NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

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MEETING MINUTES

September 2, 2016

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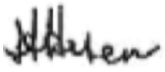
B. Scott Gaudi, Chair



September 2, 2016

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Hashima Hasan, Executive Secretary

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Ingenicomm

Wednesday 20 July

Introduction and Announcements

Dr. Hashima Hasan, Executive Secretary of the Astrophysics Subcommittee (APS) of the NASA Advisory Council (NAC), opened the meeting by welcoming the Subcommittee members. She noted that a few APS members had conflicts of interest with specific topics on the agenda. During those presentations, the conflicted members would be allowed to listen to the presentation, but they would then be required to leave the table during the discussion.

Dr. Scott Gaudi, APS Chair, reviewed the Federal Advisory Committee Act (FACA) rules. Under these rules, the meeting was open to the public and all statements would be public. Only public discussions during the meeting would form the basis for recommendations to NASA. Non-members were allowed to speak only when recognized by the Chair. The meeting schedule included two public comment periods.

Finally, Dr. Gaudi introduced three new APS members: Drs. Asantha Cooray, Debra Fischer, and Feryal Ozel. In addition, this was the first meeting that Dr. Beth Willman was able to attend in person. Dr. Paul Scowen was participating via teleconference.

Astrophysics Division Update

Dr. Hertz said that the Astrophysics Division (APD) sought APS comments and recommendations on a number of matters, and some of the resulting discussion was likely to extend to the October meeting. He reported that Dr. John Grunsfeld recently retired as Associate Administrator (AA) of NASA's Science Mission Directorate (SMD). The Acting AA is Mr. Geoff Yoder, who has held a number of significant positions within SMD, including Deputy AA. In addition, Dr. Marc Allen retired from NASA, Dr. Jeffrey Newmark is SMD's new Deputy AA for Research, and two new deputy division directors have been appointed.

APD works from a number of driving documents. The next of these to be updated will be an implementation plan that responds to the mid-Decadal Survey (mid-DS) report. APD is also planning for the 2020 DS. The mid-DS report is due within a matter of weeks.

Science Highlights

Dr. Hertz next reviewed recent science highlights. These include a refinement of the Hubble constant, which employed the Hubble Space Telescope (HST), the Chandra mission, and other sources to measure dark matter distribution. Chandra X-ray data and ground-based data were the basis of a study of young stars in a stellar cluster, which should help elucidate expectations for smaller stars. A combination of data from the Spitzer mission and ground-based sources measured a protoplanetary disk inner gap.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) found that most of the water vapor in the young star, AFGL 2591, is in the outflow material of the star. Transit data from the Kepler 2 (K2) mission were used for a probabilistic analysis to validate candidate exoplanets by category. Finally, an HST image of the dwarf planet Makemake showed a satellite. Brief discussion among APS members indicated that the existence of a satellite to Makemake, while not entirely unexpected, was still important for establishing the occurrence rate of companions to large Trans-Neptunian Objects.

APS Structure

NASA is proposing to charter the four SMD subcommittees, of which APS is one, to become stand-alone FACA committees. The resulting committees would advise the appropriate division directors and operate under a charter rather than the current terms of reference. Should the NASA Administrator approve this change, the proposal will go to the General Services Administration (GSA), then on to Congress.

This change will provide a home for community-based studies like Senior Reviews, science definition teams (SDTs), etc. APS will become the Astrophysics Advisory Council (APAC). While APAC will no longer report through the NAC Science Committee, the APAC chair will have a seat on the Science Committee. All current APS members will move over to the new committee, and the meetings and workload will be the same. A difference is that APAC will send its meeting report to the APD Director instead of to the Science Committee.

Once APAC is chartered, Dr. Hertz can establish the Program Analysis Groups (PAGs) as subordinate groups. This will not change the way the PAGs operate unless APAC makes a recommendation to do so. The PAGs will not operate in an advisory capacity, because in order to do so, they would need to have a defined membership and essentially operate as a subcommittee. Dr. Hertz added that this is a proposal, and he was not sure how fast the change will occur. It was possible that it could be before the next meeting, but he saw that as unlikely.

APD Overview

The President's Budget Request (PBR) for Fiscal Year 2017 (FY17) continues to support APD. The Congressional committees have gone through the mark-up exercise but not the reconciliation. There is no risk to the basic program budget of $1.35 billion, which includes full funding for the James Webb Space Telescope (JWST). The budget also includes funds for Wide Field Infra-Red Survey Telescope (WFIRST) formulation, the Research and Analysis (R&A) activities, and the SMD science, technology, engineering, and math (STEM) education activities.

The operating missions continue to generate important science results, and new missions are under development for the future. APS was to receive a full R&A update at this meeting, which would include proposed changes to the funding of named fellowships. Dr. Hertz sought an APS response at the October meeting, and noted that the Subcommittee could establish a working group if needed.

The draft Announcement of Opportunity (AO) for the mid-sized Explorer (MIDEX) went out on July 14, and APD was about to release a draft Second Stand-Alone Mission of Opportunity Notice (SALMON-2) Appendix for an Explorer Mission of Opportunity (MoO). The MoO identifies some launch opportunities for small payloads for a $20 million charge to a principal investigator (PI)-managed mission cost. The SMEX and MoO down-selection from 2015 is ongoing.

APS was also to hear a presentation on the recent Senior Review, which had three panels. HST and Chandra each had their own panels, while the main panel addressed Fermi, K2, Nuclear Spectroscopic Telescope Array (NuSTAR), Spitzer, Swift, and XMM-Newton. The Senior Review found all of these missions worthy of continuation from a science perspective, with the following ranking: Swift, K2, NuSTAR, XMM, Fermi, and Spitzer. APD has found a way to extend all of them, though that involved some replanning of the FY17 and FY18 budgets. Fermi and Spitzer were given reduced budgets that will necessitate changes, and the Senior Review approved end-of-mission plans for K2 and Spitzer. K2 will operate until it runs out of fuel, which is expected to occur in FY19, and Spitzer operations will cease once JWST is commissioned. Dr. Hertz was not at liberty to explain the APD budget readjustments that would allow all of these missions to continue; those changes will become public once the NASA FY17 operating plan is accepted by Congress. .

In the Suborbital program, APD launched a super-pressure balloon (SPB) from New Zealand that circumnavigated the globe and eventually meandered out over the Pacific Ocean, which was great for the science. SPB payloads must be able to be lost, since recovery cannot be guaranteed, but this one was brought down in Peru which allows recovery of the payload and for the balloon itself to be examined from an engineering perspective. APD now plans to do a New Zealand SPB launch every year.

The European Space Agency's (ESA's) Laser Interferometer Space Antenna (LISA) Pathfinder launched in February with NASA's Disturbance Reduction System (DRS) aboard, and the DRS is in testing mode. There are a couple of anomalies with the DRS that are being worked around, but plans are to restart DRS commissioning soon. NASA will receive an additional month of DRS operation time. The LISA Pathfinder mission tests half of the technology that will be needed for a full LISA system.

SOFIA is in New Zealand, where an engine crack has been addressed through an engine swap. Some of the lost time has been made up. SOFIA is the world's largest airborne observatory. Some German instruments are going through commissioning, and concept studies have come in for the third-generation U.S. instrument.

The Neutron-star Interior Composition Explorer (NICER) has been tested and will go to the International Space Station (ISS) in February 2017. The Cosmic-Ray Energetics and Mass investigation (CREAM) is ready and will launch in June 2017. The Transiting Exoplanet Survey Satellite (TESS) is in the fabrication/integration phase, with the launch planned for December 2017. For JWST, everything is on schedule and the cost reserves are sufficient for a October 2018 launch; APS was to hear a complete presentation the next day. WFIRST is well into Phase A. The formulation science working group has been meeting and defining the wide-field instrument requirements. The notional launch of WFIRST is in the mid-2020s, though it is highly budget-dependent and could launch sooner if enough funds are appropriated.

NASA continues discussions with ESA about NASA's role in the Athena mission. Nothing has been agreed to at this point; however, U.S. scientists will be part of the instrument teams. This is the NASA response to the DS International X-ray Observatory (IXO) recommendation. NASA is deciding on its role and defining the possibilities, though the plan is to contribute hardware in the $100-150 million range, while also running a Guest Observer (GO) program and the U.S. data center. NASA hopes to partner at the same level on ESA's L3 mission, which is likely to be a gravitational wave observatory. A study team is determining what the U.S. contribution might be, and the study results will be posted upon completion of review.

Budget

Dr. Hertz next reviewed the budget, starting with the FY16 appropriation. APD submitted, and Congress has approved, changes due to the need to allocate a $36 million unspecified reduction relative to the FY17 request. Specific reallocations include $11 million that TESS does not need this year from the Explorer budget, and $7 million in reserves from Hitomi (formerly Astro-H). Spitzer had another $3 million in savings due to SMD support. That means that the greatest impact was a $3 million cut in R&A over a 2-year period, about 3 percent.

More specifically, portfolios must add up to a top line that is constantly changing. So every year, usually twice, APD replans the entire budget. There will be directed changes from Congress as well as changes the Division wants to make. That creates a situation in which reserves are held, then used if needed and otherwise made available to float. Regarding WFIRST, Congress told APD to move faster than the Division had planned, allocating some extra funds and directing APD to find the rest from elsewhere. APS can weigh in on Dr. Hertz's decisions once they are known publicly, though this would be guidance for the future.

Dr. Hertz explained that TESS has unspent reserves that may be needed in FY17 and FY18 but are not needed in FY16. R&A was the only remaining program with money that could be moved. He cannot change what Congress directs. Taxpayers and the DS affect Congress, which is why WFIRST is so well-funded. APD had established plans for a range of budget contingencies.

Early spending saves money, and an optimal profile for WFIRST would have more funding in FY17 and FY18, enabling an earlier launch and overall cost savings. NASA informs Congress of these implications, but each appropriation subcommittee of Congress itself has a cost cap for its appropriation. The FY16 appropriation and the FY17 request are good budgets with a large total funding being applied to Decadal Survey priorities. The minor impacts are manageable.

Dr. Hertz presented some of the details of the FY17 PBR, along with the Congressional mark-ups. The Congressional schedule makes it unlikely that a budget will be in place by the beginning of FY17, but APD programs and projects will not be negatively impacted by a Continuing Resolution (CR). While both houses agree on JWST funding, there are tweaks and differences. The Senate wants a mirror technology project, for example, while the House wants APD to work on a starshade. However, all of the major players on the relevant committees are interested in science and space, and they are generally very knowledgeable, with a good layperson's understanding of the science. The starshade reflects an interest in exoplanets, while the mirror work would apply to large missions beyond JWST and WFIRST.

Mission Updates
NASA plans to operate HST until something breaks, though there will be no more servicing. SOFIA is envisioned as operating for a long time, but it will go to the Senior Review in 2018. Large mission studies are well under way in anticipation of the 2020 DS. APD is now planning studies for medium-sized missions, or probes, as recommended by the PAGs and APS. The next step is to solicit mission concept studies, for which the guidelines will include feasibility, costs, and scientific merit. Selected studies will have support from mission design labs, and there will be cost assessments by NASA. The studies will go to the DS panels. If the DS panels want more detail, APD will comply, though the timing is a question at this point. There will be cost and schedule analyses conducted for the four large flagship missions being proposed.

Dr. Hertz next discussed the situation with the Hitomi mission. Drs. James Bock and Debra Fischer recused themselves from this discussion. Dr. Hertz explained that NASA worked with the Japanese Space Agency (JAXA) to develop the Hitomi mission. The launch was successful, but a month into commissioning, there was an anomaly that led the mission to end. JAXA is finalizing the analysis of the anomaly, and Dr. Hertz thought JAXA did a good analysis. JAXA is proposing to rebuild Hitomi and has asked NASA to consider rebuilding its contributions as it was for the first mission (build-to-print). NASA is considering this, but Dr. Hertz wanted APS to discuss it and provide feedback.

The 2010 DS endorsed the capability, the community supports the technology, and there are many benefits to science from this mission. If NASA were to undertake the build-to-print project, the cost would be roughly $70-90 million over 4 to 5 years. He did not know whether the budget would go up to accommodate this; if not, that would be a consideration. However, the approximately $20 million per year over the build period is in the range of what he deals with every year. So the impact would be acceptable and unlikely to be noticed outside of NASA, as it would involve rephasing, a few funding profile changes, and launch dates shifts. There would be no funds coming from R&A or the upcoming AOs. It could create a slight change in the Small Explorer (SMEX) development schedule. But the plan would be to work with JAXA to address the issues and to improve all future JAXA/NASA collaborations. This will be done regardless of whether the build-to-print mission occurs. Should a rebuild go forward, the NASA portion will be directed to the Goddard Space Flight Center (GSFC) rather than being competed. The GO portion of the original mission would be fully realized. The next discussions with JAXA were scheduled for August.

Dr. Gaudi identified three main concerns: financial, which Dr. Hertz seemed to have under control; political; and risk. Dr. Gaudi thought it would require more oversight than JAXA would like. Dr. Hertz said that NASA would not oversee JAXA, but will discuss some NASA best practices that JAXA does

not yet have. JAXA approached NASA on this and sought the Agency's help. If this goes forward, there will be at least as much observing time for NASA, if not more. Dr. Gaudi expressed concern about the urgency of this issue.

R&A Update (including Postdoc Fellowships)

Dr. Linda Sparke, APD Research Program Manager, noted that a new requirement for Research Opportunities in Space and Earth Science (ROSES) is that proposals must have a plan for data management, or explain why there will not be data. Proposers to ROSES-2016 are also required to estimate and justify expected requirements for NASA-supplied High-End Computing (HEC). This will help APD to project its needs for high-performance computing and other resources. APD has asked prior HEC applicants to provide this information as well. Dr. Jeffrey Hayes of NASA explained that he is part of the high-performance computing group, and the Agency resources are very over-subscribed. This is a significant long-term issue despite the fact that it is being managed in the short term. The models are complex. Dr. Sparke added that there is a need for massive connectivity that cannot be rented commercially. A good estimate of need will be helpful, and she welcomed APS input.

All R&A selections in the past year were announced within 150 days of the proposal due date. APD's selection rate is about 22 percent for R&A and 28 percent for GOs. In FY15, the proposal numbers grew faster than the funding. There is a new focus among proposers on cubesats and suborbital class payloads.

Postdoctoral Fellowships

APD supports three named postdoctoral fellowship programs. The Einstein, Hubble and Sagan Postdoctoral Fellowships support roughly 100 Fellows at any time. In 2016, 35 fellows in their first year will receive a stipend of $67,500, with benefits, and $16,000 for research expenses. The fellowships are granted for 3 years, though not all recipients participate that long. Dr. Sparke explained the differences among the fellowships, noting that they are all highly prestigious and very competitive. About 200 scholars receive PhDs in astrophysics each year.

Since 1990, the total funding for these fellowships has doubled. Qualified individuals can apply multiple times, possibly receiving more than one fellowship, and the program is open to foreign applicants. The success rate is about 10 percent. APD wanted to rebalance support in the direction of fewer postdoc awards towards R&A opportunities because support for postdocs has increased faster than the R&A support over the past decade. Reducing the number of new fellowships by roughly 30 percent would achieve a corresponding 30 percent cost reduction within 3 years. The reduction would not affect current fellows.

Dr. Gaudi noted that Drs. James Bock, Yun Wang, and Jason Kalirai were recused from the discussion. Dr. Hertz explained that there are constraints on what can be done with the rebalancing, and APD had not worked through the implementation. The Division is concerned about the relative amount of spending on fellowships compared to R&A. Dr. Sparke explained that the stipend amount is based on a survey of comparable fellowship stipends by the Space Telescope Science Institute, which administers one of the fellowship programs.

Dr. Gaudi advised APS to focus on what else they might need to know in order to make the best informed decision. He wanted to know if this proposal would imply a rebalancing of the number of assigned fellowships vis-à-vis the subject area. He also wondered what fraction of the fellows end up doing second or third postdocs, or even leaving the field. Dr. Sparke said that it is possible to follow the fellows' careers for a time after the fellowships end, but not for their lifetimes. The National Science Foundation (NSF) follows applicants who just miss the cut for their comparable fellowship, and has learned that those individuals still succeed.

Dr. Rachel Somerville said that if the driver was the underfunding of R&A, this might not be the best way to handle it. She suspected that one of the big funding items in proposals is for postdocs. She wondered if there might be a need to increase graduate student funding instead. Dr. Gaudi said that it was not obvious to him that the fellowship program reduction would have a significant effect on R&A funding. In addition, there was no evidence found in the AAAC Proposal Pressure study that an overfunding of postdocs contributed to the low R&A selection rate. Dr. Dingus said that the Department of Energy (DOE) and NSF fund early-career professors who then fund postdocs who are more aligned with the funded proposal area. This helps get early-career professors their tenure. She wondered how much postdocs are funded through the proposals. Dr. Sparke said that while NSF tracks this, and finds that about 10% of the funding in the Astronomy and Astrophysics Research Grants program supports postdocs, NASA does not. If the fraction is similar to that at NSF, then 80 to 100 postdocs are funded through NASA R&A awards. It would require labor-intensive work to confirm this.

Dr. Ozel thought that this would be a minor adjustment to the major problem of underfunded R&A. Without a specific proposal, she did not feel that APS was in position to assess the impact. She also agreed that there was a need for more data on the relative success of fellowship recipients. Her own data on the Einstein Fellowships indicated that about 66 percent are in faculty positions. Dr. Gaudi said that this would increase R&A by 5 percent, and while the community is concerned that R&A funding is too low, the fellowships are very successful. A change would be risky.

Dr. Willman said that it was hard to weigh the pros and cons without an implementation plan. Dr. Gaudi agreed that APS needed more information. He also considered the Hubble stipends to be "shockingly high." He wondered if that might be a trade space that could be explored. Dr. Mark Devlin was concerned that the rebalancing would shift funds from a protected zone into an unprotected zone from which the APD director could move funds when addressing a shortfall. The funding change might not be good in the long term. Dr. Cooray noted that all of the university systems have postdoc scales, and they are not that high.

Dr. Hertz said that the DS recommended more funding of R&A. An inflation-corrected curve would reflect the 2010 DS level. Dr. Fischer pointed out that the Hubble and Sagan fellowships are driving up the postdoc costs at universities, setting the level, which the universities must then meet. She thought that fellowships should be limited to one per person and wondered if a more modest reduction might follow the lowering of stipends and salaries.

Dr. Scowen said that the target audience seems to be a small, well-performing group of people. Shifting funds would fund postdocs differently, and he wondered if that might fund a broader group. Dr. Sparke said that APD did not have the data, as PIs do not report it, and it would be a labor-intensive task to compile it. In answer to another question, she explained that the institutions waive the overhead on named fellowship stipends, while NASA pays full indirect costs for fringe benefits at the institution's standard rates, though everyone gets health insurance. So the universities must provide part of the resources for a named fellow. This cannot be done with grant-funded postdocs since there are constraints on cost-sharing.

Dr. Gaudi asked APD to return with information on where the funds will come from and where they will go. Dr. Natalie Batalha observed inconsistency in the numbers, which could mean that the same people are getting these over and over. She pointed out that she had raised this issue before. She wanted APS to have this in the letter as a recommendation to avoid multiple awards, irrespective of the results of the funding shift proposal.

Dr. Gaudi said that they need to know if astrophysics is self-sustaining as a discipline, and they need more information in order to evaluate the long-term health of the field. Dr. Somerville said that it felt like they were out of balance in R&D, which this does not address. Dr. Sparke explained that a rocket payload

costs about $2 million, while CubeSats and balloon payloads run about $4 to 5 million. Transferring $4 million from the fellowships to R&A would fund another new balloon payload or a CubeSat, or two new rocket payloads, per year.

Dr. Hertz told the Subcommittee that APD would bring in a notional proposal the next day. This would include a scheme for splitting the cut to the fellowships and shifting funds to R&A. Demographic data were not available. He would also try to get information regarding a salary baseline, post-fellowship career paths, and the percentage receiving multiple fellowships.

Discussion

Dr. Gaudi asked APS to continue discussing Hitomi in order to define the main issues. Drs. Fischer and Bock recused themselves from this discussion. Dr. Ozel stated that the financial issues should be examined. Hardware would cost up to $90 million, and there could be related costs. Dr. Neil Cornish pointed out that the GO funds would have been in the budget already. Dr. Ozel reiterated her concern about the source of the funds. She also wanted them to think about what U.S. x-ray capabilities will be for the next decade or more. Chandra might not last another full decade, and while NASA is partnering on ESA's Athena mission, she worried that the Agency is too focused on collaborating on x-ray missions led by international partners rather than investing further in U.S.-based capabilities. Finally, this was JAXA's third failure, so she saw assurance of risk mitigation as a prerequisite to funding further collaborations with them.

Dr. Cornish was concerned that the upcoming mid-DS report could impact the distribution of funds. This is something that Dr. Hertz will have to respond to. In the bigger picture, Hitomi is in the same trade space as some of the mid-DS recommendations. Based on his knowledge of the mid-DS report, which he could not discuss directly, he considered this to be "awkward timing" and expected more pieces to be in play. Dr. Hertz noted that the earliest fiscal year in which the mid-DS recommendations could have an impact would be FY19, as the FY18 budget has been formulated.

Dr. Gaudi posited that NASA decided that Hitomi was originally worthwhile to do and invest in, and that nothing has changed since that decision. He was tempted to believe Dr. Hertz when he said he could find the money to pay for the rebuild.. NASA wants to continue working with other international collaborators, which will become increasingly important as mission costs grow. The working relationship has to go both ways, and JAXA seems willing to work with NASA. Therefore, he felt they should go forward.

Dr. Dingus pointed out that this was JAXA's third failure, and none of the losses were due to NASA's involvement. She wanted to know what was done last time to make sure there was not another failure. Dr. Hertz explained that all three events differed. Dr. Rich Kelley of NASA, the Hitomi SXS instrument Principal Investigator, provided more detail. The first failure was due to the launch vehicle, and the second was accommodation of the instrument on the spacecraft. The feeling in APD is that JAXA must not just delegate, but also focus on the best ways to avoid mistakes. Dr. Hertz added that whether or not the Agency proceeds with the next Hitomi, APD intends to work with JAXA to review best practices in building in robustness and mission assurance processes. NASA wants to help JAXA infuse these into their processes. There is no interest in trying to force NASA culture on them, but JAXA itself has said that that agency must change its culture. Dr. Gaudi pointed out that NASA currently has the most influence on this process that it will ever have.

Dr. Hertz cautioned that there are no guarantees. However, NASA does not want to go into missions without feeling comfortable with the partner. Regardless of what APS were to recommend, there will be further agreements with JAXA. NASA only wants successful partnerships resulting in successful missions. Dr. Somerville said that while she is not an x-ray astronomer, the science from this was very

exciting and she agreed that it is necessary to maintain the capabilities. She wondered if there might be another way to handle it. Dr. Hertz said that APD can only make these changes due to the existence of flexible and movable funds. The fellowship issue reflects the community interests, not the monetary situation.

Dr. Cornish said that the Hitomi science is fantastic, but that is true of many missions and explains why senior reviews are so complex. In supporting Hitomi, APD might lose opportunities to do other fantastic science. Dr. Hertz replied that the rebuild would be equivalent to a MoO. It is also possible that the 2020 DS will recommend a probe to do the science. There are timing issues. JAXA wants to start right away, in this calendar year with a launch in 2020. That would be well in advance of the Athena launch. He concluded that no one else can propose to do this other than Rich Kelley's team at GSFC. The total cost of Hitomi under JAXA was about $300 million; it would have been more had NASA done it. NASA collaborates with international partners by taking on defined tasks. Dr. Ozel asked whether he could explain to Congress what happened in order to ask for additional funds and why the science is necessary and time-sensitive. The congress has responded to urgent needs before after all, such as the proposed $5 million line item for mirror development. Dr. Hertz agreed that he could propose this through the budget formulation process.

Working lunch

During lunch, Dr. Gaudi suggested that APS think about recommendations that might go into the meeting letter. Dr. Cornish cautioned that the mid-DS report was taking a long time to go through the standard review process, but it would be issued soon and should affect the Hitomi situation. It will make recommendations about some changes in the program reflecting the last DS, and APD will need to look at Hitomi in that light. Dr. Gaudi said that the APS recommendation would be based on the assumption that Dr. Hertz can find the funds without hurting other parts of the DS.

When asked about the timing of the APS decision, Dr. Hertz explained that the Japanese government had not yet approved JAXA's request to move forward. The JAXA proposal assumes the partners will contribute as they did before. So no decisions are being made yet. He himself does not make the decision on the NASA end, as the U.S. government has a decision-making process. He was not sure that JAXA could replace the U.S. contribution. Dr. Kelley added that it was unclear if they have the technology.

Dr. Hertz said that he did not know the point at which the final decision will be made. Input from APS at this meeting would be helpful and valuable. The mid-term report is all advice, but it could tell him to fund in other areas that are not covered by Hitomi. After the mid-term report is out, APS could do a teleconference for a briefing to revisit any other advice. Dr. Gaudi said he would write something.

Roman Technology Fellowship Program

Dr. William Lightsey explained that the Roman Technology Fellowship (RTF) Program provides start-up funds for candidates who are within 7 years of receiving their PhDs and not yet on the tenure track. As the number of proposals has declined, APD has determined that the proposal-writing and review processes, as well as the administrative costs, are high relative to the number of awards. The RTF program as currently constituted appears to be inefficient, and perhaps it is time to simplify.

APD looked at the Planetary Sciences Division (PSD) Early Career Fellowships as a model. In the proposed revision, candidates will propose to the Astrophysics Research and Analysis (APRA) or Strategic Astrophysics Technology (SAT) programs, then check a box that they qualify for RTF. Those who are selected for an APRA or SAT award will then be eligible for the "fellowship funds" once they are holding a tenure track position. The basis for the peer review would be their technology proposal. Requests for start-up funds would be a second step for those chosen as fellows. Applicants must ask for the additional funds, which is where APD will assess whether they can benefit from the fellowship. In

addition, applicants must be the primary proposer, not a member of the team. Applicants can ask for the funds after the initial award expires, and the proposal must be submitted prior to the applicant being 10 years past receiving his or her PhD.

The intent is to turn the RTFs into an extension of the APRA/SAT awards rather than running it as a separate award program. Dr. Lightsey is working with PSD on how to manage this. Dr. Cornish observed that most universities do not let postdocs serve as Principal Investigators (PIs). Dr. Hertz said that the applicant would have to be the science PI, but if the institution still does not allow it, NASA has a way to enable this.

Dr. Lightsey added that the APRA application must stand alone. The fellowship funds do not augment the APRA award and can go into other activities. What NASA is doing now does not work, in part because it requires two peer reviews due to the two-step application process. He reminded APS that applicants can be considered later in the term of the APRA/SAT award and can delay applying until after the tenure track job is acquired. Becoming a fellow gives them a title and the opportunity to apply for additional funds. Dr. Fischer said that sometimes her institution has proposed through APRA and been told that certain topics are not being considered. She asked if this would restrict the types of instruments developed under the program. Dr. Michael Garcia, APRA Lead Program Officer, said that the awards focus on NASA's needs. Dr. Hertz added that the program tries to fund technologies that will be on NASA missions, not general technologies.

Dr. Lightsey asked the APS members to review a white paper on this topic that had been sent to them by Dr. Hertz. He asked them to comment at their October meeting. Dr. Hertz added that the intent is to keep the same funding and just change the process, but there is always the concern that they might create a situation of unintended consequences. That was one thing he wanted APS to consider.

Operating Missions Senior Review Report

Dr. Megan Donahue reported on the recent Senior Review. There were three panels: one each for Chandra and Hubble, and a "main" review for the remaining missions. She chaired the main review. The charge was to assess missions through FY18 and the following 2 years, then rank them and provide specific findings. Under review were Fermi, K2, NuSTAR, Spitzer, Swift, and XMM. The panel looked at the overall portfolio strengths and contexts of near-future missions, projected science returns, science tradeoffs, and opportunity costs in extensions or termination compared to future astrophysics missions.

The panel used three criteria and gave grades for each area:

- Science Program (40%)
- Relevance and Responsiveness (30%)
- Technical Capability and Cost Reasonableness (30%)

Each mission submitted a proposal. The panel then had face-to-face meetings and discussed each mission. Each panelist gave a numerical grade and a ranking to each mission. Dr. Donahue showed how each mission ranked according to the three criteria, along with the costs, the latter being derived from the proposals. The missions were all excellent and relevant, though Spitzer and Fermi had higher costs.

The panel found no science reason to discontinue or cut funding for any of the six missions, determining that they are highly synergistic and together have a greater value than their individual parts; Dr. Donahue provided some examples of these synergies. The budget was extremely uncertain at the time of the review. While the panel was not asked to solve these problems, they did identify some cost savings within each mission budget and made corresponding recommendations. The panel also tried to call out strengths that should be considered. NASA ultimately approved extending all of these missions.

Dr. Gaudi asked if there had been any specific ideas on how to cut Spitzer and Fermi. Dr. Donahue replied that the Fermi coverage could be cut, but not the gamma-ray burst monitor. Spitzer has a limited lifespan, while Fermi could go another decade. On the other hand, Spitzer management has been clever and effective in cutting costs. The science for all of the missions was outstanding and the team presentations were strong.

Dr. Hertz explained that the reports for Chandra and HST are online, with recommendations for changes. These senior reviews are required by law. The next review will not include Spitzer and K2. Dr. Alan Boss observed that it has not always been the case that everything was approved to move forward. Dr. Hertz agreed, noting that there were more missions 10 years ago. Since then, funding has been channeled into JWST, and there has been less Explorer funding. While the budget has improved, the lag resulted in this low number of missions. In addition, these were all great missions, whereas before there were some that were not so good, though many of those were also small. After JWST launches, Spitzer will not be as valuable. In 2012, he decided to have separate reviews for HST and Chandra, because they are reviewed against different standards than other missions. No senior review is going to turn off HST, so it should be evaluated in terms of what more it can do, not whether to continue it.

Public Comment Period

The agenda provided an opportunity for the public to comment. Dr. Kenneth Sembach, a former APS member, spoke by phone. He said that he was intrigued by the fellowship discussion, as he is a former Hubble fellow. He was not going to weigh in on their decision, but he wanted to make sure that they considered the benefit to the science community. He worried there may be unintended consequences. The fellowships are given to the best and brightest, and 95 percent of them remain in the field.

The discussion he heard earlier was nebulous, and there was no clear explanation of the use for the reprogrammed money. Dr. Somerville asked "a good, direct question" about whether to shift some of the funds to graduate fellowships. He thought that an unintended consequence might be in gender diversity. Right now, the ratio of the fellows is 30 percent female, which reflects the ratio in PhD programs. It is important to avoid decreasing these opportunities for leadership. He also thought that cutting the number of Hubble fellows would probably result in more science per dollar from the named fellow grants.

GPRAMA Guidelines

Ms. Jennifer Kearns of SMD provided the background of the Government Performance and Results Act Modernization Act (GPRAMA), which requires each Federal entity to provide a strategic plan, an annual performance plan, and an annual performance report to evaluate progress made in key areas. In SMD, the measures address milestones for missions and development.

APD has three Annual Performance Indicators (APIs) for science goals in NASA's Annual Performance Plan, against which APS is asked to assess progress:

- API AS-16-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.
- API AS-16-2: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.
- API AS-16-5: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.

APS was free to evaluate anything that occurred during the last year, though they were only to consider items funded in whole or in part by NASA. That funding did not need to come from APD specifically. Dr.

Hasan had sent them a document with items that they could consider, but they were free to add to it or delete the suggestions.

Another requirement was for a color rating, as follows:

- A rating of Green meant that the expectations of the research program were fully met in context of the resources invested;
- Yellow meant that there were some notable or significant shortfalls, but some worthy science advancements were achieved; and
- Red meant that there were major disappointments or shortfalls in scientific outcomes in context of resources invested, uncompensated by other unusually positive results.

Finally, the document was to be written for the intelligent layperson.

Dr. Gaudi noted that APS usually includes three examples for each area. There was no need to be comprehensive, and this is not an advocacy document. They were to simply evaluate whether NASA is making significant progress as planned in each of these three goals, and include examples. Typically, the Subcommittee begins with a summary in each area, and then includes subsections with important results and press releases. Ms. Kearns explained that the report has been streamlined, so there is no longer a need for the summaries, which would be deleted.

Dr. Gaudi continued, explaining that if there are areas of disappointment, APS should note that. He had never seen a failure, however. The audience is the Office of Management and Budget (OMB), Congress, and the general public. Ms. Kearns said that for any rating other than Green, SMD needed a strong rationale. Accomplishments and disappointments can be combined in a given area and that area can still be judged as Green.

GPRAMA Discussion

Dr. Gaudi led the discussion of the first group of results, which relate to physics of the cosmos. After deciding on the specific examples to include, the Subcommittee considered adding a section stating that they are saddened by the loss that Hitomi represents. Dr. Marshall Bautz noted that the instrument worked extraordinarily well, and there is a paper from it. Dr. Gaudi said that he would come up with some language for them to review the next day. While this is not an advocacy document, they could make it clear that the loss is significant for science and not NASA's fault. It was agreed to declare this area Green.

For the other two areas, APS members chose examples and again agreed on Green ratings. Dr. Gaudi said he would assemble something for them to review the next day. Ms. Kearns asked that there be a formal vote on the color; what had occurred had been informal. Dr. Gaudi therefore led the formal voting process for each of the three areas separately.

For API AS-16-1, the vote for Green was unanimous, coming to 16 votes in favor and none opposed. This included Dr. Scowen, participating via phone.

For API AS-16-2, the vote for Green was unanimous, coming to 16 votes in favor and none opposed. This included Dr. Scowen, participating via phone.

For API AS-16-5, the vote for Green was unanimous, coming to 16 votes in favor and none opposed. This included Dr. Scowen, participating via phone.

It was agreed to review the Hitomi issue again on the second day of the meeting.

Wrap up for Day 1
The meeting was adjourned for the day at 2:57 p.m.

Thursday 21 July

Opening Remarks
Dr. Hasan opened the meeting for the second day. Dr. Gaudi once again asked conflicted members to recuse themselves from the discussion as needed. He then reviewed the rules for FACA meetings.

ExoPAG/PhysPAG/COPAG Updates
The chairs of the three Program Analysis Groups (PAGs) provided updates on recent activities.

ExoPAG
Dr. Boss said that the Exoplanet PAG (ExoPAG) is in good shape, with a strong Executive Committee that has the needed expertise and balance. He provided an update on the Study Analysis Groups (SAGs). Seven are complete, five are active, and APS was to receive proposals for two new ones.

Active SAGs include SAG 12 on astrometry, which is considering what to do after ESA's Gaia mission concludes. There could be a proposal for a probe-class mission. SAG 13 addresses exoplanet demographics and yields; the approaches are converging. SAG 14 had proposed a rather large project that has not proven feasible. There will be a report on the TESS mission, and the SAG is interested in concerns about radial-velocity (RV) jitter. SAG 15 discusses key science questions beyond habitability and biosignatures, while SAG 16 addresses biosignatures. The latter is having a workshop leading to a draft document in October. This SAG is a much larger and broader reboot of the defunct SAG 4.

The first proposed new SAG, SAG 17, will address the community resources needed for K2 and TESS planetary candidate confirmation, looking at how to refine targets and define resources that can be used to that end. SAG 18 would focus on metrics for direct imaging with star shades, seeking to define contrast, suppression, limits, etc.

ExoPAG is also now part of the technology gap process and will update gap lists going forward. Future activities involve teleconferences and SAG activities. The PAG is also looking at whether to seek a far infrared (FIR) exoplanet SAG. The PAG will review the technology gap list planning, which should be ready for the next ExoPAG meeting, to be held prior to the 229th American Astronomical Society (AAS) meeting in Grapevine, Texas, in January 2017. .

When Dr. Boss asked APS to approve SAGs 17 and 18, Dr. Gaudi noted that SAGs are chartered for the short term to answer specific questions, while a Science Interest Group (SIG) advocates for a certain approach. He wondered if, with the five active SAGs already working, ExoPAG might be spread too thin. He also wondered about duplication of effort with other groups, like space technology definition teams (STDTs). Dr. Boss replied that some of the SAG members are on the STDTs. He hopes the SAGs might lead to community inputs to the STDTs. Dr. Gaudi noted the need for coordination.

Dr. Cornish asked if it make sense to have a single direct imaging SAG that would consolidate some of the studies. Dr. Boss explained that that had been discussed, but after considering expertise and other factors, ExoPAG broke it out more finely. Some of this is unique. Dr. Gaudi observed that the more specific the SAG goal, the more likely it is to get done, so merging SAGs is not necessarily productive.

Dr. Batalha expressed concern about the purpose of the PAGs, saying there is a danger of casting them as authoritative science analysis groups, resulting in competition rather than an effort to catalyze the work.

She saw no problem at this level, but wanted to urge caution. Dr. Boss agreed. It has worked at the higher level of giving advice to APD and APS, but he would like to pull in more participation. Dr. Kalirai added that he knew of several communities outside of the PAGs that are organizing to put in JWST Early Release Science proposals.

Dr. Gaudi suggested that Dr. Boss, as ExoPAG Chair, provide guidance to ensure that the SAGs are not competing or overlapping too much. In answer to a question, Dr. Boss explained that SAGs are initiated when someone comes to the Executive Committee with a proposal. Following discussion, a draft charter is created, and after additional discussion, it goes to APS. It usually targets a gap in knowledge. He plans to gently nudge the SAGs that are not making progress.

The vote to approve the two new SAGs was unanimous.

PhysPAG
Dr. Bock explained that the Physics of the Cosmos PAG (PhysPAG) has a different structure from ExoPAG, with permanent SIGs. PhysPAG held a couple of physics-based conferences at which the inflation probe and gravitational wave SIGs presented. There are also active x-ray, gamma-ray, and cosmic-ray SIGs. The cosmic structure SIG is new. Its members have been organizing ideas for what can be done on flagship missions.

The gap technologies review carried over 22 items from last year and added 10 new ones. The review found that seven of the new items overlapped with existing items, so those were merged; the remaining three new items were added. Seven of the 22 existing items were significantly updated. Dr. Ozel asked how one might initiate a study when identifying a gap in expertise. Dr. Gaudi advised her to join the PAG and propose a SAG, or refer someone to do so.

Dr. Rita Sambruna of NASA explained that after the gap list review, the list goes to Dr. Thai Pham at NASA, who pulls together a group to rank the gaps. This group then produces a lengthy volume, the Program Assessment Technology Report (PATR), which is online. It serves as guidance to NASA regarding community investment priorities. Dr. Bautz added that when a particular technology is called out in ROSES, it reflects the PATR.

PhysPAG/Hitomi
Dr. Bautz explained that he chairs the X-ray SIG within PhysPAG. The community had done a lot of work for Hitomi. He reviewed the Hitomi mission and chronology up through the launch. When the NASA instrument, the X-ray micro-calorimeter "integral field" (non-dispersive) spectrometer (SXS), was turned on, it exceeded its goals. It had remarkable spectral sensitivity and would have produced the first high-resolution x-ray spectroscopy of extended sources. It was 100 times better than the previous best for measuring velocities, supernovae, and starburst galaxy flows.

The X-ray SIG held a teleconference to discuss a response to the loss of Hitomi. The call had very large number of participants and the SIG prepared a white paper that was released in early July. No agency had made public comment at that point, but the SIG decided that the science case for a recovery mission is at least as strong if not stronger than it was for the original Hitomi. There is consensus that they should not wait for Athena, so any launch needs to be timely. There was great community interest in the trade-offs and costs, but that information was not available. There was also concern about the impact a new mission would have on the APD Explorer program. The white paper only addresses the importance of the science and the timeliness of a potential reflight of the SXS and a suitable mirror.

Dr. Bautz presented examples of other activities that could be done with the SXS. Overlap with HST and JWST would be important. The pairing of JWST and SXS would offer extraordinary new capabilities,

particularly in penetrating and understanding the infrared range. In addition, the SXS would serve as a science and technology pathfinder for more complex instruments on Athena and an x-ray surveyor.

Dr. Dingus noted that there were three NASA instruments on Hitomi. Dr. Bautz said that the SIG focused on the SXS. Another instrument was not yet turned on, and the third was rather standard. He added that there is almost no overlap between the SMEX polarimetry candidates and SXS.

COPAG
Dr. Scowen provided the update on the Cosmic Origins PAG (COPAG). Discussions with the community indicate that there is no current need for a possible SAG on JWST; this concept will be revisited as the launch date draws closer. The PAG also proposed reopening SAG 8, dealing with WFIRST, but that is being left for the Science Investigation Team (SIT) at present. SIG 2 deals with ultra-violet spectrum research. A recent SIG 2 meeting at the SPIE conference in Edinburgh discussed technology needs, funding, and terminology, while also looking at capabilities that could be brought to bear on the STDTs. One action item resulted.

COPAG has membership on three of the four STDTs for the four flagship missions being discussed in advance of the next DS, and two members are covering the activities of the fourth STDT. COPAG has sent letters of support to the STDTs, and a concern about the Large UV/Optical/IR Surveyor (LUVOIR) has been addressed.

The technology gap analysis was completed and a document delivered to NASA on June 30. There remains some concern that the process is vulnerable to factual errors. It was suggested that COPAG establish a Technology Interest Group (TIG) to review the technology gaps document each year to ensure that claims and priorities were in fact reflective of community needs rather than the interests of individual research groups.

SIG 1, which addresses FIR, has a new leadership and structure. A webinar series engages the community on FIR; these are scheduled for the first Friday of each month. SIG 2 focuses on UV-visible science and technology, and is involved in the STDTs for both the Habitable-Exoplanet Imaging Mission (HABEX) and LUVOIR. The third SIG studies the cosmic dawn. Members are involved with the FIR Surveyor STDTs, and have asked all STDT chairs to present to the SIG.

COPAG was not requesting any APS action. Plans were to continue ongoing activities and engagement with the STDTs. The TIG will be a group that can speak with some authority about the state of play of detectors, coatings, etc., and will review technology gap input. This year, they did not feel they had the resources to do so.

<u>Webb Telescope Update</u>
Dr. Eric Smith, JWST Program Director/Program Scientist, provided an update. He began by showing the telescope mirrors configured at GSFC in April. Ambient testing will occur this fall. The Integrated Science Instrument Module (ISIM) was recently installed and integrated; this integration is final and it will not be taken apart. The Optical Telescope element / Integrated Science (OTIS) module was undergoing deployment testing prior to integration of instrument flight electronics. There is a mock-up of the center section of the flight telescope for the final practice test in the thermal vacuum chamber at the Johnson Space Center. After that, the flight hardware will be tested in the cryo-chamber. Within a year, the science payload will go to Northrup Grumman for final integration and testing. The practice testing of the tests themselves is standard procedure and was done with Chandra. The pathfinder approach builds ever-increasing fidelity, resulting in fewer problem reports.

Four of the five sunshield flight layers have been completed, with three delivered to Northrup Grumman. Dr. Smith described the flight core assembly, cable brake, and unitized pallet structures as examples of what is involved in the sunshield in addition to the flight layers. These are all in testing. He next showed the spacecraft, including the solar array, propulsion tanks, the six reaction wheels, and other elements.

Dr. Smith reviewed the various challenges for the spacecraft and sunshield. The solar array is the pacing item on the spacecraft schedule, while remanufacturing of a membrane tensioning system component is the pacing item for the sunshield. The latter is taking 2 weeks of schedule reserve. All of the Level 1 requirements are being met as projected, though some items are close and will be watched through launch. The schedule has thousands of milestones; the team reports out the high level ones to NASA, the White House, and Congress. There are three new deferrals related to the sunshield membrane.

The critical path has 7 months of funded schedule reserve and flows through the sunshield. With the delivery of the cryo-cooler, it is no longer the pacing item. Its issues have been resolved and it exceeds performance requirements. Dr. Smith showed a chart with the use of schedule reserve. He expects OTIS to take up some schedule reserve, as its progress is a bit slower than expected. If there were no more delays, the project would finish 7 months early – and would be the first ever to do that. So he expects to use some reserve. If the current reserve were to drop below plan, it would then stabilize. Dr. Hertz explained that there could be situations calling for a re-optimization of the schedule to get back on the path.

Dr. Smith said that the ground system also has deliverables and testing. Different versions of the software are being fed into the system. That schedule is now relevant. Next, it goes to STSCI and the activities of the science community. The mission operation center is complete, and the hardware at Northrup Grumman and other contractors is 85 to 90 percent complete, while the software is keeping up.

There are five observation categories, which Dr. Smith briefly reviewed. Early Release Science (ERS) will be science the community proposes. These data will be made public immediately. The proposal timeline will be resolved in time for the January AO. Dr. Somerville was concerned about the ability of the community to turn around the observations and share them in a timely manner. Others had expressed these concerns to her as well, and she was not sure where to take them. Dr. Smith agreed that this is a concern, and it is being reviewed. Dr. Smith said he would confirm the Cycle 1 time for Guaranteed Time Observers (GTOs). The first cycle will have at least 50 percent GO observation time. Commissioning will last 6 months, during which there could be some science-grade observations made.

Community outreach activities are increasing, and there are some meetings planned at major international science conferences. There will also be topical science meetings and workshops, user training workshops, and JWST community days to be hosted at and by various institutions. Dr. Gaudi noted that the timing seems less than ideal in terms of ERS. He could imagine ERS PIs at these workshops wanting to discuss how to reduce the amount of data to be analyzed. Some PIs will not want to attend these meetings unless they know they will have time. Dr. Hertz advised talking to PSD, which often facilitates this kind of activity regarding Mars missions.

Dr. Smith described the user tools. The timeline is similar to the proposal release timeline and indicates what will be released when. He also showed the science parallels, which were not in the original JWST plan. However, the mission can do parallels and those data can be proposed. There will be pure parallel and coordinated parallel support in Cycle 1. Additional coordinated parallels will be supported in Cycle 2.

The commissioning timeline of 6 months is long, but some activities will occur during that time. The first deployment will happen 30 minutes after launch, leading to full deployment once the mission is beyond the moon.

WFIRST Update

Dr. Neil Gehrels and Mr. Kevin Grady provided an update on WFIRST activities. Dr. Gehrels said that the formulation science team is making good progress towards a completion of Phase A. WFIRST will have HST-quality images over 100 time more sky, at much higher power, providing the first comprehensive set of measurements for supernovae distances, weak lensing distances, and galaxy baryon acoustic oscillation (BAO) distances. The aperture will be much larger than that of the Euclid mission.

Dr. Gehrels showed microlensing yields in looking at the galactic bulge, with a comparison to Kepler. Microlensing is the only way to detect free-floating planets, which may equal the number of bound planets. The coronagraph is a technology demonstration, but it has greatly moved the field forward already and will help define needs for future coronagraphs. Imaging at high contrast provides direct detection and spectroscopy of exoplanets. Disk science is an area that can be addressed through this.

The GO program will have 25 percent of the observing time during the prime 6-year mission and 100 percent thereafter. Science community engagement activities are beginning. The formulation science working group members come from a range of sources, such as academia, government, and industry. Currently, the international representatives are not official members, though that is likely to change. Dr. Kalirai added that the science working group is looking at optimizing the science and science throughput without driving up costs. One idea is to provide an improved filter, though that has not been finalized.

Mr. Grady reported that the Key Decision Point A (KDPA) was completed in February. The team is now in the formulation phase, which involves writing down requirements. A number of formulation trades are in process, and some have been completed. The next major review is planned for June of 2017. The goal is to lock down a design in the coming months, then create the models and analyze their performance.

The coronagraph and IR detectors continue making great progress. The IR detector fabrication yield will be a cost factor, so the team is trying to pin that down. Being in formulation and with the upcoming Acquisition Stratgey Meeting (AS), a lot of time is spent on acquisition. The wide field instrument is being worked on with industry. The Canadian Space Agency (CSA) is hoping to make two instrument contributions. The team has completed two industry studies, with Ball Aerospace and Lockheed Martin and the roles for the follow-on study have been refined.. There is the possibility of an increase in the FY17 budget, and the team hopes to get continued Space Technology Mission Directorate (STMD) support. There are two development schedules that reflect FY18 funding possibilities. Another activity is development of a descope plan in case the costs run too high.

Recently, Dr. Hertz asked to see if there could be compatibility with a starshade, with a minimal number of WFIRST changes. It would offer an opportunity to increase the science yield. The team will study this, and Dr. Hertz will determine whether to keep or remove the starshade capability before KDPB. Dr. Hertz added that if there is a starshade mission, it will be a substantial, large mission. NASA will not do it unless it is a DS priority. However, APD wants to determine what it takes to use WFIRST with a starshade. It would be contingent on costs and science production not being impinged. Mr. Grady said that some of the early thoughts are that a minimal implementation could be two or three filters added to the coronagraph, or a mechanism added to the integral field spectroscope and a crosslink with an antenna and transponder. The starshade and internal coronagraph use much of the same hardware with different masks used in different ways. The team will have to cost the entire mission, and will separate the additional cost of the starshade elements. It looks like it would be fairly modest.

Mr. Grady presented a depiction of the observatory and showed the projected schedule. If funding were optimal, they could develop WFIRST in 82 months, to launch in 2024. If the funding in FY18 is lower and prolongs Phase B, they would be looking at 95 months of development and a 2025 launch. The

funding profile will change the schedule somewhat. The funding wedge opens up more fully in FY19, but the project is probably constrained in the first 3 years. Dr. Hertz said that the numbers change every year. The order of magnitude in the first years is significant. The extra funds needed would be $100 million per year in the early years. The total would be less if they could build it faster, but that would bring less budget flexibility. Mr. Grady noted that the detectors and coronagraph are thus far comparable in their portion of the total technology budget.

Public Comment Period
The meeting provided another opportunity for the public to comment, but no one came forward.

Lunch Talk: Dusty Universe
Dr. Gaudi explained that henceforth, new APS members will give presentations on their work. Dr. Cooray therefore gave a presentation on dust in the universe.

GPRAMA Discussion (continued from Day 1)
Dr. Gaudi shared his draft GPRAMA document with the other APS members. He asked them to review the document, with particular attention to the paragraph about Hitomi. The paragraph reads as follows:

> The APS had no reservations about NASA's progress toward these goals, but did note with disappointment the loss of the unique scientific capability of the Hitomi satellite so early in its mission lifetime, and in particular the loss of the revolutionary Soft X-ray Spectrometer (SXS) instrument on Hitomi, which was developed and built by Goddard scientists working closely with colleagues from several institutions in the United States, Japan, and the Netherlands. Even during the brief time that Hitomi and the SXS were operational, they made unprecedented observations of the Perseus Cluster, as described below. Indeed, the APS concludes that an array of frontier scientific fields at the heart of the 2010 Decadal Survey, the NASA Physics of the Cosmos program, and the 2013 NASA Astrophysics Road Map would have been transformed had the Hitomi spacecraft not been lost.

APS then reviewed the press releases cited. The members agreed to accept the document.

APS Discussion
The Subcommittee discussed topics that might warrant presentations at the next meeting, which was to be a teleconference. Dr. Kalirai asked for updates from the STDTs, including whether they have the resources they need, with additional input from Dr. Hertz on the resources. It could be that the resources discussion would pose a conflict for some APS members. Dr. Cornish surmised that the reports should be possible even if there is no discussion of funds. The L3 study team will be ready by then. Dr. Gaudi noted that it would be too early to discuss probes.

Dr. Kalirai next observed that there are a lot of questions about the ERS on JWST, which might warrant dedicated time for discussion. Another topic will be restructuring of the named fellowships, as well as the mid-DS report. Dr. Gaudi added to the list, mentioning the Aerospace Corp. costing methodology, which could have a bearing on the progress of the STDTs.

Dr. Bautz recommended receiving more information on the long-term impact of the balloon program and the science, including the rocket program. He also wanted more on how ground-based assets best support space assets. Dr. Fischer agreed that there is always tension between ground and space, and she would like to know about the overall policy and how ground assets can be supported. She added technology development to the list. Other suggestions were for the science on SOFIA, updates on HST and Chandra, summaries from the HST and Chandra Senior Reviews, and the possible use of cubesats in astrophysics.

Roman Technology Fellowships
Dr. Gaudi thought it was obvious that the current RTF structure is inefficient, but the proposed restructuring was not perfect, although it would improve the program. There was broad agreement on both points. Dr. Fischer advised looking at the original motivation and purpose of the awards. She pointed out that writing 15-page proposals is something that investigators do all the time. Checking a box would exclude those whose APRA proposals are rejected. It was not clear what NASA is trying to achieve with the RTFs. She was also not confident that the proposed restructuring would be the best way to select technology developers. Dr. Hertz pointed out that the RTFs resulted from an APS recommendation. He needed a response no later than the October meeting. It was agreed that APS members would do some fact-finding and talk to community members between meetings. Dr. Gaudi assigned Dr. Fischer to organize the effort.

Follow-Up on Named Fellowship Program Changes
Dr. Hertz presented additional thoughts and information on a draft proposal to reorganize the named fellowships. The funds reallocated from the named fellowship programs would augment the APRA program, which supports technology development and suborbital class payloads. The number of suborbital missions is limited by the payloads developed, not the capacity of the launch programs, so this reallocation would allow another one or two payloads to be selected each year.

He looked at three ways to balance the fellowship science topics without altering the balance or mix of science topics:

1. Expand the range of science topics for the Hubble fellowships beyond cosmic origins, and reduce the Einstein and Sagan fellows.
2. Consolidate the application and review process into a single review process, and then assign the fellows to the programs. This would eliminate duplicate applications.
3. Consolidate all named fellowships into a single program.

Dr. Boss said that while it would be nice to have more suborbital flights, it might make sense to send the $4 million to the Astrophysics Theory Program (ATP), where the funds would go further.

When asked about the DS, Dr. Hertz said that the demographics section stated that the number of named postdoctoral fellowships had doubled over the preceding decade, with a slight decline in advertised permanent positions. APD takes that as support of the rebalance. Other activities supported by these fellowship programs include a workshop organized by the Sagan Fellowship program, and a symposium for each of the three programs, plus management. These are relatively small budget numbers for which he could provide data.

Dr. Kartik Sheth of NASA reviewed the history of the fellowship amounts, which were deliberately set to be higher than comparable fellows. Dr. Fischer noted that this has driven up costs across all fellowships. She believed most in the field would want more fellows at lower funding. The question was raised about whether the fellowship programs considered under-represented groups. Dr. Sheth said that NASA has not tracked demographic data for proposers. Dr. Hertz added that the bulk of postdoctoral funding is through R&A, which has no reporting requirement. Dr. Bautz disagreed with the notion that there is no attempt to achieve balance. He sees an effort to address gender balance, which is easy to identify.

Dr. Somerville said that she was strongly opposed to this change. There are other areas in R&A that are oversubscribed and underfunded. This program is extremely popular in the community and has been very successful. She thought it should be left alone, perhaps with minor tweaks. Dr. Gaudi agreed. The program works, and it was not obvious to him that the negative implications will be worth the repercussions. He asked for data on duplicate fellowships and the percentage of fellows that go into permanent positions. Dr. Sheth cited some limited data, such as that 83 percent of Astronomy PhD

graduates from U Maryland College Park from 1966 to 1980 had stayed in the field. For those graduating from 1986 to 1999, the percentage was comparable, and roughly the same as the numbers quoted for the named fellows. Additional data show that very high levels of named fellows stay in the field.

Dr. Fischer said that this did not surprise her with the named fellows, who are the best and the brightest. The Sagan Fellowships always have great gender, geographic, and topic balance. Dr. Gaudi added that if there were an overproduction of postdocs, most of these people would not pursue the fellowships. Dr. Cornish said that it was not that they want fewer postdocs, it was about the percentage of total R&A spending. Dr. Batalha saw this as a response to the ongoing concern about the low R&A success rate. Dr. Gaudi thought it would be a large decrease in the fellowship programs resulting in a small increase in R&A. Dr. Fischer repeated her suggestion of cuts to the stipend. Dr. Hertz said that he expected more questions to evolve and asked that APS collect them, then send them on to Dr. Sheth. Dr. Somerville volunteered to handle that. Dr. Gaudi asked for comparative salaries for postdocs and information on any formal diversity programs.

Dr. Hertz noted that an award to build a suborbital payload does not go for hardware, it goes for people. The type of work is where the variance comes in. The perception in APD is that they are falling shortest on building pipeline for technology and instrumentalists. They are not worried about theorists. Dr. Ozel said that ATP is so underfunded, it is like playing the lottery.

After further discussion, Dr. Gaudi asked that APS members send their questions to Dr. Somerville, who would send them to Dr. Sheth by the middle of August.

Recommendations, Actions

Dr. Gaudi said that in addition to the thanks for presentations, APS would recommend that NASA invest in the next Hitomi mission, provided it does not affect other priorities or conflict dramatically with the mid-DS report. He agreed to have Dr. Cornish review the statement on that.

APS approved the new SAGs for ExoPAG. Dr. Boss reported that SAG 12 will close down by January. Dr. Gaudi planned to send the list of possible topics to send to Drs. Hasan and Hertz. The Subcommittee commended STSCI for work done on the observing modes on JWST. The letter would also state that APS will go into fact-finding mode regarding the fellowships, including the RTFs. There was unanimous approval of GPRAMA.

Dr. Hertz thanked the APS members for their participation, and Dr. Gaudi thanked the new members.

Adjourn

The meeting was adjourned at 2:58 p.m.

Appendix A
Attendees

Subcommittee members
B. Scott Gaudi, Ohio State University, *Chair, Astrophysics Subcommittee*
Nathalie Batalha, NASA Ames
Marshall (Mark) Bautz, Massachusetts Institute of Technology
James J. Bock, NASA JPL
Alan Boss, Carnegie Institution for Science
Asantha Cooray, University of California, Irvine
Neil John Cornish, Montana State University
Mark Devlin, University of Pennsylvania
Brenda Dingus, Los Alamos National Laboratory
Debra Fischer, Yale University
Jason Kalirai, Space Telescope Science Institute
Feryal Ozel, University of Arizona
Paul Scowen, Arizona State University (via teleconference)
Rachel Somerville, Rutgers University
Yun Wang, IPAC, California Institute of Technology
Beth Willman, University of Arizona

NASA attendees
Paul Hertz, NASA HQ, *Director, Astrophysics Division*
Dominic Benford, NASA HQ
Terri Brandt, NASA GSFC/HQ
Joan Centrella, NASA GSFC
Mark Claman, NASA GSFC
Jeanne Davis, NASA HQ
Mike Garcia, NASA HQ
Neil Gehrels, NASA GSFC
Michael Gorey, NASA HQ
Kevin Grady, NASA GSFC
Shahid Habib, NASA HQ
Thomas Harris, NASA HQ
Hashima Hasan, NASA HQ, *Executive Secretary, APS*
Jeffrey Hayes, NASA HQ
W. Vernon Jones, NASA HQ
Jennifer Kearns, NASA HQ
Richard Kelley, NASA GSFC
Stefan Muller, NASA HQ
Susan Neff, NASA GSFC
Deborah Padgett, NASA GSFC
Mario Perez, NASA HQ
Andrea Razzaghi, NASA HQ
Rita Sambruna, NASA HQ
Kartik Sheth, NASA HQ
Eric Smith, NASA HQ
Erin Smith, NASA HQ
Linda Sparke, NASA HQ

Mark Still, NASA HQ
Anita Valinia, NASA GSFC

Non-NASA Attendees
Anita Dunsmore, Air Force
Mike Fox, Raytheon
Paul Green, SAO
Grace Hu, OMB
Ben Kallen, Lewis-Burke Associates
Chris Reynolds, University of Maryland
Elizabeth Sheley, Zantech

Webex/Telecon
Arnold Barnes, Aerospace
Dominic Benford, NASA HQ
Gary Blackwood, NASA JPL
Jeff Booth, JPL
Theresa Brandt, GSFC
Earl Bychman, Cal Tech
Monty Dibiasi, Southwest Research Institute
Megan Donahue, Michigan State University
Daniel Evans, NASA
Jeff Foust, Spacenews
Michael Garcia, NASA
Neil Gehrels, GSFC
Paul Green, SAO
Russ Henderson, JPL
Ben Kallen, Lewis-Burke Associates
Jennifer Kearns, NASA HQ
Richard Kelley, NASA GSFC
James Lochner, USRA
Mark McConnell, UNH
Deborah Padgett, GSFC
Robert Petre, NASA GSFC
Neill Reid, STSCI
Chris Reynolds, University of MD
Rita Sambruna, NASA HQ
Paul Scowen, Arizona State University
Kenneth Sembach, STSCI
Kartik Sheth, NASA
Bill Smith, Science World
Eric Smith, NASA HQ
Karl Stapelfeldt, NASA JPL
Pamela Terrell, NASA HQ
Alexandra Witze, Nature Magazine

Appendix B
NAC Astrophysics Subcommittee Members

B. Scott Gaudi, APS Chair
Department of Astronomy
Ohio State University

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

Natalie Batalha
NASA-AMES

Marshall (Mark) Bautz
Massachusetts Institute of Technology

James J. Bock
Jet Propulsion Laboratory

Alan Boss
Carnegie Institution for Science

Patricia Boyd
Goddard Space Flight Center

Asantha Cooray
Department of Physics and Astrophysics
University of California, Irvine

Neil John Cornish
Department of Physics
Montana State University

Mark Devlin
University of Pennsylvania

Brenda Dingus
Los Alamos National Laboratory

Debra Fischer
Department of Astronomy
Yale University

Jasonjot (Jason) Singh Kalirai

Space Telescope Science Institute

Feryal Ozel
University of Arizona

Paul Scowen
Arizona State University

Rachel Somerville
Department of Physics and Astronomy
Rutgers University

Yun Wang
IPAC
California Institute of Technology

Beth Willman
LSST/Steward Observatory
University of Arizona

Appendix C
Presentations

1. *Astrophysics Division Update*, Paul Hertz
2. *Astrophysics Research Program,* Linda Sparke
3. *A Summary of the NASA Astrophysics Senior Review of Operating Missions 2016*, Megan Donahue
4. *Government Performance and Results Act/Modernization Act (GPRAMA) Annual Performance Report Process*, Jennifer Kearns
5. *ExoPAG Report*, Alan Boss
6. *PhysPAG Report*, James Bock
7. *COPAG Report,* Paul Scowen
8. *James Webb Space Telescope*, Eric Smith
9. *WFIRST Status,* Neil Gehrels, Kevin Grady
10. *Dusty Universe,* Asantha Cooray

Appendix D
Agenda

Astrophysics Subcommittee Meeting
July 20-21, 2016

Wednesday, July 20, 2016

8:30 a.m.	Introduction and Announcements	Scott Gaudi
8:40 a.m.	Astrophysics Division Update (including Probes)	Paul Hertz
10:00 a.m.	Break	
10:15 a.m.	R&A Update (including Postdoc Fellowships)	Linda Sparke
11:15 a.m.	Discussion	
12: 00 noon	Working lunch	
1:00 p.m.	Roman Technology Fellowship Program	Billy Lightsey
1:15 p.m.	Operating Missions Senior Review Report	Megan Donahue
1:30 p.m.	Mid Decadal Report (To be confirmed)	Jacqueline Hewitt
2:00 p.m.	Public Comment Period	
2:10 p.m.	Break	
2:25 p.m.	GPRAMA Guidelines	Jennifer Kearns
2:35 p.m.	GPRAMA Discussion	APS members
4:00 p.m.	Wrap up for Day 1	Scott Gaudi

Thursday, July 21, 2016

8:30 a.m.	Opening Remarks	Scott Gaudi
8:40 a.m.	ExoPAG/PhysPAG/COPAG Updates	Alan Boss/Jamie Bock/Paul Scowen
9:30 a.m.	Webb Telescope Update	Eric Smith/Hashima Hasan
10:30 a.m.	Break	
10:45 a.m.	WFIRST Update	Neil Gehrels/Kevin Grady
11:15 a.m.	Discussion	APS members
11:55 a.m.	Public Comment Period	
12:00 noon	Lunch talk: Dusty Universe	Asantha Cooray
1:00 p.m.	GPRAMA Discussion (cont'd from Day 1)	APS Members
2:00 p.m.	Break	
2:10 p.m.	GPRAMA Discussion (cont'd.)	APS Members
3:00 p.m.	Recommendations, Actions	Scott Gaudi
3:30 p.m.	Brief to Division Director	Scott Gaudi
4:00 p.m.	Adjourn	