planetary Science Division (PSD) received an increase that allows it to look at going to Europa. The Heliophysics Division (HPD) will be able to launch Solar Probe Plus (SPP), NASA is moving ahead with JWST as planned, and ESD still has a large suite of activities, with four more missions in the next 12 months. As the JWST development budget ramps down, APD will explore opportunities for subsequent missions, such as WFIRST. However, community input will be needed to ensure that the Division goes in the right direction.

Discussion

Dr. Bregman observed that getting the word out is not the problem, as there has been much success in getting science into the press, students are thrilled about astronomy, and other countries invest in it. Yet with a growing GDP, there are still large cuts. He wanted to know how to improve the discussion with policymakers on the value of what APD does. Dr. Grunsfeld said that he heavily engages the executive branch as a team member to let them know that astronomy is the most popular science course in universities, and has made it very clear that the basic research SMD does is valuable, feeds into economic development, and can only be done by the government. In addition, the contractors are pushed to develop new capabilities. This makes them more competitive and helps U.S. business. The question is how the executive branch balances basic versus applied research. This administration values the latter more and gave more funds to other research and development agencies. In communicating to students and community groups, APS members should take their concerns to whatever levels they can access. Dr. Bregman observed that the national trend is to emphasize applied research. He sees it at all levels. It has been difficult to have the dialogue describing the value of basic research.

Dr. Grunsfeld said that he was disappointed that SMD did not receive a larger budget. However, there have been some positive developments, such as the authorization to move forward with WFIRST and the coronagraph study.

Dr. Melnick said that it is disconcerting how various enterprises in SMD have fluctuated, which is deleterious to the ability to plan to live within limited resources. Large jumps force draconian steps. If there were a way to moderate the fluctuations, there might be a better product for the same investment. Dr. Grunsfeld said that when budgets were higher and included more missions at different levels, it was easier to make adjustments. However, there are no more small adjustments possible. This year, the choice was to ruin all of APD or end SOFIA.

NASA did counter-propose on SOFIA with another timeline for a senior review that would have allowed the community to decide the relative merits of where cuts could be absorbed. Congress will decide, likely with some middle ground, but that remains to be seen. The great strengths of SMD and APD are intense competition and community involvement, which have resulted in the best science on the planet. He advised emphasizing those principles.

Dr. Ray asked how confident APS could be that the funding from JWST development will eventually return to APD. Dr. Grunsfeld said that he is confident, and Dr. Hertz added that while this is notional, APD was told to plan to it and will try to make it happen. Dr. Grunsfeld noted that unless NASA and the science community articulate SMD's exciting activities, the funds are at risk. Dr. Gonzalez thought that APS must say that the cuts are painful in both the short and the long term, resulting in lost expertise and lost leadership for the United States. Congress should look at these effects. Dr. Grunsfeld agreed.

Regarding E/PO, a consolidated line for SMD was placed in the APD budget. Dr. Grunsfeld is having SMD's E/PO leadership determine how to coordinate across the divisions. It would help if APS would discuss what the members would like to see. Dr. Terry Oswalt asked about the plans to eventually dispose of HST. Dr. Hertz said that this will occur beyond the current budget horizon, though everyone is aware of the need and watching the orbit. Dr. Grunsfeld added that the solar cycle has pushed out the date for this, and for now the HST orbit is stable. Disposal will be needed by 2027, and the needed hardware has been addressed. A big cost has been launch vehicles, though there is now some deflation in that area.

Dr. Melnick expressed concern that SOFIA could become a much larger public relations nightmare for NASA than is fully appreciated. Having invested over $1 billion in it is not a testament to NASA's acumen or management skills, and an explanation could be difficult to develop. The public will not understand the answer. Dr. Grunsfeld agreed, but noted that NASA is part of the administration. NASA has been funded to do SOFIA, conduct science flights, and bring on new instruments. While he believed that the science case for SOFIA is stronger than ever, this was a budget discussion. APD was told to mothball SOFIA until it can be flown with other resources. NASA must first communicate the need for other partners. In addition, the Agency is legislatively bound to continue SOFIA's work until it receives an appropriation or a modification to the current appropriation. This is very explicit. He expected to submit an operating plan change no earlier than the summer.

Dr. Sembach said that human capital is NASA's greatest asset, and asked how long the Agency could preserve the expertise. Dr. Hertz replied that it is not possible without funding. The civil servants will be reassigned. Dr. Grunsfeld added that many civil servants work on multiple activities rather than being dedicated to a single mission. NASA is always moving people around. He has briefed Congressional staff, and they are curious about the rationale and process, as well as being as surprised as everyone else. Those who support SOFIA or object to the cancellation should make their voices heard so that Congress knows. APS members and others who decide to visit a member of Congress should talk about the science they are doing and show what the United States receives for the investment.

Dr. Oswalt added that the current emphasis on science, technology, engineering, and math (STEM) education and initiatives is no good without jobs in those fields. Dr. Grunsfeld agreed.

Working Lunch – Discussion with Astrophysics Division Director

Dr. Gaudi summarized the morning discussion. There was concern about the process by which the decision to halt SOFIA was made. The feeling was that this seemed analogous to a decision that would be made at a senior review. Dr. Hertz cannot share details, but APS nonetheless wanted to know which principles were applied in making the decision. Dr. Hertz replied that APD could not manage a reduction of this size by cutting across the entire program, especially not after 2 years of moving projects around, and certainly not for more than $80 million. The only items large enough were HST, the R&A program, the Explorer program, all of the operating missions, and SOFIA. Examining these alternatives against the DS recommendations, one could say that the DS was followed. Dr. Gaudi found the explanation helpful. He asked if there might be a way going forward that APS can have input on such decisions, where there might be a hypothetical 10 percent change one way or the other.

Dr. Melnick asked if OMB said that it wanted a 10 percent reduction from APD or if it had a certain dollar amount to be taken from NASA. Dr. Hertz was not at liberty to say. The Division was told to do a worst-case scenario. He could not comment on discussions during the decision-making process, but there was a lot of input flowing both ways. Hypothetically, APD can comment on the impacts of OMB changes to the draft budget and make suggestions on doing it differently. Then, in principle, Dr. Grunsfeld would choose what to say to Administrator Bolden, who sets priorities for all parts of NASA. In this scenario, everyone involved decides the points they want to make in discussing the budget. Such discussions would happen between the passback and the President's budget request.

Dr. Nousek observed that the top-level NASA budget did not go down, which makes it appear that NASA chose APD as a "loser," which has previously happened with PSD and spaceflight. It appears that APD's budget decreased so that others could go up. Dr. Hertz said that that is possible, but the increases and decreases do not line up. He would not comment on whether this is a devaluing of APD within NASA. Dr. Bregman said that the NSF budget process begins with a letter mentioning priorities from the President. Those areas that are not priorities do not do well. The process at NSF is astonishingly fast. Dr. Hertz said that NASA receives the same letter, which is issued jointly by the directors of OMB and OSTP and annually sets research priorities across the Federal government, but the process takes months.

Dr. Gaudi said that APS also discussed the loss of continuity by zeroing out SOFIA and wondered if the working group could be expanded or augmented to consider reducing the operating costs of SOFIA. Dr. Hertz explained that the core report must address how to go forward with a zero budget, but the group will look at cheaper operations in order to bring in partners. If there is interest by the Administration or Congress in a lesser mission, he would have to do a science review. SOFIA costs what it does due to a determination that the mission was to accomplish certain things. It is not clear that a reduced program would be worth the cost. NASA has done similar reviews for SOFIA in the past.

Dr. Melnick mentioned the potential loss of the contractor support. There are five U.S. instruments with associated work being done by postdocs and graduate students, and they will be zeroed out. That would be hard to recover. He wondered if there might be a way to cobble together funding for the core contractors and retain the expertise of the scientists. Dr. Hertz said that funding would have to be transferred from another area. Everything in his budget is people, so preserving these people will result in the loss of other people. There is no path forward for SOFIA unless Congress rejects the President's budget proposal and appropriates the money to NASA. He was waiting for the working group to come back with the storage issues, but it is not possible to store a team. As for finding partners so quickly, his

assignment was to look. If someone came up with the funding, NASA would operate SOFIA on a reimbursable basis.

Overview of Context for NASA APD's Ongoing Mission Studies

Dr. Hertz said that an APD goal is to start a new mission to follow JWST, once funding is available. To this end, APD is also doing exoplanet probe studies for an external occulter and a coronagraph. These reflect DS science objectives and will be considered as options to WFIRST when it is time to make a decision. The probes will also guide technology investments. A new WFIRST SDT is examining the NRO telescopes, both alone and with the optional coronagraph, to determine a WFIRST-AFTA that is responsive to the DS. APD is not doing probe studies for LISA, but the Division is looking at partnering with ESA. APD was also going to conduct an x-ray probe study, but ESA has announced a mission that is similar to IXO. Therefore, APD terminated the x-ray probe study and is now focused on being a partner to ESA. Nothing is being done about the inflation probe because the precursor science has not yet been conducted.

NASA expects technology to be at TRL 5 for Key Decision Point A (KDP-A) and to be at TRL 6 for Preliminary Design Review (PDR). The KDP-A will take place no earlier than FY17. The President's FY15 budget includes a planning wedge for a large mission after JWST that could be used for WFIRST-AFTA if the Agency and Administration decide to do so. Dr. Harrison's NRC study provided good advice on identifying and retiring risks for WFIRST-AFTA. APD is implementing a version of WFIRST that exceeds the DS science requirements at a comparable cost to what the DS envisioned. However, there is no guarantee that starting a large mission will be approved, which is why the probes are being studied as well.

WFIRST AFTA SDT Interim Report

Drs. David Spergel and Neil Gehrels discussed the WFIRST-AFTA SDT report. SDT membership crossed a number of specialties and included representatives from Canada, Europe, and Japan. Dr. Gehrels explained that the NRO 2.4-meter telescope is the size of the HST telescope but with a field of view 100 times greater. The telescope is deeper and bigger, and has better imaging capabilities than that envisioned in the interim DRM (IDRM), which matches the DS description. WFIRST-AFTA is more complementary to Euclid and the Large Synoptic Survey Telescope (LSST), and more synergistic with JWST. The cost estimate is $1.7 billion without the launcher. The coronagraph adds about $300 million. The plan is for 5 years of operations plus 1 year of coronagraph operations, for a total of 6 years.

The NRO telescope assets have greatly increased interest in the mission, which in turn has helped get this into the NASA budget. Aerospace Corporation estimates the risk scenario costs at $150 million. Congress has added funding the last 2 years, and there is money in the President's budget request for WFIRST. These funds will be used to address the highest risk items and to lower development risks. The SDT was told to not let the coronagraph drive the requirements. The NRC review recommended moving forward despite concerns about cost and cost growth. The review further advised developing the technology as quickly as possible, making the decision for or against inclusion of the coronagraph at a later date.

The WFIRST science combines baryon acoustic oscillations (BAO), weak lensing, and supernovae. Dr. Gehrels described the surveys and said that there are notional ideas for the observing program. The wide-field instrument includes imaging and spectroscopy. The NRO mirror was designed to work at 278 degrees Kelvin (K), but the team is hoping to take it down to 240 K. Over the next year, it will be determined if the entire instrument can go colder.

The coronagraphy will be done in the visible band pass. The AFTA coronagraph is a good investment, because for the cost of an Explorer mission, NASA can have this extra capacity on a flagship mission. The DS recommended technology development in this area as well. NASA has already selected coronagraph architectures for development.

In addition to expanding our knowledge of dark energy and exoplanet science, this mission will answer many DS questions, and will even advance opportunities for deep follow-up in the area of gravitational wave studies. The science community has already shown a great deal of interest in WFIRST.

Dr. Spergel said that while a HST deep field includes about 5,000 infrared galaxies, the WFIRST-AFTA deep field images will have over 1 million galaxies. Dr. Spergel described how the microlensing magnification will operate. WFIRST-AFTA will provide exoplanet yields that are 1.6 times greater than those of the IDRM. It will also detect twice as many planets that are smaller than Earth, and have an improved ability to measure masses and distances to the microlensing host stars.

Microloensing complements what has been learned from Kepler. For example, microlensing will find hundreds of free-floating planets, which Kepler has indicated. Dr. Spergel provided details of the coronagraph capabilities, noting that WFIRST will be able to distinguish between a Jupiter-like planet and a Neptune-like planet. The coronagraph will respond to DS goals, such as discovering and characterizing ice and gas giants, furthering knowledge of the physics of planetary atmospheres, measuring the exozodiacal disk level of stars, and imaging circumstellar disks for planet interactions and planetary system formation. Critical coronagraph technologies will be further developed, though the coronagraph will not drive WFIRST requirements that could affect risk, cost, or schedule.

After showing a simulation of WFIRST-AFTA, Dr. Spergel discussed the predicted radial velocity (RV) planet detection and spectroscopy. WFIRST will use multiple techniques to look at dark energy, including a supernova survey with imaging and a high latitude survey that will include galaxy redshift from spectroscopy and weak lensing shapes from imaging. WFIRST and Euclid are complementary in examining dark energy. WFIRST will add much information, with a greater density and a richer data set. From the Background Imaging of Cosmic Extragalactic Polarization (BICEP) telescope, investigators learned that nature is full of surprises; systematics matter; the curvature scale could be just beyond the horizon; and specific elements are needed for an effective dark energy program. WFIRST will provide information across a wide range of scales and time, going quite deep in studying the Milky Way. The SDT's primary conclusion is the availability of the 2.4 telescope assets enable more powerful and richer science than envisioned in the DS, with a relatively modest cost increase. However, retirement of some of the risks is essential, and APD should try to do so as quickly as possible.

Discussion
Dr. James Bock noted some errors in the BICEP measurements; the systematics paper is coming out soon. Dr. Gonzalez asked what was being done to address the cost decision. It was explained that the team has been through the independent cost estimate process with Aerospace Corporation a number of times. Aerospace found that the cost for the AFTA version of WFIRST is in the family with the IDRM. Putting aside the launch vehicle cost, the independent cost estimate of AFTA was 8 percent higher than that for the IDRM. With the additional funding in the last 2 years, the team can move more aggressively to develop detectors. Dr. Melnick expressed concern about the differences between operating at 278 K and 240 K. Dr. Spergel said that test measurements to date make the team optimistic.

<u>EXO-S SDT Interim Report</u>
Dr. Sara Seager discussed the work done by the science and technology definition team (STDT) thus far in studying the EXO-S, an exoplanet probe-class mission referred to as "Starshade." While Starshade is

thought to be a back-up to WFIRST, the team considers it a key study and the first of its kind. It will cost less than $1 billion. Dr. Seager described how the mission will separate on orbit and provided graphics of how the shade and the telescope will align at a distance of about 37,000 km. This must be done precisely. The telescope is a conventional 1.1-meter instrument; only minor modifications will be needed on an existing design. The mission decouples the telescope aperture size from the contrast and inner working angle. No wavefront correction is needed. For retargeting, the telescope will move rather than the Starshade. Instrumentation includes an imager and low-resolution spectrograph.

The first science goal is a photometric search for new exoplanets, from Jupiter-like down to rocky planets orbiting nearby Sun-like stars. Starshade will image rocky plants in a Sun-like star's habitable zone and discover multiple planets and circumstellar dust around target stars. The second science goal is spectral characterization of new exoplanets, such as mini-Neptunes, which seem to be extremely common. The third goal is spectroscopy of known Jupiter-like planets. Starshade will look at the spectra of 17 known Jupiter-mass exoplanets, possibly more. Dr. Seager showed a list of target stars.

The prime mission is for 3 years; Dr. Seager presented an example of what data might come in for the first 22 months. Equipment realignment will be necessary for each target. Dr. Seager next described the launch configuration, separation, and fully deployed observatory, which will have electric propulsion. Graphics represented the deployment process. The petals must be customized and deployed relative to each other. The Starshade bus will be a simplified copy of the telescope bus, with repackaged avionics.

The instrument will be small and simple, and the preliminary cost estimate maintains the existing parts as a settled cost. The mission will hold a 30 percent cost reserve. Critical technologies include optical model validation; precision deployment and shape control; long distance formation flying; and stray light control. The ability to test this technology on the ground is limited, though some parts have been modeled. A video showed what the petals will look like as they unfurl.

Next steps include a baseline probe design, a "Starshade ready" design, and technology development. This is the only way to study rocky exoplanets with a relatively small space telescope. The technology progress is on track for a new start in 2017. As for micrometorite puncturing, the Starshade is multilayer, so only perfectly aligned punctures would affect it.

EXO-C SDT Interim Report

Dr. Stapelfeldt described the study of EXO-C, a coronagraph probe mission. The DS noted the need for an exo-Earth imaging mission. This has been proposed multiple times since 1999. Exoplanet science in 2024 will require indirect detections, transits, exoplanet direct imaging, and disk imaging. Indirect detection provides target lists. Science opportunities for EXO-C include optical spectra of the nearest RV planets. The mission will also search for planets beyond RV limits, such as Alpha Centauri. The mission will image circumstellar disks beyond current limits. The mission will probe a few systems for exo-Earths if telescope stability and exozodi are favorable.

Dr. Stapelfeldt gave the baseline requirements for the mission and showed a graphic of accessible exoplanet targets, some of which might be worth extra effort to study. EXO-C will also search for previously unknown planets similar to Jupiter, Saturn, and Uranus, along with super-Earths. The team expects the mission to get the spectra of 20 exoplanets and do multicolor photometry on 20 more, in addition to conducting discovery and disk imaging surveys.

The baseline design overview involves an Earth-trailing orbit for a 3-year science mission. EXO-C will use a bright science target star as the reference for precision pointing and compensation of low-order wavefront drifts. The intent is to use commercial equipment to the extent possible. A low-order wavefront

sensor is very important to measure distortion and to dial in corrections in real time while deploying. The mission could fit in a second piece of equipment if the funding were available. The pointing is very important and the requirements are similar to those of HST.

The team evaluated five coronagraph architectures: Hybrid Lyot, PIAA, vector vortex, shaped pupil, and visible nuller. The first three have been kept for further development. Dr. Stapelfeldt described the detailed thermal analysis and pitch maneuvers, noting that stability is crucial. Thus far, the thermal mechanical issues are understood. The technology is nearly ready, but there must be a demonstration to address pointing errors.

The preliminary estimates are for a cost of less than $1 billion, but Aerospace Corporation has not yet weighed in, though it will do so over the summer. The telescope and payload are each assumed to account for about one-third of the budget. Next steps involve detailed modeling of some features, performance analysis of the three coronagraph architectures, assessment of design features that are similar to Kepler, and the Aerospace analysis.

It is too early to compare this to the coronagraph on WFIRST-AFTA. A common parameter is that they have about the same inner working angle. Dr. Bregman observed that this proposal has been optimized from the ground up. Dr. Stapelfeldt said that WFIRST-AFTA with the coronagraph would provide the same science for the cost of an extra instrument, whereas this would be dedicated.

Public Comment Period

The meeting was opened for public comment.

First to speak was Dr. Erick Young of Universities Space Research Association (USRA). He thanked APS for the time they gave to the SOFIA situation, noting that the key points were raised, including the science value of SOFIA and the loss of a generation of scientists. If SOFIA is stored, it cancels the mission because it will not be possible to reconstruct the team; the contractors will be dispersed. This mission is the only access to this science. It is a critical bridge, and the United States must maintain this key capability for both science and technology.

Dr. William Latter of USRA spoke next, stating that the loss of staff would be effectively a cancellation. It touches on NASA as a viable employer of scientists. Dumping 20 to 30 scientists into the job market would mean that most or all will have to seek jobs outside of the field and that would be a loss. Losing SOFIA would mean the end of a strong knowledge base.

Dr. Robert Gehrz of the University of Minnesota said that he was from the SOFIA users group. He has spent the last 6 years helping the community gear up to use SOFIA. There is a whole generation of young scientists who expected to use this telescope, and we will lose their expertise.

Report on National Research Council (NRC) WFIRST/AFTA Study

Dr. Harrison described the NRC ad-hoc study committee evaluation of WFIRST-AFTA in context of the DS. Many of the study committee members were on the DS main panel, and some have expertise specifically relevant to WFIRST. The goal of this study was to compare the WFIRST mission described in the DS to the WFIRST-AFTA SDT DRM with or without the coronagraph. The study was to assess WFIRST-AFTA's responsiveness to the science objectives of the DS, as well as the exoplanet precursor science and technology objectives. The Committee understood that NASA is no longer actively studying the IDRM, while it is studying the implementation of the coronagraph.

The DS described multiple objectives for WFIRST, including to accomplish the following:

- Probe dark energy;
- Use microlensing to study other solar systems;
- Conduct wide-field surveys to advance understanding of stars, galaxies, and black holes; and,
- Support a Guest Investigator program.

The NRC study evaluation found WFIRST-AFTA to be consistent with the science program of the DS, meeting or exceeding the DS goals for WFIRST. In context of Euclid and LSST going forward, the NRC study found WFIRST-AFTA to be very complementary. The Committee found no current mission addressing the microlensing survey. Should WFIRST-AFTA do drift scanning, it can break degeneracies inherent in interpreting the microlensing data. The opportunity to increase the telescope aperture through the use of the 2.4-meter mirror will significantly enhance the science power of the mission.

Regarding the NWNH exoplanet technology development objectives, budget constraints will slip the start of an Earth-like planet imaging mission beyond the horizon envisioned by the DS, but a high priority is still the development of the technologies for such a mission and addressing the key uncertainties, such as levels of exozodiacal light and identifying targets. The NRC study found that the coronagraph that WFIRST-AFTA might include satisfied some aspects of the broader exoplanet technology program recommended by the DS. As for exozodiacal light, there is uncertainty due to the immaturity of the coronagraph design and uncertainty in the ultimate performance. Some of the performance curves were impressive. If the coronagraph were added, the WFIRST prime mission life would be extended by 1 year. The NRC study did not feel that the addition of an integral field unit (IFU) for supernova follow-up was a driver of cost/risk on a significant level. The orbit/servicing requirement, on the other hand, imposes a massive risk.

However, should the implementation of WFIRST-AFTA compromise APD program balance, then it is inconsistent with the rationale that led to the high-priority ranking. The DS strongly emphasized a balanced program. This is not to say that WFIRST-AFTA would negatively impact program balance; rather, it is an observation that in order to avoid damaging the program, the funding wedge for WFIRST-AFTA must accommodate the mission cost and provide contingency funds to cover the mission risk.

Dr. Hertz added that APD wants a program that is sustainable, building both Explorer and strategic missions and supporting a research program that realizes the science of the operating missions while also moving forward the science for future missions. APD is spending a lower portion of the budget on strategic missions than it did in prior decades. A healthy amount of the budget goes out to the community through R&A. The overall goal is a program that develops the critical capabilities with the most important science.

Dr. Nousek observed that the number of flagship missions in APD had has dropped significantly from what it was 20 years ago. JWST has taken more than a decade. The Decadal Surveys allocate a fraction of the budget to flagship missions, which is where the balance becomes an issue. Dr. Hertz replied that the decision to continue and complete JWST was correct. Both the DS and Dr. Harrison's NRC study committee emphasized the need to restrain the appetite with WFIRST. Dr. Harrison pointed out that the NRC study is not implying that NASA has failed to recognize this, but the Committee wanted to point out the risks. The Aerospace Corporation cost assessment for the mission is $2.1 billion in FY12 dollars. The risk assessment was medium-low for IDRM and medium for WFIRST-AFTA. The primary risks are the large focal plane for both, fine attitude control for both, risk of mass growth/low mass margin for WFIRST-AFTA only, and end-to-end testing of the optical system for WFIRST-AFTA only.

Dr. Marcia Rieke, NRC study committee Vice Chair, said that one thing that gave the Committee a lot of pause was that the AFTA optics were never designed to be run as low as 240 K. Dr. Harrison added that while Aerospace did not flag this, the Committee felt that there were risks associated with WFIRST-AFTA. The optic is designed for room temperature operations rather than what would be seen in an infrared mission. The thermal margins are low and there is a need for rework. The use of inherited hardware results in design complexity, low thermal and mass margins, and limited descope options that add to the mission risk. These factors will complicate the management of cost growth. This does not mean the risks will be realized, but they exist and should be retired.

The risk of cost growth is significantly higher for WFIRST-AFTA without the coronagraph than for the IDRM. The cost itself is not the issue, but the risk of cost growth is. Introducing a technology development program onto a flagship mission creates significant mission risks stemming from the schedule uncertainties inherent in advancing low TRL hardware to flight readiness. Missions that are specifically for technology demonstration accept a greater technology risk. These demonstrations do not usually go onto flagship missions, however.

Inclusion of the coronagraph compromises the rationale for including WFIRST as a top priority. The NRC study also found that inclusion of complex operations is not consistent with the simple operations that the DS envisioned for WFIRST. The DS envisions simple shift-and-stare opportunities, but additional operating modes are being considered with WFIRST-AFTA. The increase in operational complexity over the nominal DS concept is an additional risk for mission cost growth.

The NRC study commttee recommends that NASA move aggressively to mature the coronagraph design and develop a credible cost, schedule, performance, and observing program so that its impact on WFIRST can be determined. At that point, there should be an independent review of whether the coronagraph should be included. The NRC study also recommends that NASA sponsor an external technology and cost review of the WFIRST-AFTA mission. The review should be independent of NASA's internal processes and ensure that the proposed mission costs and technology risks are consistent with available resources. The review should occur early enough to influence the exercising of a rescoping of the mission if required.

Discussion
Dr. Bock noted that Dr. Harrison mentioned the balance and cost of WFIRST-AFTA within the balance set out by the DS. He wondered if they also considered exoplanet technology development and development of the coronagraph. Dr. Harrison replied that CAA decided that that was not in their charge.

Dr. Nousek was puzzled by the Aerospace estimate of a $2.1 billion for WFIRST-AFTA. The mission costs ranged from $0.8 billion to just over that. Dr. Harrison said that IDRM would cost $1.8 billion for a 1.3-meter telescope. Dr. Nousek responded that AFTA provides a much larger mirror that weighs more. Dr. Hertz noted that it does not require fabrication, but the rest of the mission must be designed to it, and Dr. Harrison said that the total mass increases but is not something that can be scaled. Dr. Nousek thought that mass had been an issue with Aerospace. Dr. Hertz explained that it is a risk, not an actual cost. The NRC study determined that the AFTA cost risk was a category higher than that for IDRM. Dr. Hertz thinks in terms of development time. He is comfortable saying that he believes this can be done without affecting the program balance. It may take longer to build or launch, because he can stretch it out without impacting program balance. If APD believes this can be done while maintaining program balance, he will advocate going with WFIRST-AFTA. The NRC study committee was concerned that the most obvious descope option, that of reducing the aperture, is not available with AFTA. APD will have to watch cost growth carefully. Dr. Harrison added that the Committee emphasized that there are other options, such as dropping the coronagraph.

Dr. Kouveliotou asked if this is the best and most efficient way to achieve balance and meet the goals of exoplanet planning. She wondered if the impact might be to change the goals of the exoplanet community in the near term, and expressed concern that they were setting aside probes that might be more efficient in providing science. Dr. Stapelfeldt said that this has been an issue in the exoplanet community for 15 years, but any of the three options would make many people happy.

Dr. Julianne Dalcanton asked about the mechanism for balancing the program. She worries about decision-making getting siloed. Dr. Hertz replied that APD relies on the DS to balance the different science areas. One thing that convinced the Division to move forward with the coronagraph is that WFIRST is APD's next large mission. The next DS will pick the flagship after that. A coronagraph on WFIRST will do high-priority science sooner and cheaper than would a stand-alone mission.

Dr. Bregman noted that the Europeans have claimed two of the four top DS priorities, and Kepler has produced much excitement. The coronagraph is something the United States must absolutely put up, even more than the rest of WFIRST. As envisioned, WFIRST would make a significant improvement in the study of dark matter. Euclid and LSST will do some of that, but the coronagraph is the big thing. The one area in which Europe has not leapt ahead is exoplanets. NASA can do something interesting and exciting here. Dr. Stapelfeldt added that the United States leads in microlensing and should own it.

Others disagreed, and Dr. Harrison mentioned the cost risk with the coronagraph. No one knows how it will affect the mission. Dr. Gaudi said that the risks must be retired, and Dr. Gonzalez said that one of benefits of the DS is to have a stable program. People should not rethink it.

Discussion

In regard to JAXA possibly developing the coronagraph, Dr. Gehrels said that the Japanese do not have the funds but have expressed some interest in NASA efforts to develop the technology. Dr. Melnick asked for more detail on taking the 2.4-meter telescope to 240 K. Dr. Gaudi replied that there has been some initial work down to 248 K; Dr. Gehrels added that it was a paper study. Dr. Melnick said it would worry him not to put it in a thermal vacuum chamber early on in order to avoid problems later.

Dr. Bregman thought it would be useful to identify important technologies that reside in the United States. The coronagraph is one of them. NASA should not rely on other countries for that. The roadmap is a significant change in tone from the DS report, putting great emphasis on exoplanets. Dr. Harrison observed that the DS is called "New Worlds, New Horizons" for a reason. Kepler has retired some of the uncertainty as well.

Wrap up for Day

Dr. Hertz said that APD has nominated five new members for APS but is not allowed to make an announcement until they have submitted their financial disclosure data. He is confident that they will be in place by the next meeting. In the meantime, NASA extended by several months the appointments of members who were to rotate off, and it was wonderful to see them again. The summer meeting is to be face-to-face, unless the Subcommittee would prefer to have that be virtual and do an in-person meeting in the fall.

Dr. Gaudi reviewed some topics for the next day's discussion, including SOFIA and how SMD should spend the E/PO money. Dr. Hertz said that the summer meeting will cover the outcome of the senior review. When Dr. Nousek suggested weighing in on the WFIRST-AFTA study, Dr. Hertz cautioned against committees commenting on the findings of other committees, though APS could state its

appreciation. Dr. Melnick wanted to comment on using time as the parameter in covering the cost of a mission. Dr. Gaudi thought they should say that APS supports a balanced program, then define balance.

Adjourn
The meeting adjourned at 4:53 p.m., to resume the next day at 9 a.m.

Thursday, March 27

Re-cap of Day 1
Dr. Gaudi opened the meeting for its second day. On the first day, APS heard a presentation from Dr. Hertz and had an extensive discussion about SOFIA. There were also reports from the WFIRST-AFTA SDT, the probe teams, and the Chair of the NRC study committee on WFIRST-AFTA. He identified the following topics for the APS letter to Dr. Hertz: SOFIA, the NRC WFIRST report, definition of a balanced program, and the $15 million E/PO budget.

Regarding SOFIA, APS had concerns about the decision-making process, noting that it was unprecedented. The science community feels this should have been done with consultation. APS is concerned with how the Subcommittee could affect this in future. APS is there to advise NASA, not OMB, however. Dr. Kouveliotou noted that Drs. Hertz and Grunsfeld both stated that Dr. Grunsfeld was concerned about the process but had only a short time to respond to OMB. She did not see how APS might get involved in such a decision in a timely manner. Dr. Ray cautioned that it is illegal for APS to be involved. They can only submit science priorities in advance; they cannot insert themselves into the budget process. He suggested expressing concern about the shutdown of SOFIA and the process by which it was done.

Dr. Gaudi thought they might be able to state which of three given scenarios APS might choose, and discuss what the Subcommittee would have said had this situation been presented a year in advance. There still might not be any good options, and the advice might not be heeded, but they should express it nonetheless. They could state that they are not happy with the way the process worked. Dr. Melnick said that their advice is taken as recommendations for the future. This report should be a document that is read by people who are sympathetic to science and SOFIA. The most urgent audience for this report is Congressional staffers. He thought APS should be blunt in saying that a senior review was conducted without the community. APS should reiterate the scientific value of SOFIA and state that missions normally end through a senior review after the nominal mission.

Dr. Nousek said that NASA has shut down missions suddenly due to technical problems and can shut down a mission at any time. Dr. Sembach suggested that if funding were to be restored, SOFIA might go into the next senior review in order to be in front of a science audience. Dr. Bregman said that that would also be extraordinary. Senior reviews are done after a mission's prime phase, not when seeking cover for a mission's continued funding in the operational phase.

Dr. Dalcanton noted that the issue was money. Dr. Hertz had to do something sudden and drastic. Dr. Gaudi explained that he was going to mention that by putting SOFIA in storage, NASA is effectively cancelling it because the mission expertise would be lost. The letter might also say that the volatility of budgets prevents APS from providing timely advice to NASA, prevents NASA from carrying out long-range missions, and damages international collaboration.

ESA Cosmic Visions Update

Dr. Arvind Parmar, ESA's astronomy and fundamental physics coordinator, spoke to APS via telecon. The ESA long-term program is called "Cosmic Vision" and addresses four key questions:

- What are the conditions for planetary formation and the emergence of life?
- How does the Solar System work?
- What are the physical fundamental laws of the Universe?
- How did the Universe originate and what is it made of?

The program has an annual income of 500 million Euros, which is stable, but there is no correction for inflation. The ministers must agree unanimously on a funding change. Member states also make substantial contributions, as they directly fund payloads and some of the science done on the ground. Working groups make recommendations that eventually go to the Science Programme Committee (SPC) for the final decision on program content.

The program includes L, M, S, and O missions – large, medium, small, and opportunity. L missions are flagship missions, costing ESA about 1 billion Euros, which does not include the member-state provided payload and science team, and occurring every 7 to 8 years. They are open to international collaboration up to a limit of 20 percent. L1 is the Jupiter Icy Moons Explorer (JUICE) mission, scheduled to launch in 2022 with substantial U.S. involvement. L2, to launch in 2028, has a science theme of "hot and energetic Universe." The L2 call for mission concepts closes in mid-April, and proposers can suggest international collaboration. Based on discussions with NASA and JAXA, ESA will include U.S. and Japanese scientists in the study team. ESA will assemble the science team mid-year and have an AO for instruments in early 2015. Phase A will be completed at the end of 2016, and ESA approval will be given in late 2018. The L3 science theme for 2034 is "gravitational universe," and ESA will invite NASA to participate in identifying science questions and developing the technology. The LISA Pathfinder is going well. Subsystems are being delivered, and most issues relate to engineering. The summer 2015 launch date still stands.

M missions provide flexibility and can be led by ESA or involve international collaboration. ESA expects to spend about 500 million Euros on these and have one every 3 or 4 years. Both Solar Orbiter (2017) and Euclid (2020) have substantial U.S. involvement. The call for M3 went out in 2010, and PLAnetary Transits and Oscillations of stars (PLATO), which was added back in from an earlier competition, was selected. It will follow up on Kepler and complement TESS, detecting hundreds of low-mass planets in habitable zones of bright solar-like stars, observing two regions for about 2 years each. A prime product will be a large sample of high precision stellar light curves. It is expected to launch in 2024.

The S missions are new, and allow national agencies to play a leading role in missions. The thought is to launch one every 4 years. S1 is CHaracterizing ExOPlanet Satellite (CHEOPS), which will study transits of known exoplanets and will be ready for launch in 2017. It allows for international collaboration. ESA collaborates with missions led by other agencies in its O missions, which are similar to NASA's MoOs. Examples include Astro-H and a new collaboration with the Chinese for which there was a recent workshop in Chengdu.

The program goal is to implement a regular series of missions at all levels so that there is a cadence the science community can expect. This is backed up by a published planning cycle for calls and launches, though that depends on keeping costs down. A predictable schedule provides the science community with the ability to plan. When looking at the milestones from the study process through the final selection to reach TRL6 or greater, Dr. Parmar is pleased with the way the program is going.

In answer to a question, Dr. Parmar said that ESA is not involved in JAXA's Space Infrared Telescope for Cosmology and Astrophysics (SPICA) mission, which was an MoO proposed in 2010. ESA felt that the risks were too great to move forward, though there is some thought of re-proposing it for the M4 call. The selection and timeline for M4 is uncertain. Missions that were not selected for M3 may be re-submitted. ESA covers a portion of the operating costs, usually about 50 to 60 percent, with the member states contributing the rest. There is a squeeze on extended missions, and ESA may have to turn off a mission for the first time. No one from NASA has talked to ESA about taking up the SOFIA mission yet, though Dr. Hertz assured Dr. Parmar that they will.

Dr. Parmar concluded by explaining that technology development is a shared responsibility between ESA and the participating nations. ESA reviews the plan annually in collaboration with the member states.

Explorer Update

Dr. Wilton Sanders, APD's Explorer Program Scientist, said that the only change from the previous APS meeting is that NICER has moved from formulation to implementation. APD has issued a community announcement for SMEX and MoO missions, the former through a standard AO, and the latter through a Stand Alone Missions of Opportunity Notice (SALMON) program element appendix. U.S. Participating Investigators (USPI) will be solicited through ROSES. The cost cap is $125 million for SMEX and $65 million for MoOs, except suborbital missions, which are capped at $35 million. Investigators may propose the International Space Station (ISS) as a platform for a full SMEX; access is provided by NASA. The process does allow science enhancement options in a two-step process mentioned previously.

Dr. Ray asked about cubesats, which Dr. Hertz said are inserted into a queue for a NASA-provided launch. They are solicited through the APRA program in ROISES, though they not been selected yet in APD. The prime mission for investigations on the ISS must end by 2024, consistent with the current ISS extension decision.

Discussion with Astrophysics Division

SOFIA

In answer to a question on how to keep SOFIA going to FY16 in order to transition more smoothly, Dr. Hertz said that the President's budget proposal allows NASA to seek partners but is not consistent with going to FY16 using NASA funding. The joint working group is looking at options, one of which is to propose to carry over funds from FY14 to FY15. NASA could ask for permission to do that. The working group's assignment is to determine what it takes to put SOFIA into storage, but the group will also consider alternatives. APS can provide comments, findings, and recommendations on this.

Dr. Melnick said that the more immediate threat is the loss of people. He would try to save as much as he could in FY14 in order to extend employment as long as possible and determine whether future partners could be found. Dr. Hertz said that APS could discuss this. The amount spent on salaries is large, about 75 percent of the SOFIA budget. The plan for FY14 is to not fly for 4 months in order to do heavy maintenance. Dr. Gaudi wondered how many people could be lost before the capacity for continuity is also lost. Dr. Bregman suggested identifying the core group. Dr. Hertz added that of the approximately 200 people involved in the mission, about two-thirds are contractors.

Dr. Sembach advised identifying the key scientists or operations staff, and asked if there might be classes of people who could be reconstituted later. Dr. Young of USRA said that that is the case, but noted that there are about 100 people with unique abilities. Dr. Sembach suggested that APS could safely state that there is unique expertise on this project, and that NASA should try to preserve that.

E/PO
Dr. DeVore reported that she spoke to the E/PO lead for SMD and learned that there will be a meeting to formulate a plan for the next year. The Global Learning and Observations to Benefit the Environment (GLOBE) initiative, which is primarily about ESD, will continue. She has seen no announcements from the Smithsonian. DoEd has its first ever call out on STEM education; it has a short timeline. She had previously determined that DoEd had no STEM office. Dr. Bregman observed that it is unclear how much should be done. He would like to see a way to explain how to go about defining what E/PO should be, then backing out how much APD should spend to enable articulation of a good case to NASA, Congress, and others. Dr. Hertz was not sure how useful it would be to direct this at APD only. It might be more useful for the NAC Science Committee to direct recommendations to SMD. For impact, the recommendation needs to link to CO_STEM reports and explain how SMD E/PO adds value. The focus should be on how to spend the FY15 funds wisely.

Dr. DeVore said that NASA must ensure that the E/PO experts remain at the Agency, as with SOFIA and its personnel. E/PO has a structure that may not be apparent; it is not simply conducted within each mission. Dr. Hertz said that the appropriation says that APD should keep doing E/PO, but Congress did not add money back. Dr. Ray asked about the extent to which the E/PO allocation would affect press releases. Dr. Hertz replied that public affairs is seprate from E/PO and should not be impacted. Dr. Sembach said that APS should have metrics to back up its statements. The American Astronomical Society (AAS) has compiled data on E/PO. He promised to send APS members the link, and encouraged them to look at the data.

ExoPAG Update
Dr. Gaudi began his discussion of recent activities within the Exoplanet Program Analysis Group (ExoPAG) by listing the membership of the executive committee. ExoPAG had a meeting in January and planned to have ExoPAG10 at the upcoming AAS meeting in Boston. He then noted the current science analysis groups (SAGs) and their status:

- SAG4: Planetary Measurements Needed for Exoplanet Characterization – Draft report completed.
- SAG8: Requirements and Limits of Future Precision Radial Velocity Measurements – Report started, final report by end of year.
- SAG9: Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics – Scope revised, final report by end of the year.
- SAG10: Characterizing the Climate of Transiting Planets with JWST and Beyond – Outline of report started, final report by end of the year, title change from “climate” to “atmospheres” as approved by APS at the last meeting.
- SAG11: Preparing for the WFIRST Microlensing Survey – Report started, finished in spring 2014.

SAG10 hopes to identify the measurements needed for JWST, along with the time required to take them. The ExoPAG9 meeting was very successful. Most of the talks are available online at http://exep.jpl.nasa.gov/exopag/exopag9/agenda/ .

ExoPAG has learned a number of lessons since the last report:

- The continued investment in taking science from Kepler is worthwhile;
- The telescope time needed for precision RVs to support NASA missions will far exceed available resources;
- In looking at the frequency of habitable planets, investigators should specify distribution functions or agree on a definition;

- There is a need to identify overlap of RV surveys and ground-based direct imaging, as it is far from clear what fraction of the targets will or have been discovered through RV;
- Investigators must identify what is needed to characterize exoplanets and whether or not JWST can characterize habitable planets; and,
- The science community should identify the future roles of astrometry and interferometry.

At the last meeting, Dr. Gaudi mentioned an idea for a new science interest group (SIG) that would be address a near-term exoplanet community plan. The goal of the proposed SIG is to start developing a plan for exoplanet exploration, especially where NASA can contribute. The SIG will collect community input on priorities for the study of exoplanets, an effort that will provide input into future planning activities to present a more coherent picture when the development of the next DS begins. This is deliberately open-ended to allow members of the community to present ideas as they see fit. The hope is that the community will then be less fragmented when providing input for the next DS. The previous APS discussion advised ExoPAG to formalize the SIG.

Dr. Nousek thought that the charter was closer to that of a SAG, which develops reports. A SIG reflects ongoing interest. He advised coming up with a clear definition. Dr. Gaudi said that there may not be enough consensus for a report, but the goal is to move in that direction. The intent is to prepare for the next DS and identify missions and concrete examples of how to answer the science questions. APS had previously suggested calling it a SIG. Dr. Oswalt proposed stating that this is ExoPAG's main priority. Dr. Gaudi replied that creating a SIG will draw attention to the activity. It is preparation for more formal strategic planning activities.

APS chair, Dr. Bradley Peterson, who was participating by phone, called a vote to approve the SIG. All APS members approved it with the exception of Dr. Nousek, who voted against it.

PhysPAG Update

Dr. Nousek, chair of the Physics of the Cosmos Program Analysis Group (PhysPAG), noted that Dr. Bock would become the PAG's chair in 2015. There are great expectations in this area, in that three new missions, LISA, IXO, and inflation probes, and the part of WFIRST that deals with dark energy science, called out in "New Worlds New Horizons", fall within the PCOS area.

At the January AAS meeting PhysPAG has held parallel sessions with ExoPAG and the Cosmic Origins Program Analysis Group (CoPAG). The PhysPAG met on Sunday, January 5 with morning parallel sessions of three SIGs (X-rays, Gamma-rays, and Inflationary Probe) and an afternoon plenary session, which was very well attended. Dr. Kouveliotou noted that the PAGs meetings are held during the AAS executive sessions preventing some from attending, and asked if these meetings can be held during the week or after the AAS meeting itself. Dr. Nousek remarked that attendance can be affected by the fact that many people are unwilling to take another day off from work. Dr. Bock added that it is very hard for this group to get everyone together, because of the different areas of interest in the PhysPAG which call for specialized meetings outside the AAS.

Dr. Nousek reviewed some of the SIG activities. In light of the recent possible detection of B-mode polarization from the ground, the Inflation Probe SIG (IPSIG) has an opportunity to reassess the case for space missions. The Gamma-SIG, dedicated to gamma rays, is preparing a white paper. The X-Ray SIG (XRSIG) will have an informal planning meeting at the June AAS meeting in Boston, will meet again at the High Energy Astrophysics Division (HEAD) meeting in August to discuss a longer-term plan for X-ray astrophysics . The Cosmic Ray SIG (CosmicSIG) is gathering input for a similar assessment. The Gravitational Wave SIG (GWSIG) is concerned that NASA is not investing sufficient resources to

optimize the outcome of the LISA Pathfinder, and feels this is an opportunity that the United States should not miss. The GWSIG hopes that the successful launch of the Pathfinder in 2015 will provide the impetus to do a new gravitational wave mission.

COPAG Update

Dr. Sembach began his COPAG update by listing the members of the executive committee. Recent COPAG activities include the establishment of three new SAGs, as approved by APS in 2013:

- SAG 6: cosmic origins science enabled by the WFIRST-AFTA coronagraph.
- SAG 7: cosmic origins science enabled by overlap between HST and JWST, to identify any compelling science that requires both observatories operating simultaneously.
- SAG 8: the possibilities for cosmic origins science enabled by the WFIRST-AFTA data archive.

All three are well underway and planning meetings at AAS and over the summer, with final reports to be presented to APS in the fall.

COPAG also established SIG 1, which was approved by APS at the previous meeting and addresses long-term objectives in far-infrared cosmic origins science and technology development. SIG 1 met prior to the January AAS meeting and will begin in earnest in May.

COPAG and the SAGs and SIG will meet with the science community at the June AAS in Boston, and a joint session with ExoPAG will occur if possible. The group is considering creating a series of informational webinars and would like to expose the community to various opportunities that might not be well-known. NASA has approved a May workshop, to be held at Goddard Space Flight Center (GSFC) called "Bringing Fundamental Astrophysical Processes into Focus." Finally, COPAG would like APS to accept the report from SAG 4, Technologies for a Future Far-Infrared Mission, and formally close that SAG. If there is any future activity related to the topic, COPAG will either reconstitute SAG4 or establish a new SAG with a focused product.

Dr. Gaudi proposed accepting the report and leaving SAG 4 open. The APS vote to do so was unanimous. Dr. Sembach concluded by noting that SAG 5 is still open and has done no work since 2012. The plan is to get the report written and close the SAG.

R&A Update

Dr. Linda Sparke, Research Program Manager, began her update on the R&A program by discussing the budget, which has been essentially flat since a ~10% increase in FY12. The FY14 pie chart denoting distribution is similar to the FY13 pie chart. Success rates are lower than in the past, and no new Roman Technology Fellowships were competed in FY14 due to funding. The R&A program is expected to grow slightly with the FY15 budget request. The number of proposals has grown faster than the funding, however. From 2006 to 2013, funding went up 25 percent, but the number of submitted proposals roughly doubled. The funding per proposal award is essentially steady when averaged.

A graphic of the ROSES competition selection rates provided more detail. APD has been meeting its notification targets, although some programs, such as the Strategic Astrophysics Technology (SATs) take as long as 180 days because they are complicated. An analysis of 2013 ROSES selections by rating showed that of those scoring Very Good or better, 39 percent were selected.

In tracking publications from ROSES awards, the program found that about one-third of those acknowledging an Astrophysics Theory Program (ATP) award are published more than 4 years after the award is given, and hence would not have been included in the final report. Ten percent of awardees did

not include the grant or proposal number in any publication. APD must have this information to track the awards and show their value. It is also a requirement of most awards.

Dr. Stapelfeldt noted that there has been concern regarding PSD's reorganization of its R&A program. He wondered if APD had made any changes to the joint APD-PSD exoplanet program. Dr. Sparke said that this was not the case, except that the first step of the two-step submission is a requirement. Permission from the program officer is required to change the principal investigator (PI) and co-investigator (co-I), after the first step. If a proposal is submitted to the wrong program under Step 1, it will be moved to the right program. Dr. Melnick said that the increased demand on the grants program has led to tension in the community about where to go for funding to support research. Extended missions cannot be as generous to guest investigators as they once were. In its letter, APS planned to discuss what the members consider a healthy nominal program in APD. He hoped that Dr. Sparke's numbers would be the baseline for establishing a healthy grants program. It would be good to see the percentage of proposals accepted increase.

Dr. Gaudi said that there is a need to discover the reason behind the increase in proposal dubmissions. He was not sure that increasing R&A funding is the answer, and the community might need to adjust. Regardless, APS should analyze the make-up of a healthy community and healthy program. Dr. Sembach pointed out that some strong proposals are not being funded. The field is producing more PhDs than in the past, and more are leaving the field due to funding issues.

Dr. Melnick said that missions that have received very high marks in senior reviews have had to decrease their operating budgets; less funding for guest observers may have increased proposal pressure in the R&A programs Dr. Gaudi replied that not all contributing factors are known. Dr. Melnick suggested that Senior Review panels ask each mission whether they are granting sufficient funds to approved programs to allow the data to be reduced, analyzed, and published. Dr. Oswalt asked about the number of co-investigators who submit multiple proposals to the same program. Dr. Sparke said that it is hard to track personnel on multiple proposals, but NSF has found that about 10 percent were involved in multiple submissions, and it seems to be the same in APD.

Balloon Update

Dr. W. Vernon Jones, Senior Scientist for Suborbital Research, described the latest activities in the balloon program. He began by discussing the tracks of a super pressure balloon and a zero pressure balloon, both of which flew in the Antarctic in FY13. The FY14 balloon campaign was cancelled due to the Federal shutdown. NASA conducts 10 to 15 balloon missions per year in a variety of locations, including New Mexico, Texas, Sweden, Australia, and Antarctica. New Zealand is about to be added to the list. Before taking a payload out of the country, SMD does integration and testing in Texas. Antarctica is the centerpiece of the NASA balloon program. NASA has flown 44 flights there since1991.

The shutdown eliminated the FY14 campaign in Antarctica, and those missions are off the schedule for now. In FY15, the candidate missions are the Antarctic Impulsive Transient Antenna (ANITA), the Large Angular Scale Millimeter-wave Polarimeter, and the Compton Spectrometer and Imager on the Super-Pressure Balloon (SPB). The SPB will fly a major payload in over the Southern Ocean. NASA cannot recover a payload that goes out over water, so the PI has to be willing to lose the payload. The FY16 campaign is undetermined and may include a mission that had been planned for FY14.

The Super Trans-Iron Galactic Element Recorder (Super-TIGER) flight was inverted in the Antarctic ice and has not been recovered. NASA now has a mix of short duration and long duration balloons, the Agency is trying to move to more SPBs for more ultra-long duration balloons. Funds are available for a new building in Antarctica. The overall flight rate is down; the DS recommended more.

JWST Update

Dr. Eric Smith presented an update on the status of JWST. At this point, the mission has 13 months of schedule reserve, reflecting that the project has used almost none of the reserve from the 2012 replan. However, that may soon change due to upcoming tests, especially in regard to the Optical Telescope and ISIM (OTIS) test.

The spacecraft critical design review (CDR) was passed in January, and is the last major design review. More than 97 percent of the observatory by mass is now built, in fabrication, or ready for fabrication, including the sunshield. All five layers of the engineering model sunshield have been completed; these are being used to test folding and deployment.

JWST has reached a major milestone with the science instruments, as all were mounted on the Integrated Science Instrument Module (ISIM) as of March 25. All except for the Mid-Infrared Instrument (MIRI) must come back out after cryo-vacuum testing. The Fine Guidance Sensor (FGS) and the Near InfraRed Spectrograph (NIRSpec) will have new components added. New detectors are already on the Near Infrared Camera (NIRCam), a task that was completed 9 months ahead of schedule. A new NIRSpec Focal Plane Array (FPA) has been delivered to GSFC, and two of four new detectors have been selected for the FGS Near InfraRed Imager and Slitless Spectrograph (NIRISS).

In ISIM testing, the next major event is the summer-long cryo-vac (CV) testing. The team will insert the replacement parts after that point, and will conduct the final CV test in 2015. The telescope optics have been delivered, and the team will assemble them in 2015. The mirrors will sit on the backplane, with a large cage underneath to hold ISIM. The strength tests are going as planned for the flight backplane centersection and backplane support fixture.. The center section pathfinder will test the assembly of mirrors and ground support equipment. OTIS ground support and procedure testing will begin in early 2015 at Johnson Space Center (JSC). For this, NASA had to build a clean room sub-building, which can be re-used in the future for other missions.

The program tracks performance by using milestones, some of which will be complete late, are forecast to be completed late, or deferred. Some just move from September to October, which creates a shift in the fiscal year. This year, the deferrals are related to the MIRI cryo-cooler. Other delays are associated with the government shutdown.

Dr. Smith presented the program watch list, which includes the following:

- Low FY14 unencumbered unallocated future expenses (UFE), which is the reserve and which will probably be retired soon from the watch list.
- The MIRI cryo-cooler has had schedule, technical, and cost problems all along. Testing continues.
- Other issues include the ¾-inch nonexplosive actuator, the star tracker assembly, and the spacecraft radiator. Four actuator bolts generated too much shock, but the new design appears to work. There is also a new design to address star tracker instability. The radiator prevents the sunshield from heating the spacecraft; the first design was too complicated and had too much potential for issues.
- Mid-infrared stray light.
- Resolution of the FGS-ISIM communications issue. During ISM tests, there were occasional communications fall-outs. This is a Canadian piece and completion of that work is subject to that country's funding which at present appears to be sufficient.

This year, the peak year for funding, the team will focus on manufacturing and construction. The team is deep into integration and testing (I&T) activities, and technical progress is good. The unfurling of the sunshade will watchable only via telemetry, as it will occur beyond Earth view. The primary mirror segment closest to the spacecraft bus will operate at around 50 K, while the upper-most mirror will have temperatures between 30 and 40 K. Part of the observing program challenge is to have minimal skewing that changes the temperature profile.

Everyone has done a great job of maintaining the schedule. Dr. Smith credited Congress for holding up their end of the replan deal; steady funding makes a difference. Installation of the NIRSpec and NIRCam into ISIM went in fast, and replacement parts are rather straightforward to include after the cryo-vacuum testing this summer. MIRI needs some new electronics. New detectors are no more problematic than usual. His concern is the Canadian part, because the Canadian Space Agency has implied there will be no additional funds after the augmentation they recently received. Thus it is important that their replacement of FGS/NIRISS components go as planned.

Public Comment Period

No members of the public came forward when Dr. Gaudi announced the public comment period.

Discussion

Dr. DeVore said that if APS wanted to ask the NAC Science Committee to create a task force on E/PO, they should work with Stephanie Stockman and the division contacts within SMD. There is a structure and a leadership for E/PO within the Directorate. Dr. Gaudi said that APS was recommending that the Science Committee create a task force. Drs. Peterson and DeVore agreed to write the recommendation.

Dr. Gaudi then raised the issue of what constitutes a balanced program in APD. This was related to the findings of the NRC study report on WFIRST, but APS wanted to make the point independently. It goes beyond funding to address timing. Dr. Melnick questioned whether APS had the metrics necessary to take on this issue. He would add that meaningful participation in international collaboration opportunities should be covered by the budget. Since time is the functional reserve for this, it is important that WFIRST not take up most of the next decade and preclude 2020 DS recommendations from moving forward. If WFIRST launches in 2024, APD would be able to address the 2020 DS recommendations.

Dr. Harrison pointed out that when the DS was written, there was a sense that the program was out of balance. Dr. Nousek asked to make a distinction. At time of the last two decadal surveys, both estimated the available funding and divided it in a balanced way. Dr. Hertz now talks about rate of spending instead of a balance among programs. It is not possible to fly flagship missions as fast as the DS recommended, which pushes some science back and does not allow additional opportunities. Dr. Harrison agreed. Stretching things out is not optimal and often not practical.

Dr. Gaudi observed that they were saying they agreed that the cost of WFIRST should be watched very carefully in order to keep the low-risk, low-cost balance the DS envisioned. Dr. Nousek wanted to make the program balance clearer, noting that Dr. Hertz interprets balance in terms of year-by-year spending. Dr. Melnick said that if spending on a program is capped, there is a risk that it could result in an increased cost over time. He agreed with the NRC study report, but wanted to raise the issue of whether a balanced program has been fully defined and to reiterate the APS view of a balanced program. Using the time axis as reserve is not something anyone is eager to see happen if it precludes APD from acting on the 2020 DS. He wanted to explicitly state that both schedule and cost were concerns.

Dr. Harrison said that it is important to plan appropriately with sufficient reserves, and rescope if necessary. Dr. Dalcanton agreed, but noted that it is possible to set too firm a line with the new accounting method. Sometimes it really is necessary to "rob Peter to pay Paul" over the short term, which is what Dr. Hertz is doing. Cancelling SOFIA was the alternative to cutting everything else in some way.

Dr. Melnick said that they have seen and lived with the effects of a project that has exceeded its boundaries, and they do not want to see it happen again. Therefore, they are reiterating their support for a balanced program and for doing WFIRST in a timely fashion. Dr. Gaudi suggested that APS state that it commends the NRC study committee for an excellent report, strongly endorses the conclusions, and wants to support a balanced program.

Dr. Melnick added that he was surprised to hear Dr. Gehrels say that the decision to operate WFIRST at 240 versus 278 K was to be based on subsample testing. Dr. Gaudi replied that he had received an email saying that the team will start that way and either fully test at some point or run it warm.

Dr. Gaudi suggested a study on proposal pressure. Several members noted that this had been done by the DS, AAS, and others. Dr. Hertz asked if the issue was the status quo. If so, he would like suggestions for change. Dr. Oswalt stated that a colleague compared psychology and astronomy, finding that it is not worth writing a proposal when the acceptance rate is below 18 percent. APD is close to that. Dr. Melnick said that as JWST ramps down and WFIRST funding increases, APD has an opportunity to increase R&A funding and select more proposals. The question is whether to assume that the current level is the baseline, borderline unhealthy, or something else.

In discussing how to address the hypothetical increase in R&A funding that Dr. Melnick described, Dr. Dalcanton said that when the National Institutes of Health (NIH) had a large funding increase, then returned to much lower funding levels, it was catastrophic. Dr. Hertz added that it is less about the money and more about what a situation like that would do to the community. Dr. Nousek explained that NSF put stimulus money into grants, which resulted in investigators being kept on for 2 years, at which point they had no funding. Dr. Gaudi said that it is important not to make things worse. Dr. Bregman noted that there is also the buy-out of faculty that occurs at some institutions, in which faculty receiving 40 percent or more of their salaries through NASA are not obligated to teach. Dr. Sembach held that since NASA is investing $8 billion into JWST, more funds should go to the Guest Observer and archival programs. Data show that archival data are good for years, even decades, which could happen with JWST, which he described as a "data machine." Dr. Stapelfeldt suggested that APD give APS a presentation on all of the community funding, not just R&A.

Dr. Hertz provided additional charts showing the President's FY15 budget proposal for APD, as well as current year funding for missions in senior review (except for HST and Chandra), the extended mission budget, and the Mission Operations and Data Analysis (MO&DA) budget. He then reviewed some of the issues for various mission, including the revised Kepler (K2). Whether or not K2 is funded, the Kepler team will receive support for completing analysis of prime mission data. Dr. Hertz removed funds from all programs for future strategic mission lines in order to study WFIRST. None of the DS priorities are in cosmic origins, while exoplanets are a priority. The APD budget is projected to go up in FY17. However, JWST must launch on time. If it does not, Congress could cancel it. Congress has capped JWST at $8 billion for development and $800 million for 5 years of operations.

Discussion with Astrophysics Division Director

Dr. Gaudi said he would draft the letter and run portions by interested individuals before sending it to the entire Subcommittee. Dr. DeVore would draft the E/PO statement. He would also write the endorsement of the CAA study of WFIRST-AFTA and bring up the issue of a balanced program. There were no

recommendations on proposal pressure beyond Dr. Hertz making a presentation on the history of APD support for the community, which was to be about science support, not instrument support. Dr. Gaudi said that Drs. Melnick and Kouveliotou would prepare the statement on SOFIA. Dr. Gaudi committed to sending the materials to the members within a couple of days, and asked for a quick response.

Adjourn

The meeting was adjourned at 2:57 p.m.

Appendix A
Attendees

Subcommittee members
B. Scott Gaudi, Ohio State University, *Vice-Chair, Astrophysics Subcommittee*
Hashima Hasan, NASA, *Executive Secretary*
James Bock, Jet Propulsion Laboratory
Joel Bregman, University of Michigan
Julianne Dalcanton, University of Washington
Edna DeVore, SETI Institute
Giovanni Fazio, Harvard Smithsonian Center for Astrophysics
Gabriela Gonzalez, Louisiana State University
Fiona Harrison, Caltech (via phone)
Chryssa Kouveliotou, Marshall Space Flight Center
Gary Melnick, Harvard University Center for Astrophysics
John Nousek, Pennsylvania State University
Terry Oswalt, Embry-Riddle Aeronautical University
Bradley Peterson, Ohio State University (via phone)
Paul Ray, Naval Research Laboratory
Karl Stapelfeldt, Goddard Space Flight Center

NASA attendees
Paul Hertz, NASA HQ, *Director, Astrophysics Division*
Dominic Benford, NASA HQ
Joan Centrella, NASA GSFC
Jens Feeley, NASA HQ
Mike Garcia, NASA HQ
Neil Gehrels, NASA GSFC
W. Vernon Jones, NASA HQ
Julie McEnery, NASA GSFC
Rita Sambruna, NASA HQ
Wilton Sanders, NASA HQ
Amber Straughn, NASA HQ
Eric Tollestrup, NASA HQ
Dan Woods, NASA HQ

Non-NASA Attendees
B. G. Anderson, USRA
Francesco Bordi, Aerospace
Dominick Conte, Millennium Space Systems
Debra Emmons, Aerospace
Robert D. Gehrz, University of Minnesota
Jason Kalirai, STScI
William B. Latter, USRA
James Lochner, USRA
Elizabeth Sheley, Zantech
Erick Young, USRA

Webex
Barbara Adde, NASA HQ
Mansoor Ahmed, GSFC
Louis Barbier, NASA HQ
Natalie Batalha, NASA Ames
Eric Becklin, USRA
Dominic Bensord, NASA HQ
Michael Bicay, NASA Ames
Gary Blackwood, NASA JPL
Jeff Booth, NASA JPL
Carol Christian, STScI
Stephen Clark, Space Flight Now
Dominick Conte, Millennium
Casey Dreier, Planetary Society
Debbie Fairbrother, NASA WFF
Michael Garcia, NASA HQ
Jessica Glover, NASA HQ
Thomas Griffin, NASA GSFC
Lewis Groswald, National Academy of Sciences
Sara Heap, NASA GSFC
Ingolf Heinrichsen, NASA JPL
Cuong Huynh, NASA HQ
Ann Hornschemeier, NASA GSFC
Brooke Hsu, LPI
Hussein Jirdeh, STScI
Jason Kalirai, STScI
Louis Kaluzienski, NASA HQ
Jennifer Kearns, NASA HQ
Robert Kellogg, Aerospace Corp.
Irene Kloutz, Space News
David Lang, National Academies of Science
Leah Lapiana, NASA HQ
Peter Lawson, JPL
Dan Leone, Space News
Daniel Lester, University of Texas
James Lochner, USRA
Keith MacGregor, NASA HQ
Pamela Marcum, NASA Ames
Mario Perez, NASA HQ
Randy Persinger, Aerospace Corp.
Robert Petre, NASA GSFC
Larry Petro, NASA HQ
Marc Postman, STScI
Bill Reach, USRA
Aki Roberge, NASA GSFC
Wilton Sanders, NASA HQ
Paul Schechter, MIT
Nick Seigler, NASA JPL
Denise Smith, STScI
Eric Smith, NASA HQ
Marcia Smith, spacepolicyonline.com

David Spergel, Princeton University
Robin Stebbins, NASA GSFC
Timothy Tawney, NASA HQ
Pasquale Temi, NASA ARC
Stephen Unwin, NASA JPL
Michael Warner, NASA JPL
Debra Werner, Space News
Alexander Witze, Nature Magazine
Hans Zinnecker, USRA

Telecon (presentation and associated discussion)
Arvind Parmar (ESA)

Appendix B
NAC Astrophysics Subcommittee Members

Bradley Peterson, Chair
Department of Astronomy
Ohio State University

Hashima Hasan, Executive Secretary
Astrophysics Division
Science Mission Directorate
NASA Headquarters

Gary M. Bernstein
Professor of Physics and Astronomy
University of Pennsylvania

James J. Bock
Jet Propulsion Laboratory

Joel Bregman
Department of Astronomy
University of Michigan

Julianne Dalcanton
Professor of Astronomy
University of Washington

Edna DeVore
Director of Education and Outreach; Deputy CEO
SETI Institute

Giovanni Fazio
Harvard Smithsonian Center for Astrophysics

B. Scott Gaudi
Department of Astronomy
Ohio State University

Gabriela Gonzalez
Professor, Physics and Astronomy
Louisiana State University

Fiona Harrison
Professor, Physics and Astronomy
CalTech

Chryssa Kouveliotou
Marshall Space Flight Center

Gary Melnick
Senior Astronomer
Harvard University

John A. Nousek
Professor of Astronomy & Astrophysics
Pennsylvania State University

Terry Oswalt
Chair, Department of Physical Sciences
Embry-Riddle Aeronautical University

Paul S. Ray
Naval Research Laboratory

Kenneth Sembach
Space Telescope Science Institute

Karl Stapelfeldt
Goddard Space Flight Center

Appendix C
Presentations

1. *Astrophysics Division Update*, Paul Hertz
2. *NASA APD's Ongoing Missions*, Paul Hertz
3. *WFIRST AFTA SDT Interim Report*, Neil Gehrels/David Spergel
4. *Probe Class Starshade Mission: STDT Progress Report*, Sara Seager
5. *Interim Study Report: Exoplanet Direct Imaging: Coronagraph Probe Mission Study*, Karl Stapelfeldt
6. *Evaluation of the Implementation of WFIRST/AFTA in the Context of New Worlds, New Horizons in Astronomy and Astrophysics*, Fiona Harrison
7. *Cosmic Vision*, Arvind Parmar
8. *Explorer Update*, Wilton Sanders
9. *ExoPAG Report*, Scott Gaudi
10. *Physics of the Cosmos Program Analysis Group: Status Report*, John Nousek
11. *Cosmic Origins Program Analysis Group*, Kenneth Sembach
12. *Astrophysics Research Programs*, Linda Sparke
13. *Balloon Program Update*, W. Vernon Jones
14. *James Webb Space Telescope*, Eric Smith

Appendix D
Agenda

Astrophysics Subcommittee meeting
March 26-27, 2014

AGENDA

Wednesday, March 26, 2014

9:00 a.m.	Introductions and Announcements	Scott Gaudi
9:10 a.m.	Astrophysics Division Update	Paul Hertz
10:00 a.m.	Discussion	APS members
10:45 a.m.	Coffee Break	
11:00 a.m.	Discussion with SMD AA	John Grunsfeld
12:00 noon	Working Lunch – Discussion with Astrophysics Division Director	Paul Hertz
1:00 p.m.	Overview of context for NASA APD's Ongoing Mission Studies	Paul Hertz
1:15 p.m.	WFIRST AFTA SDT Interim Report	Spergel/Gehrels
2:00 p.m.	EXO-S SDT Interim Report	Sara Seager
2:30 p.m.	EXO-C SDT Interim Report	Karl Stapelfeldt
3:00 p.m.	Public Comment Period	
3:15 p.m.	Break	
3:30 p.m.	Report on CAA WFIRST/AFTA Study	Fiona Harrison
4:00 p.m.	Discussion	APS members
4:45 p.m.	Wrap up for Day 1	Scott Gaudi
5:00 p.m.	Adjourn Day 1	

Thursday, March 27, 2014

9:00 a.m.	Re-cap of Day 1	Scott Gaudi
9:30 a.m.	ESA Cosmic Visions Update	Arvind Parmar
10:00 a.m.	Explorer Update	Wilton Sanders
10:15 a.m.	Discussion with Astrophysics Division	Paul Hertz APS members
10:35 a.m.	Break	
10:45 a.m.	ExoPAG Update	Scott Gaudi
11:00 a.m.	PhysPAG Update	John Nousek
11:15 a.m.	COPAG Update	Ken Sembach
11:30 a.m.	R&A Update	Linda Sparke
11:50 a.m.	Balloon Update	Vernon Jones
12:05 noon	Lunch	
1:00 p.m.	JWST Update	Eric Smith
1:30 p.m.	Public Comment Period	
1:45 p.m.	Discussion	APS members
2:15 p.m.	Break	
2:30 p.m.	Discussion with Astrophysics Division Director	Paul Hertz
3:15 p.m.	Wrap-up, Recommendations, Actions	Scott Gaudi
3:30 p.m.	Brief to Division Director	Scott Gaudi
4:00 p.m.	Adjourn	