NASA Astrophysics

ASTROPHYSICS ADVISORY COMMITTEE

March 5-6, 2020
Washington, DC

MEETING MINUTES

May 4, 2020

_____

Charles Woodward, Chair

May 4, 2020

_____

Hashima Hasan, Executive Secretary

Table of Contents

Prepared by Elizabeth Sheley
Electrosoft

Thursday, March 5

Introduction and Announcements

Dr. Hashima Hasan, Executive Secretary of the Astrophysics Advisory Committee (APAC), opened the meeting by welcoming the Committee members. Dr. Hasan then reviewed the Federal Advisory Committee Act (FACA) rules. As a FACA meeting, this meeting was open to the public, and minutes were being taken for the public record. There would also be opportunities for public comment. Each APAC member had been appointed on the basis of his or her subject matter expertise and must comply with Federal ethics laws applying to Special Government Employees (SGEs). Dr. Hasan noted that a number of APAC members had conflicts of interest (COIs) with specific topics on the agenda: James Webb Space Telescope (JWST, or Webb), Drs. Margaret Meixner and Michael Meyer; Laser Interferometer Space Antenna (LISA), Drs. John Conklin and Leonidas Moustakas; Wide Field InfraRed Space Telescope (WFIRST), Drs. Meyer, Moustakas, Asantha Cooray, William Jones, and Laura Brenneman; and Stratospheric Observatory for Infrared Astronomy (SOFIA), Dr. Meixner. These members were required to recuse themselves from discussion during the presentations for which they were conflicted. Any questions related to ethics should go to her.

Dr. Charles Woodward, APAC Chair, thanked Dr. Hasan and the members. The outcome of the meeting was to be a report to Dr. Paul Hertz, Director of NASA's Astrophysics Division (APD). Dr. Woodward asked members to consider items for future meetings to help focus projects and areas of concern. Dr. Conklin had agreed to serve as APAC Vice Chair for the next 12 months. Members then introduced themselves and described their areas of expertise. Drs. Moustakas, Lucianne Walkowicz, and Kelly Holley-Bockelmann were participating by phone.

Astrophysics Division Update

Dr. Hertz began his presentation by noting the upcoming thirtieth anniversary of the Hubble Space Telescope (HST) launch. Some anniversary activities have been delayed due to coronavirus concerns. The Spitzer mission recently ended after 16.5 years. This Great Observatory exceeded expectations. It is now in permanent safe mode. A science conference at Caltech celebrated its many science achievements. The Transiting Exoplanet Survey Satellite (TESS) has been up for 1.5 years and is delivering great science. TESS was designated for extended operations following the recent Senior Review (SR). The mission is currently in sector 22 of 27 in the prime mission, with 1,700 planet candidates detected thus far. Data are deposited in the public archives very quickly. A high school intern, Wolf Cukier, at the Goddard Space Flight Center (GSFC), discovered a new planet through TESS data.

Diversity and Inclusion

APD is part of NASA's Science Mission Directorate (SMD), whose Associate Administrator, Dr. Thomas Zurbuchen, is extremely committed to diversity issues and seeks to address the roadblocks and challenges faced by underrepresented communities. One of the focus areas for this effort is the pipeline for Principal Investigators (PIs). SMD has found that a number of elements pose difficulties for those not already in the system. Among the efforts to address this, SMD is creating resources and is ensuring that all review panels reflect community diversity across multiple axes. Announcements of Opportunity (AOs) now carry the expectation that mission leaders will mentor early career (EC) professionals. SMD held the first "PI Launchpad", aimed at researchers and engineers who would like to submit a NASA space mission proposal in the next few years but don't know where to start, at the University of Arizona in November 2019, providing networking opportunities with peers and industry partners. There have also been townhalls at professional meetings. The next PI Launchpad will be at the University of Michigan.

APD sponsors the Roman Technology Fellowships (RTFs), with three new fellows selected in November. APAC has previously discussed the Hubble Fellowship program. Most recently, APAC raised the issue of fellows having employee status at their sponsoring institutions, with parental leave and retirement benefits. The Space Telescope Science Institute (STScI) is proposing this as a requirement for Hubble Fellow host institutions, to go into effect with the 2022-23 academic year. The policy will hold for all institutions, though they can ask for waivers. Dr. Hertz was not aware of any requests for waivers, but STScI is collecting these, not NASA. The Future Investigators in NASA Earth and Space Science and Technology (FINESST) awards go directly to the institutions. APD has decided to double its funding for this program, thus doubling the number of graduate student researchers, which will result in 45-48 astrophysics graduate student researchers in the program at any given time.

Budget

The Fiscal Year 2019 (FY19) budget for APD came to $1.496 billion. At the time of the meeting, the budget for FY20 was still being worked out in terms of the operating plan and could not be shared, but it will be comparable to the FY19 budget allocations. About half of the budget goes to developing great observatories. Community support accounts for about 20 percent of the budget, as do operating missions, with management coming to about 5 percent. Community support includes the Research Opportunities for Space and Earth Sciences (ROSES), technology programs, GO programs, and research infrastructure. Operating missions include great observatory missions and Explorers. These percentages remain roughly similar over time.

The FY20 budget is $1.7 billion, the largest appropriation APD has had recently. This is $233 million more than FY19 and $532 million over the President's Budget Request (PBR). WFIRST is fully funded despite the PBR zeroing it out. The budget also fully funds Webb and specifies numbers for HST, SOFIA, and the astrophysics research program. It provides adequate funding to execute the rest of the plan.

The FY21 PBR was submitted in February. It is a great budget for NASA and SMD, though not so much for APD. Dr. Hertz noted some elements of that budget for NASA and SMD, which advances some of the compelling science priorities the National Academy of Sciences (NAS) identified in the last Decadal Survey (DS), including JWST. The SMD budget strategy will support the Artemis campaign, implement a balanced and integrated science program, and advance compelling science. A chart of SMD budgets over the years shows that Congress has typically appropriated more than the PBRs in recent fiscal years.

About ten years ago, NASA changed how it committed to cost and schedule, and began to budget at a 70 percent confidence level for every mission. Project managers are expected to work within their budgets, while Headquarters holds a portion of the budget in reserve as Unallocated Future Expenses (UFE). Some missions come in under and some go over, but the portfolio as a whole is 3 percent under the total budget commitments. The UFEs are designated for each specific project, rather than being in a pool. The process of deciding when to spend the UFE involves a set of reviews that goes to the governing program managing council and designated NASA managers.

The FY21 PBR for APD supports the launch of JWST; maintains the regular cadence of Explorers and Missions of Opportunity (MOs); initiates Pioneers, a new line of smallsats and major balloon missions; and terminates both WFIRST and SOFIA. It also extends operating missions beyond FY20, supports formulation of a probe mission as early as 2022 if one is recommended by the Decadal Survey, and supports mission concept studies and technology investments to implement the priorities of the upcoming Astrophysics Decadal Survey. Congress is already marking up this proposed budget, and Dr.

Hertz expected to have some information on that at the next APAC meeting in June. APAC was to have a presentation on the Pioneers program that afternoon.

The reasons behind the proposed termination of SOFIA were high costs and low science productivity; Congress will determine what to do. This is the third year in a row that the PBR zeroed out WFIRST, and Congress has previously reinstated that funding. The SOFIA and WFIRST losses are why this is not a great budget for astrophysics.

A DS wedge includes probe and the mission concept/technology investments. The latter addresses an increase in the technology budget beyond 2021 to enable a response to the DS; it provides flexibility. Dr. Hertz then presented graphic illustrations of what has and has not changed in the last two PBRs. On the sand chart, some of the change is due to Webb, but the drop depicts SOFIA and WFIRST ending. If Congress were to accept these cancellations, there would be some carryover for ramp-down. The appropriations committees will mark up the budget in the coming months, providing a signal of how each chamber will handle this. If it looks like they will terminate a mission, APD will have to start preparing for that, but the Division is not planning for termination of either mission at this point.

R&A Program

APD's Research and Analysis (R&A) program is robust. An analysis found that SMD brings in 300 new PIs each year, with a "new PI" defined as someone who has not been funded by the specific program in the last 5 years. This means that not all the same people win all the awards. SMD has several initiatives that involve APD. These include the Dual Anonymous Peer Reviews (DAPR), designed to reduce the impact of unconscious bias, and a High-Risk/High-Impact (HR/HI) research initiative to review and select more of these proposals, starting with ROSES 2020.

As yet, there has not been a DAPR pilot on technology or theory programs, just the HST Guest Observer (GO) program. The HST GO pilot showed that the initiative does reduce unconscious bias. APD's first smaller mission to experiment with DAPR will be the Nuclear Spectroscopic Telescope Array (NuSTAR), which was to begin panel reviews in 2 weeks. There will be levelers in each panel to make sure the reviewers concentrate on the science rather than the proposers. NASA wants to select the best science rather than just the names people recognize. There will also be a pilot for non-GO programs. APD will include the Astrophysics Data Analysis Program (ADAP) in that pilot. Guidelines will be available to the community on how to anonymize proposals and how to refer to their own work. There are two pieces to a DAPR proposal, the anonymous section and the non-anonymous section. Reviewers rate the first section but not the second. However, they can add comments on the non-anonymous section. STScI found no comments stating that the proposers were not qualified once they were identified.

APD had previously discussed the HR/HI initiative, and SMD took the input. There is a perception in parts of the community that NASA peer reviewers are biased against HR/HI proposals. A review of the selection rates indicated that HR proposals were not selected at lower rate, and reviewers did highly rate proposals on the basis of HI. Nonetheless, the perception that such proposals are disadvantaged remains. Therefore, to ensure SMD is managing this appropriately, PIs will self-identify whether they think their proposals are HR/HI. The panels will not see this. After the reviews, SMD will determine, based on the scientific evaluation, which of the non-selected proposals can go to a blue-ribbon panel that will do a further review. This is being done as a 3-year pilot. Dr. Massimiliano Galeazzi noted that PIs will figure out that they get a second chance if they designate the proposals as HR/HI. Dr. Stefan Immler pointed out that only a few proposals, which were deemed fundable based on their evaluation, will go forward. Dr. Meixner asked if HR referred to new technology. Dr. Hertz explained that it refers to

high intellectual risk, something that is off the beaten path and could affect the PI's reputation. The panels will validate whether the proposals are HR/HI, regardless of score. "Risk of reputation" is not his wording, but he has heard others in SMD define it that way.

Another concern was great ideas that might fall into gaps between ROSES elements. This has generated a great deal of discussion within SMD. The Directorate therefore put out a Request for Information (RFI) for thoughts on areas of science and types of proposals without a ROSES home. SMD received about 100 responses, about 25 of which mentioned astrophysics. SMD will look at these strategically to assess whether there should be changes to ROSES. Dr. Hertz wants no gaps in APD ROSES elements, so that every relevant idea is reviewed. Dr. Jessica Gaskin felt that the RFI did not address how to more efficiently use technologies and analyses, etc., across SMD. Dr. Kartik Sheth noted that she is not the only one to bring this up. Dr. Hertz promised an update at the next meeting.

There was to be an update on the R&A program, where new additions to ROSES would be described. These included APD participation in Topical Workshops, Symposia, and Conferences (TWSC), XRISM Guest Scientist, Astrophysics Explorers U.S. Participation Investigators (APEX USPI), Pioneers, Data Management Plan (DMP) will be evaluated as part of the intrinsic merit of proposals, announcement that ROSES-2021 will enable open software/code/source/models. An update on the SMD Strategic Data Management Working Group (SDMWG) findings would be provided to the APAC.

Technology and Missions

APD actively manages technology and is now doing an integrated biennial technology report instead of breaking it out by Program area. The Division maintains a database of the technologies in which it invests, indexed by individual projects, and the report covers gaps. NASA cannot afford to invest in everything, but there are priority tiers, and APD invests in the top tiers. Some of this is awaiting the upcoming DS priorities. Dr. Gaskin noted that she could not find suborbital in the database, and since new PIs usually go after the smaller projects, an inclusive database would be amazing. Dr. Patricia Knezek said that this discussion is ongoing, and while suborbital is not yet in the database, the intent is to include it. Dr. Hertz added that it would not be a good use of time to make the database encyclopedic, so learning what would be useful would be great feedback.

For Webb, the March, 2021, launch date is still on. The team is completing all changes after the last round of environmental testing, and there will be a final set of environmental tests. Final deployments will follow during the summer. NASA will do a schedule risk analysis at that time. The APAC meeting included an update on the agenda. The Webb team is where they need to be at this point and will not need to move, so any travel restrictions are unlikely to affect them.

There would also be an update on WFIRST, which completed Preliminary Design Review (PDR) and Key Decision Point C (KDP-C). The Agency funding commitment is $3.2 billion through launch plus commissioning. The coronagraph funding is separate, cost-capped at $334 million. With a 5-year prime mission, total costs should come to about $3.9 billion. The team is working to an October, 2025, launch date and has 12 months of schedule reserve. About 1/3 of the funds have been spent already through the FY20 appropriation. The coronagraph is a technology demonstration and thus will affect neither mission success nor the schedule. NASA wants to demonstrate the technology, but this element has a drop-dead delivery date. A lot of work has been done to ensure that it can be executed, including a

"tiger team" to identify reductions to cost and schedule risk, as well as off-ramps. A big change is to do the high-order wave front work on the ground. It simplifies the design. The WFIRST data will be public.

Missions in development include the Imaging X-ray Polarimetry Explorer (IXPE), which is in Phase C. The Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory (GUSTO) is on track and doing great on cost and schedule. The NASA portion of the X-Ray Imaging and Spectroscopy Mission (XRISM) is ahead of schedule, but the team is not traveling now due to the coronavirus. Euclid detectors have been delivered. The Spectro-Photometer for the History of the Universe Epoch of Reionization and Ices Explorer (SPHEREx) will have its PDR in the summer. The European Space Agency (ESA) is leading the Atmospheric Remote-sensing Infrared Exoplanet Large-survey (ARIEL) mission, to which NASA is contributing the fine guidance instrument, Contribution to ARIEL Spectroscopy of Exoplanets (CASE). This is a MO. For the Explorer program, APD is on track for a Small Explorer (SMEX) announcement soon and a Medium Class Explorer (MIDEX) AO in 2021. APAC was to hear a presentation on the Pioneers program, but Dr. Hertz noted that it will not be managed like a flight project, but rather like a suborbital program with additional oversight.

There was to be an update on SOFIA, which is fully funded for FY20. Dr. Hertz has told the team to keep going and will not make any changes until the Congressional markups are available. Dr. Cooray pointed out that the documents from the SOFIA reviews were highly redacted, to the point of being useless. Dr. Hertz replied that those were pre-decisional and not public.

Smallsats, Cubesats, and Suborbital

Dr. Hertz next listed currently funded astrophysics suborbital PIs, all within the Astrophysics Research and Analysis (APRA) program. Smallsats and cubesats are part of that. A second round of smallsat studies is included in ROSES 2019. APRA now funds one cubesat per year. APD is enhancing its management oversight of cubesats because this area is new to many PIs and some need additional help; these projects are not as easy as initially perceived. APD will make sure the projects are within cost and have the resources they need, etc. There are size issues among the Explorers, smallsats, and other smaller projects. For the recent SMEX AO, APD received multiple proposals that had no NASA Centers involved. To do a complex spaceflight mission – and SMEXes have tight limits – a PI will probably have to partner with an experienced organization. Some universities fall into that category. There is no requirement to partner with a NASA Center. SMD coordinates rideshares and smallsats.

The next balloon campaign is in New Zealand. The window opens in April. There will be two test flights before GUSTO takes off from Antarctica. There are three sounding rockets on the 2020 schedule as well. Dr. Hertz showed the schedules for the balloon launches. APAC had recommended that NASA investigate alternatives to the site in Palestine, Texas. Several candidates have been identified.

Artemis

All science opportunities enabled by Artemis will include astrophysics. Thus far, the Commercial Lunar Payload Services (CLPS) have selected two astrophysics payloads. From an internal NASA call, the program selected Low-frequency Radio Observations from the Near Side Lunar Surface instrument. A ROSES call selected Next Generation Lunar Retroreflectors. The APD 2019 MO included opportunities enabled by Artemis. The most important criterion for all proposals that leverage Artemis remains the astrophysics science merit. Regarding DSN bandwidth, humans on the moon will have large communications requirements, but when they are not there, the bandwidth can be available to science.

Dr. Hertz invited the APAC members to read the APD responses to the October, 2019, APAC recommendations. He added that the DS panels are asking NASA for a lot of information, and the Agency is being responsive.

ROSES Update

Dr. Immler began the R&A update by showing the ROSES-19 program balance. APA accounts for about half of the funding, with ADAP at 20 percent and Astrophysics Theory Program (ATP) at 13 percent. These are from a total funding of $95 million. APRA includes balloons, detector development, supporting technologies, and other elements. Strategic Astrophysics Technology (SAT) is outside of R&A. Dr. Immler showed the numbers of proposals reviewed, including GO programs. The total was 3,449, with 2,364 coming from missions and 1,085 from R&A. Selection rates were 26 percent for GO and Guest Investigator (GI), and 20 percent for R&A. Smaller solicitations are more focused and have higher selection rates. FINESST went from 4 to 11 percent; this includes partial funding. From the panel review scores, the Excellents (Es) and Excellent/Very Goods (E/VGs) are close to fully funded. Proposals with lower ratings are sometimes partially funded to enable the proposers to move forward and improve. This helps increase selection rates.

Dr. Suvrath Mahadevan noted that the low rate of funding for the Exoplanet Research Program (XRP) is a source of frustration. Dr. Immler explained that SMD is in the process of consolidating exoplanet research programs so that there is a single home for all exoplanet proposals from all divisions. The other science divisions are contributing to the funding of XRP, with APD's allocation being greatest. This is still in process. Dr. Galeazzi asked if this reflects the delay in APRA. Dr. Immler replied that the APRA rate is typical, but APD can carry deferred proposals due to budgets. There is a need to keep funds for ongoing work. Dr. Meyer said that the Exoplanet PAG (ExoPAG) discussed the resources for this program. The community is nervous. Dr. Hertz explained that the research budget is set. If APD were to increase XRP, that would necessitate decreases elsewhere. The Division does not move funds from missions to R&A. It is in APAC's purview to share thoughts about where funding might come from.

Dr. Immler presented notification dates by R&A line, noting the reasons for some of the longer timelines. Eighty percent of PIs are notified in less than 87 days, with the average 112 days across R&A programs and 108 days across GO/GI programs. Moving APRA and SAT to another time of year will likely improve their notification times. Of all the missions in operations, the Neutron star Interior Composition Explorer (NICER) was fastest to notify PIs.

Data on new PIs indicate that about half are new, with GO/GI programs having about one-third new PIs and R&A programs having 70 percent new PIs. Well-established missions tend to have well-established communities, while new fields tend to be attractive to new PIs breaking into the field. Only HST has had the Dual Anon reviews thus far, and those reviews resulted in a significant increase in new PIs.

Inferred PI gender ratios have females at 25-28 percent. One area where APD has influence is panel make-up, where the Division had 36 percent female on GO/GI reviews and 26 percent on R&A. Dr. Hertz noted that the most common question coming from DS panels is about gender. If there were to be a recommendation to not guess gender, that would create a tension between those in the community that want to know and those who do not want NASA to infer. Dr. Walkowicz advised working with the community to identify a solution; she did not think this was the correct way to address it.

Dr. Immler explained that selection rates are roughly consistent with submission rates, at 27 percent female on GO/GI and 23 percent for R&A. Dr. Galeazzi observed that the big issue in the submission

process is how to bring in more female submitters. Dr. Immler agreed, adding that career stage and institutions are related considerations. NASA is working on this from a number of angles; he showed panel data because that is an easy thing to do. Dr. Michael Garcia said that SMD is trying to be proactive, citing the PI Launchpad, which was an effort to help young and diverse people do spaceflight missions. It was noted that for the segmented telescope design research, the panel was all male panel, and they selected all females. This is a very small program, but ATP also had a 50 percent increase in the number of women.

Dr. Immler next discussed selection rates, which have been falling due in part to the proposals becoming more expensive and coming in at greater numbers. He provided data on cost and funding growth over the past 10 years. APD has not yet examined how higher university expenses factor into this. NASA will meet with the National Science Foundation (NSF) to learn what they have tried and learned. Dr. Immler listed the three new RTF fellows, then showed a sand chart of suborbital funding, which accounts for about half of APRA. APD has added $5 million per year to fund cubesats and has a healthy space in the budget out-years to make meaningful selections. HaloSat, APD's first cubesat, has been in orbit since mid-2018, producing excellent data. It will likely re-enter late this year. Dr. Immler listed upcoming cubesats, five of which are in development.

He moved on to discuss the ROSES elements for 2020, noting that some programs are not solicited every year. There will be a Topical Workshop, Symposia, and Conferences (TWSC) line funded by SMD. The XRISM GI will be a one-off. APD will enforce the data management plan as part of the proposal evaluation. Starting with ROSES 2021, all software, code, sources, and models must be made open. If PIs want to keep data proprietary for a while, they can make a case to do so, but they will need to keep data in a form that can be made public. University servers and other sources can function as archives. This will affect costs for some, and there has not been a study of the cost-benefit, but NASA is trying to be flexible on this. Dr. Woodward noted that some codes are export-controlled and cannot be released. The idea of curation opens up the Agency to understand what the data management actually involves. If there are disparate architectures, there will be issues. This could inadvertently disadvantage institutions that do not have the capacity to do this. Dr. Immler agreed, noting that in that case, the PI could explain the need for extra funding to address this. Dr. Woodward wanted APAC to come back and discuss this further.

Dr. Immler addressed the APAC recommendation on removing barriers to greater diversity. APD has implemented steps in this direction, which he listed. These include doubling of FINESST funding, a number of steps previously discussed regarding peer reviews and panels, and the Dual Anon program. APD welcomes APAC recommendations on how to further reduce barriers. Dr. Holley-Bockelmann suggested a competed apprenticeship for new PIs, and Dr. Woodward asked her to send an email with some thoughts on this. In answer to a question, Dr. Immler said that he would verify the XRP contributions from the other divisions, and get details on how that review will be conducted.

Next in rolling out APD's Dual Anon peer reviews will be NuSTAR Cycle 6. The review could be virtual due to travel issues. By later in the summer, all reviews will be Dual Anon. APAC had had two recommendations on this, to which NASA has responded by implementing a number of initiatives that Dr. Immler listed along with the communications timelines. Dr. Galeazzi noted that the WebEx event on March 3 exceeded capacity. Dr. Immler said that a redirect allowed everyone to participate, but NASA is aware of this and will watch for issues. The materials will all be published. Since FINESST is an SMD solicitation, he would have to check to see if that review would be Dual Anon.

Engaging in Global Issues as a Sagan Fellow

For the lunch presentation, Dr. Raphaelle Haywood, a Sagan Fellow, discussed how astronomers can use their positions in society to address environmental issues. Exoplanet research often seeks Earth-like planets, more precisely planets with observable properties similar to those of Earth. Kepler and other missions have enabled us to determine some of these characteristics and what is meaningful. About 21 percent of the exoplanets examined thus far fit the category, but we have only looked at a small portion of all stars. The expectation is that with 300 billion stars in our galaxy, there are 63 billion temperate, Earth-size planets. This gives perspective on our own planet.

Dr. Haywood described her personal journey from astronomy into sustainability. She obtained a certificate in sustainability from the Harvard extension program, which being a Sagan Fellow allowed because it paid her tuition. She pulled her astronomy work forward into this area by modeling what Earth would look like if observed from outer space as an exoplanet. She presented spectrum and models that give the signature of vegetation. When that model is applied to the ocean and the rainforest, the wavelengths indicate that the rainforest is part of Earth's astronomical identity. Dr. Woodward asked about wavelengths and noted that there is an assumption of habitability that relates to stability, and an active flare environment would affect many planets. Dr. Haywood agreed that flare activity would be exciting to observe, especially if there are biosignatures on some of those planets. She was not sure how the wavelengths would change with planetary rotation. Similarly, the impact of binary stars is unknown.

ExoPAG Report

Dr. Meyer began the update on ExoPAG activities by noting upcoming changes in the Executive Committee. He then showed the status of the two Study Analysis Groups (SAGs) and the existing Science Interest Group (SIG). A new SIG is being proposed. Recent activities include a session at the January American Astronomical Society (AAS) meeting. ExoPAG is experimenting with having a mini-science symposium, and wants to integrate student presentations and align the symposia with the science gap lists. There is a community data challenge to compare algorithms in finding planets in ground-based direct imaging datasets. There was also a cross-PAG meeting of ExoPAG, the Venus Exploration Analysis Group (VEXAG), and the Outer Planets Analysis Group (OPAG).

SIG 2, which addresses exoplanet demographics, is ongoing and long-term with a broad charter and a number of different parameters. The members are gathering data and will release a report soon, with additional reports in the future. SAG 20 dealt with the JWST delay and has a report on the site.

ExoPAG 21 generated several findings. The first was to endorse assembling a catalog of target stars, for which there are precedents. Vetting the data can be intensive, and ExoPAG is trying to determine what the needs would be. The second finding was to share ExoPAG's work with other divisions, while also receiving reports from those divisions. Finally, ExoPAG wants close monitoring of XRP outcomes and funding in order to avoid unintended consequences.

ExoPAG is proposing SIG 3, on Exoplanet/Solar System (ExoSS) Synergies. The goals are to provide opportunities for discussions on exoplanet comparative planetology, and to explore how exoplanet and solar system missions can benefit from each other. This would be a tool to promote communications and cross-disciplinary interactions. ExoPAG is formulating two additional SAGs that are not yet ready for submission. One is on stellar contamination and transit spectroscopy. The other would address cataloguing stellar properties for future missions.

SIG 1 has a close-out request. ExoPAG would also like to close SAG 19 and initiate SIG 3, and welcomed input on the new SAGs in development.

PhysPAG Report

Dr. Graca Rocha, chair of the Physics of the Cosmos PAG (PhysPAG), presented the update. PhysPAG has six SIGs, addressing cosmic rays, cosmic structure, gamma-ray astrophysics, gravitational waves, inflation probes, and x-ray astrophysics. There is also a Multi-Messenger Astronomy (MMA) SAG, which Dr. Rocha discussed in more detail. The MMA SAG seeks to: identify science goals that could be achieved by combining different astrophysical messengers; identify measurements that can be made by existing and planned ground- and space-based observatories through the early 2030s; determine how these goals align with APD priorities; and identify the key technical drivers needed to achieve these science goals. The SAG is organized around astrophysical sources rather than wavelengths or spectra.

To date, MMA SAG has solicited membership, held monthly telecons and source team meetings, generated white papers, and organized conference sessions. PhysPAG sent APAC the final report before the meeting, and was asking the Committee to accept the final report and close out the SAG. Dr. Rocha listed the findings, then gave brief updates on the six SIGs. The PAG is now discussing how to best meet its goals, especially at under-resourced institutions. This involves information-gathering and communication. PhysPAG is also preparing for the DS outcomes. There were plans for a PhysPAG/Physics of the Cosmos (PCOS) session at the April American Physical Society (APS) Meeting, and the PAG was organizing sessions for the AAS High Energy Astrophysics Division (HEAD) meeting in September.

COPAG Report

Dr. Meixner presented the Cosmic Origins PAG (COPAG) update. The PAG made presentations at AAS in January. COPAG has two active SIGs: UV SIG and IR SIG. There is a Technology Interest Group (TIG) as well. These groups have had some leadership changes. SAG10, on Great Observatories, completed its report and closed out. SAG11, which addresses the Cosmic Dawn, is recruiting members.

After the AAS sessions, COPAG developed some directions for improvement. For example, it was observed that technically minded people arrive early and attend related splinter sessions, so it might be helpful to have a broader TIG discussion before AAS. Since the science-focused JWST presentation was not well-attended, the PAG will try to improve communications to AAS attendees. The Great Observatories splinter session was the best attended, and this effort may be continued. The PAG will consider scheduling and communications for future sessions.

Dr. Holley-Bockelmann felt that there might be a missed opportunity, given that JWST will launch soon. She would start thinking programmatically and also about traditional observatories, as well as strategic campaigns and applications. Dr. Woodward suggested thinking about how to get this to be tangible and real to the community, possibly through more concrete interaction discussing the key issues. Dr. Holley-Bockelmann agreed, stating that it would be good for the major players and observatories to acknowledge that MMA presents a major opportunity.

Dr. Meixner said that the IR SIG has been very active, publishing a comprehensive newsletter and getting grad students and postdocs involved. She described their AAS splinter session. They have new, young co-chairs who are reaching out to the JWST and WFIRST communities. SAG 10 is closed out, and APAC was helpful in vetting the report. Dr. Meixner described the focus, goals, and schedule for SAG 11, the

Cosmic Dawn SAG. COPAG is recruiting for the TIG, which assesses technology gaps. COPAG will continue with future activities and did not require any action from APAC.

Dr. Woodward suggested planning a formal technology conversation early on at the conferences, to include industry people. Dr. Meixner thought that might work, since the technical people tend to show up early. Dr. Conklin thought it might also be a good way to align the PAG activities. Dr. Woodward agreed, noting that there is more and more cross-fertilization. APAC could think of this as a recommendation.

Dr. Gaskin asked if COPAG looks at technology gaps. Dr. Meixner said that it does, but it would be nice to have a standing group to get more community engagement and ensure representation. Dr. Meyer observed that ExoPAG might have a different culture from COPAG. He got the impression that there was a lot of focus on the technology gaps and industry, and that was balanced by pulling in more science. It seems the technology gap lists are handled differently. ExoPAG is getting more scientists and fewer industry types. Dr. Sheth said that it would be good to get away from the wavelength orientation. ExoPAG seems to be moving in that direction. Dr. Gaskin was concerned that separating by wavelength will define the community sizes and propagate some of the stovepipes. It would be challenging. Dr. Sheth said that APD has had positive feedback since shifting the fellowships to being science-based.

Astrophysics Pioneers Program

Dr. Hertz noted that there had been a question on how much had been spent on WFIRST thus far. Out of the $3.2 billion to be spent on development, the mission will be at $991 million through the end of FY20, which is 31 percent. The project has spent 51 percent of the coronagraph funds. The two combined account for 33 percent of the projected development funding.

Dr. Garcia explained that the Pioneers Program was introduced in the FY21 PBR as a new class of small missions. It will fill the gap between ROSES and Explorer MO investigations, in the $10-35 million range. These will be managed as R&A projects with enhanced oversight, and will be solicited through ROSES rather than as Explorer MO proposals. The Program will include smallsats, large cubesats, cubesat constellations, major balloon missions, and International Space Station (ISS) attached payloads. There will be much less paperwork than with Explorers, and the Program should relieve the Explorer MO proposal burden.

This is a good idea because there are numerous opportunities for low-cost rideshare and spacecraft buses. Super-pressure balloon capabilities are now coming online and can incorporate lessons from a number of missions. The Program also strengthens APD's partnerships with commercial providers. SpaceX will do ESPA-class payloads monthly, starting soon, and it will be cheaper than what NASA currently does. Some of the other partners are new; Dr. Garcia gave some examples.

Dr. Michael New said that on every launch that has extra capacity, NASA will have ESPA rings. Dr. Cooray asked if there might be guidance to teams on the various launch capacity options, given that ESPA rings have different mass and volume limitations. Dr. Garcia said that this is evolving, and a rideshare user guide is in development. The thinking about separate launches is also evolving. The most developed standard is the ESPA ring. The goal is to do compelling astrophysics science in smaller forms and at lower costs than Explorers. Among other changes, NASA will no longer solicit ISS attached payloads within APRA, but will do them in this line instead. Similarly, the Pioneers Program will be the source for soliciting major balloon payloads; those with cost compatible with APRA can be proposed there. Pioneers will include smallsats, cubesats greater than 6U, major balloon payloads, and modest ISS

attached payloads with a $20 million cost cap, not including launch. The Program will employ lessons learned to carry out these science missions using enhanced research project processes with defined gates and light management. The light touch will enable greater risk. The Wallops Flight Facility (WFF) will provide limited support in a slightly different role from its usual mission management. Dr. Hertz clarified that "mission manager" at Headquarters refers to a person who is the liaison to the program office but not part of the management team. Here it refers to a WFF program office providing oversight, not a deeply involved individual.

Dr. Garcia explained that there will be defined criteria. The projects can include new technologies, but science is the focus. The Program will also include training of the next generation of investigators as a review criterion. Proposals must include plans for trades to be considered during Phase A, and proposers are invited to work with NASA design labs. NASA will provide a second, uniform design lab run for all concepts as part of Phase A; this will be specific to smallsats and cubesats. Much of the prior data has been based on large missions. Proposals must include costs and schedules for Phases A through E. NASA will provide the launches via the CubeSat Launch Initiative (CSLI), rideshares, ISS commercial cargo, balloons, etc., and these will be outside the cost cap. There will be a single ROSES peer review, with no separate Technical, Cost, Management (TMC) panel. Missions will be cost-capped at $20 million; anything under $10 million is ROSES/APRA, and anything more than $20 million is Explorers MO. There will be a maximum of 5 years for the projects.

There will be a peer review and a Phase A study that will include costing. Dr. Hertz added that the schedule includes soliciting community input. Dr. Garcia noted that of the smallsat studies APD has done, three quarters have come from universities. Dr. Brenneman was concerned that the schedule seemed compressed. Dr. Garcia explained that APD will do mandatory notices of intent to help assemble peer review panels. Dr. Meixner suggested providing a spreadsheet that shows what needs to go into one of these in terms of infrastructure. Dr. Hertz noted that NASA is seeing that not every university can manage a simple cubesat. The question arises then as to how PIs recognize what they need to be successful. NASA does not want to imply that everyone can do projects at this level on their own. The Agency needs to make sure it has the pipelines set up. Dr. Gaskin asked if this will be HR/HI. Dr. Hertz replied that the rules will have to be developed, though it would be hard if he had to do an extra one. Dr. Linda Sparkes stated that they are all going to be high risk.

<u>WFIRST Update</u>

Dr. Woodward listed the COIs for the WFIRST presentation: Drs. Cooray, Jones, Brenneman, Meyer, and Moustakas. Those APAC members had to recuse themselves from participation in this update.

Dr. Jeff Kruk presented a graphic of the WFIRST design. There have been no changes in the science program. The mission passed the confirmation review, KDP-C. The last WFIRST presentation to APAC was during the mission PDR. The only changes to the mission baseline since then involve the coronagraph status, which is now Class D. As a technology demonstration, it will have no Level-1 baseline performance requirements. It also has a separate cost cap and schedule. The team has tried to keep the same design and performance requirements, and the greatest concern relates to maintaining schedule rather than performance.

Dr. Kruk described the Standing Review Board (SRB) findings. By time the Directorate Program Management Council (DPMC) met, the team had implemented most of the SRB recommendations. There is now a stakeholders group for the coronagraph and the future mission concept studies. There

will be a presentation to the DS panel, which wants the project status. The next mission milestone is the Critical Design Review (CDR) in July, 2021, which does not have a headquarters KDP associated with it.

The flight mission elements have been in Phase C since their respective PDRs. The data processing work is still effectively in Phase B, with workshops and working groups moving forward. One of the engineering test unit filters (ETU) for the wide-field instrument has a slight deviation from the specifications, but it is quite small; the other ETU filters met all specifications. The telescope primary mirror has completed cold tests and is ahead of schedule. Because the inherited telescope did not provide everything needed, the mission has been fabricating some engineering test units for new hardware components. Reconfiguration of the secondary mirror is almost complete.

Five detectors have passed acceptance testing and appear to be good flight candidates, and characterization testing has begun. If the flight yield continues to meet expectations, the 18th detector should arrive next January, which would be on schedule. These are not on the critical path but are close to it. A substrate issue slowed things down. The team wants a reasonable set of detectors in order to begin testing. Thus far, those that have come in are passing all tests and exceeding design goals. Dr. Kruk presented the test data from the five he mentioned.

The ground system architecture has not changed. The team has negotiated some of the international agreements for data. Work is now being done on the computing, which will likely be in a cloud environment to enable high-volume computing. The plan is for the mission to cover those costs. SMD has a cloud computing initiative. IT security and other parts of the infrastructure will not cost the project.

WFIRST is pursuing an early acquisition of the launch vehicle through NASA's Launch Service Program (LSP) in order to better define its planning. Dr. Woodward asked at what point in the schedule the coronagraph stops being a driver. Dr. Kruk replied that that happened the previous Friday. The design has to be to the specifications they have now. He showed the launch vehicle environments for which the team will be doing analyses. They are also doing the Science Requirements Documentation (SRD) requirements verification, which involves very high fidelity simulations of the observation program. The master schedule shows that the launch date has slipped from September to October 2025.

Dr. Kruk noted that there were about 130 engineering peer reviews leading up to PDR. The engineering development units of many hardware items are already built, and for many components the current design is what will be built and fly. FY20 and 21 are the peak budget years, with almost 1,000 people working on the mission. Although the FY21 proposes cancellation, the team will proceed according to plan while Congress deliberates. The plan is to still launch in 2025.

Dr. Gaskin asked Dr. Kruk about his major concerns. He replied that missions start running into issues at this juncture. He is less concerned about the hardware than the data processing, which is uncharted territory. The people on it are good, yet the world of cloud computing is changing rapidly. Dr. Woodward observed that assembly is a potential challenge. Dr. Kruk said that this is the year during which they will be building the focal planes. Dr. Holley-Bockelmann raised the issue of user support. Given that the model for the pipeline will be different, she wondered about access to the cloud and any specialized hardware. Dr. Kruk replied that the intent is that it will be transparent. In the coming year, the team hopes to start community participation, which should be extensive.

Dr. Hertz explained that there is a lot of concern about travel, and many potential peer reviewers will do a virtual review but not in-person reviews at this point. Therefore, at least through end of April, all peer reviews will be virtual. The Division will make calls on a rolling basis after that. APD will collect data on the performance of virtual panels as they go along. There have been virtual panels in the past.

Public Comment Period

The meeting was opened to the public for comment, but no one came forward.

While the meeting participants waited to hear if there were any comments from the phone lines, Dr. Meyer said that the process for selecting Pioneers sounded very similar to the SOFIA next generation call in the way it was organized. He wondered if the assumption was that the costing was not the big issue. Dr. Sheth explained that APD was thinking of dates for the suborbital program, which might be more similar. The Division wants to ensure they catch whether PIs need help and if they can do the project.

Dr. Jones was concerned that while the Pioneers Program can do great good, a funding profile of $20 million over several years will favor NASA Centers, and a university might have trouble scaling up. It will favor certain applications over others and will lean to off-the-shelf technologies. It may also affect different sorts of investments inconsistently. Dr. New said that SMD had experience with the Earth Venture Instrument (EV-I) missions, which are similar.

The public line was then closed.

Discussion

Dr. Woodward said that the Pioneers Program seems laudable, but there are questions on the details. He wanted APAC thoughts on this. First, however, he wanted to know if there were any comments on the APD and ROSES updates. Dr. Gaskin said she was struck by the success of the PI Launchpad. She would like to see follow-up on that and learn how those new PIs implement what they learn. She wondered if it should be a training situation. She found the HR/HI initiative to be interesting, and would like to see the technology development database include suborbital work.

Dr. Meyer wanted to applaud the accomplishments of HST and bid goodbye to Spitzer. A follow-up on the PI Launchpad would be a great idea, maybe as a post-survey to see if there are barriers participants still encounter. Dr. New said that he was involved in PI Launchpad. SMD plans on doing a focused incubator after conducting two or three more launchpads. Work is still being done to analyze the pre- and post-Launchpad surveys from November. The team plans to put most materials online, and also set up a Slack channel for participants. He will raise the issue of a longitudinal study. The core group is still together and wants to do the next one later in the year in Michigan. It would be great to have someone from the south help host the next one after that. NASA does not historically provide funding for people to write proposals to NASA. However, the Planetary Science Division (PSD) has had a summer school at JPL that goes through all the steps, and the Heliophysics Division (HPD) will run a similar one this year. He urged APD to consider this as well.

Launchpad participants had to have proposed something somewhere at some point, but the organizers did not want people who had been in a leadership capacity. Some participants had a passing acquaintance with this work but many did not. SMD has learned that there are gateway institutions that have strong relationships with NASA. However, at the many institutions not in that category, students and postdocs are often totally at sea. Dr. New explained the funding of the effort, much of which came through the Heising-Simons Foundation, and which he hopes will continue.

Dr. Cooray said that the redactions made to the SOFIA review documents made available to APAC concerned him, and he wanted an official response from the review board Chairs. Dr. Jones added that the response effectively blinds APAC, and Dr. Woodward agreed that the absence of information precludes APAC assessment. There was to be a SOFIA presentation the next day, at which time Committee members could ask questions that would inform their recommendations. Dr. Hertz noted that the executive summary has been made public. Dr. Woodward countered that APAC wanted a response to the recommendations, and the documentation they received was too redacted to be useful. Dr. Meyer added that the mission team said they could not do some of recommended actions. Dr. Gaskin pointed out that there were things that were unclear and others that were nonresponsive. Dr. Meyer concluded that the issues they wanted addressed were not dealt with to their satisfaction. Dr. Woodward suggested further thought on this topic.

Regarding WFIRST, Dr. Woodward added that KDP-C is a notable accomplishment, but he had concerns about the mechanism for launch vehicle selection. Dr. Hertz explained that NASA typically leaves open multiple options for launch vehicles because there are multiple options available. WFIRST will put out an RFP for bids. In the meantime, it needs to be designed for compatibility to the potential launch vehicles. This chicken/egg problem reflects procurement laws. LSP has engaged with APD on working through these issues, however. This happens for all of NASA's strategic missions. The project has experts advising on the interface issues, and he is not looking to APAC for that kind of advice. Dr. Woodward confirmed that the salient observation is that WFIRST has sought to engage early.

Dr. Holley-Bockelmann said that she would synthesize some of her ideas on the PI Launchpad process. Dr. Moustakas wanted follow-up on the funding levels and approaches for XRP. Dr. Hertz asked him to send Drs. Immler and Woodward his specific questions. Dr. Mahadevan asked about the balanced program in R&A as pertains to XRP. Dr. Hertz explained that there has been a lengthy discussion about the right way to balance R&A. He prefers to invest in the most compelling proposals rather than fund in reaction to proposal pressure. There has not been usable advice come from studies of the issue. Dr. Conklin observed that XRP seems to have much narrower range of topics than ADAP or APRA. Dr. Meyer pointed out that ExoPAG has a finding that the acceptance rate is worth paying attention to. The big concern is the evolution of the program. If the PAG feels more strongly next year, they will state it more strongly. Dr. Woodward suggested that APAC think about when to make a statement.

Another point was the proactiveness of the MMA and great observatories rather than scrambling after the fact. It is comparable to this way of looking at exoplanets. The more junior members of the field approach the science differently now – they are more cooperative regarding the science goals rather than the wavelength goals.

Adjourn Day 1

Meeting was adjourned for the day at 5:03 pm.

Friday, March 6

Opening Remarks

Dr. Woodward opened the meeting for the day.

Science Data Management Working Group Report

Dr. Knezek discussed the report that the Science Data Management Working Group (SDMWG) put together on computing and data management (DM) for the next 5 years. This is not a new effort, but rather builds on the Big Data Task Force (BDTF) efforts of 2015-17. In parallel to that, SMD identified DM and computing as a priority area for assessment and action. SDMWG began work in 2018. The NASA Advisory Council (NAC) Science Committee (SC) had recommended investments, partnerships, and other actions. In response, SDMWG tried to create the infrastructure to move some of these ahead, also using the open code recommendations from a National Academy of Sciences Open Code Recommendations for NASA's Earth Sciences report.

SDMWG's principles were to improve discovery and access for all SMD data to enable more science; leverage technology and enable new technology; identify large-scale and cross-disciplinary users; and champion robust theory programs. Given the breadth of the various SMD communities, the Working Group sought broad input, and therefore held internal and external workshops, while also issuing an RFI. More than 450 people participated in those efforts, and the astrophysics community had strong representation. The input was used to develop core tenets: the status quo will not work, SMD wants to be proactive and flexible, there should be greater coordination among divisions but not full centralization, and the efforts should be reassessed periodically.

The driving force is to enhance how the community can access data. At present, cross-disciplinary access is not possible, and the High-End Computing (HEC) is not state-of-the-art. If NASA can develop the infrastructure for that, it will help the science. ESD and HPD are already addressing this. In addition, decentralization leads to some reinvention of the wheel. The divisions want to learn from each other and those in other areas in order to learn best practices and coordinate when appropriate in order to facilitate more science using NASA data. Awareness, and uniformity across platforms, will facilitate this.

The SDMWG is at the early stages with software, which has trailed DM efforts. Dr. Woodward said it sounded like new investments are needed for infrastructure. He also wanted to hear more on the proposed centralization. Dr. Knezek said that it is up to the divisions to determine how to implement the policies for their communities. This also responds to the requirement for public access to science. The findings and recommendations addressed open data/open software, as well as the associated funding. Dr. Meixner asked if this also means there will be no proprietary data. Dr. Hertz said that the initial drafts state that, and there is discussion of APD's 6-12 months of GO proprietary data, which no other division has. The other divisions make data available immediately.

Dr. Knezek said that the HEC program is recommended to be assessed no less than every 5 years. Recommendations on archives modernization aim to enable additional access and allow more science to be done. The goal is to enhance the ability to do science. There is a server, called PubSpace, that allows access to manuscripts that result from NASA-funded research. The Working Group made recommendations for advanced capabilities, and also recommended that SMD have a data officer to coordinate both internally and externally. SMD will be advertising for the job within the month.

A number of ROSES 2020 changes address the recommendations. First, software created as a result of a ROSES award is to be publicly available where practical and feasible, and where there is a scientific purpose. However, it is not necessary to provide every piece of code, just what is useful. She believes there is a guide to a number of repositories for the kinds of data that SMD researchers generate. There

are descriptions of the kinds of software and examples. Dr. Brenneman was concerned that the language was vague. Guidelines need to be definitive for the benefit of both proposers and reviewers. Dr. Jones agreed, and suggested including language about the proposer's track record of making data available. Dr. Galeazzi concurred, stating that the DM needs to be part of the review. Dr. Hertz said that that change has been made. Dr. Brenneman advised that this be substantive, and Dr. Hertz asked to have that in the letter. Dr. Gaskin cautioned about removing flexibility from PIs, especially on small grant proposals where they are already struggling. If they are held accountable for their first efforts yielding less-than-great results, there is a risk that NASA will miss out on innovation. In addition, not everyone has the same resources.

Dr. Walkowicz said that data access is neither binary nor arduous. Putting data on a website is not a robust way of enabling access. Even where results are not spectacular, it is important to share the tools that led to the results. Dr. Knezek said that there has been a lot of discussion, and the language is vague because the guidance will be in the individual elements. SMD does not want to be prescriptive at the top levels. The last new thing is that there is a placeholder to support open source tools and resources. ROSES requires publications to be uploaded into NASA Pubspace, NASA's section of the PubMed Central (PMC) repository. This will be part of the Senior Reviews, which will now include archive reviews. The PMC requirement goes through the Office of the Chief Scientist (OCS). Dr. Hertz added that in APD, it is completely redundant with the Astrophysics Data System (ADS). It is also transparent to the user.

Webb Update

Dr. Eric Smith provided the JWST update. Webb has been approved to enter Phase D, integration and testing (I&T), and is working to a March, 2021, launch readiness date (LRD). The observatory successfully completed post-spacecraft element testing and repairs. In the area of science and operations, ground segment testing and operations rehearsals are ongoing, software elements are exceeding requirements, and the call for Cycle 1 GOs was released in January. The schedule shows 63 days of funded schedule reserve. The flight software is frozen 6 months in advance of launch. All FY20 milestones are ahead or on time thus far, with the remainder looking good. Dr. Smith listed the remaining I&T activities. The team is working at the observatory level on this. There are only four first-time activities left, two of which are minor and relate to shipping.

Nonetheless, Webb is very complex. One of the upcoming tests, comprehensive system test (CST) 4, will be an important verification for all of the electronics (one more, CST 5 will happen before launch). The team is developing criteria for the final test ratings, which will be pass/fail and externally reviewed. The project carries an extensive risk database. Deployment risks reflect plans that have been rigorously followed for years. The criteria will help keep the team from letting things pass in order to meet schedule pressure.

Technical issues include the Traveling Wave Tunable Amplifier (TWTA), one of which failed prior to spacecraft element thermal vac testing. After obtaining and testing two new ones, it was determined that the problem was in the electrical power system portion of the TWTA. There is redundancy; each of the two Webb TWTAs has its own electrical system. These (TWTAs) are commodity products, and the manufacturer makes thousands of them. The Command and Telemetry Process (CTP) also had a failure, which has been reproduced. The problem is now being addressed. Fairing depressurization came up when another system had residual pressure at fairing pressurization (Atlas launch, but with the same fairing). The Arianespace team tested more sensitive pressure transducers, and will test again in June. The fairings themselves lack seals on their edges. They will be sealed for the June launch. Engineering is looking at the implications of this. The target residual pressure differential is 18 pascals. The team needs

to determine the error bars on this value for the upcoming test. There is also a question of whether the project is carrying too much margin when it developed this target. The systems engineering team has been tracking this for 2 years and is looking at the level of conservatism built into the number and its validity. Dr. Woodward said he would like an update at the next APAC meeting, currently scheduled for June 23 and 24. Dr. Smith said that the current worst-case scenario vis-à-vis schedule pressure would come in before the observatory post-environment deployments begin.

There have been issues with the membrane release devices (MRDs), which hold down the sunshield, and non-explosive actuators (NEAs), which release it. Engineers found that during ascent, there are negative margins on some MRDs. The concern is that during vibration, a collet might bend and causing the release pin to stick. The MRDs collets are being remade of a different material and will be tested. Different issue: One of the NEAs got hung up during a test, so the mission has slightly increased the thickness of the wire. This has been flown in other contexts hundreds of times. This will not affect the schedule, but there are 107 of these, and all must successfully fire to deploy the sunshield.

Preparations for operations continue. STScI conducted nine launch and commissioning rehearsals in 2019 and will conduct more in 2020 with increasing fidelity to the launch and commissioning timelines. Cycle 1 proposals are due in early May. Experience from the last call indicates that people did not allow enough time to familiarize themselves with Webb proposal tools. The team is urging investigators to start earlier.

Dr. Smith described the process of shipping to Peru and showed a graphic of the complex there. There are charts for every day of activity there. For example, the NEAs that hold the telescope to the spacecraft bus are put in after shipping in order to avoid stress. The ship will have a Navy escort out of California. Nine days before launch is the hoist onto the launch vehicle, and 6 days before is the encapsulation.

Every year since 2011, the mission has had a General Accounting Office (GAO) audit. The schedule margin is tight for the March, 2021, launch; if everything had been perfect, there would be 2 additional months of reserve. The team will reassess the schedule in May. They want to avoid getting “launch fever,” but they also want this telescope in orbit. There will have been another schedule assessment by the next APAC meeting. Dr. Woodward asked about activities that could add stress to the schedule. Dr. Smith said that the most stressful would be things learned in the upcoming observatory post-environmental deployment testing. The full observatory vibration test could present challenges, which will show up in the observatory post-environmental deployment testing. The team is confident, however. Northrup Grumman has been working well. Good management attention on I&T and high-level personnel have made a big difference. NASA has embedded a lot of people at Grumman as well.

Dr. Mahadevan asked about options if the current launch date cannot be met. Dr. Smith replied that there are launch windows almost every day of 2021. Dr. Gaskin asked if there might be anything APAC could do to help the mission. Dr. Smith said the members could tell their colleagues to get familiar with the proposal tools early. STScI will help. They are holding classes and doing everything they can, but people wait. Dr. Jones said it would be good to get input from STScI on the first round. Dr. Smith said that the May, 2020, date will not change even if the launch shifts. It would help to get that message out.

Dr. Walkowicz said that a short list of what people could have done thus far, including common mistakes, would be helpful. Dr. Meixner said that STScI encourages use of the help desk, which collates and develops FAQs. She asked APAC members to tell everyone to start now. Dr. Walkowicz observed

that a more effective way of getting people to start is by giving them ways to improve and scaring them a bit. Dr. Holley-Bockelmann agreed. Dr. Mahadevan asked Dr. Smith what was not in the presentation that worries him most. Dr. Smith replied that his worries are in the observatory post-environmental deployment tests and the criteria of what the mission can accept. Can the team be smart enough to think of everything before they go into this? Before the Challenger launch, NASA was doing the right things and still missed something.

Discussion

Dr. Woodward thought they had a reasonable discussion of the launch date and concerns, and believed the rest of the issues had been satisfactorily described. He asked if there were any other thoughts about Webb. Dr. Conklin said it seemed like the use of margin has slowed, which is good news. Dr. Brenneman asked if anyone in the room had tried to start a JWST proposal; several members raised their hands. She said she had heard some pushback on having a single phase proposal process. Dr. Meixner explained that most GO proposals are single phase now, as it is faster. Dr. Brenneman was concerned that it might be arduous for the proposers. Dr. Woodward thought that was a reason to urge the community to start early. The available tools have improved. It is important that the help desk get the range of questions so they can develop a dynamic database. He was concerned more with resource allocations and the time estimator. The community also needs to be aware of changes in the documentation structure. Dr. Brenneman wondered if it might make sense to have two stages, given the likely number of proposals. Dr. Woodward thought the community understands it will be a highly competitive environment.

Dr. Moustakas asked what level of funding will be available to the community for proposals and if it is comparable to HST. Dr. Smith replied that it is larger than for HST, with $40-45 million to the community. It is possible to submit an archival proposal for it, and it has not even launched yet. Dr. Galeazzi asked how open data will affect this. Dr. Hertz said that NASA already has many observatories with no limits on the data access, and the Agency funds people for research on them. There are no plans to switch the model unless the community recommends it.

Dr. Mahadevan said that with HR/HI and putting reputations on the line, that should be the opposite of what they want. Dr. Hertz replied that, based on the data SMD collected during the 1-year pilot, they believe NASA is rewarding people for high risk. The 3-year pilot will reassure the community of that. Dr. Woodward asked if there were thoughts on the implementation of the vision presented for the Pioneers Program. Dr. Gaskin said it felt too early to comment and she would like community feedback first. Dr. Jones was concerned about unintended consequences, which might even be negative. He wants NASA to think about this. Dr. Conklin thought there might be problems with some institutions not having access to NASA Center assistance during Phase A. Dr. Hertz explained that NASA has run several programs in which that access has been negotiated after selection. Dr. Conklin asked how that might operate if he is writing a proposal and wants to work with a NASA Center for information. Dr. Hertz said that for the APD smallsat study call, the Division arranged for multiple NASA Centers to make their services available to proposers. APD will ensure that Pioneers will not be an “in crowd” program. The various design labs have varying strengths. Dr. Galeazzi said that the labs ask for about $80,000 and do not offer more beyond general support for the proposal. He suggested this as a good topic for the next APAC meeting, at which point they will know more about the call.

Dr. Mahadevan asked what, with the gate being the NASA Center costing and the risk profile being lower, the balance is between the NASA Center costing and nimbleness in use of funds. Dr. Hertz said that he could not answer that question yet. NASA has to use some tool to assess the chances the PI will finish the project within the budget. One such tool is a cost model. SMD has run several cycles of

smallsats in various divisions and is aware that the Center costing models yield high value but sometimes are not credible. The Pioneers Program will use a smallsat model, not an extrapolation of the standard model. But they are at the beginning. The risks are real, and APD is aware of them. These are some of the birth pangs. He did hear from Dr. Garcia that the Pioneers call will include all the contact information for the NASA design centers, like the smallsat calls did. That worked pretty well. APD is trying to lower the entry gate. Dr. Gaskin thought that the problem was less costing and more comparing the grass-roots parametrics for cost models. The reviewers need to be aware of how to assess the cost. She would like APD to remind reviewers and proposers. Dr. Hertz replied that the parametric models do not cover this regime very accurately, but NASA will develop them if the data make it feasible. Dr. Galeazzi said it would help to have parameters so the PI knows how to structure the budget and how it will be reviewed.

Dr. Woodward noted that APD is giving $4 million for XRP funding. Other divisions are also contributing. However, the ROSES 2020 call shows the total budget for XRP as $4 million. Dr. Hertz explained that the budget shown in ROSES is the amount available for new selections. When SMD talks about total budget, that refers to how much the divisions are spending, which encompasses several years of selections. Dr. Woodward asked about the growth factor of ROSES 2020 compared to prior calls. Dr. Hertz said that he did not have that number at hand, but he would take an action to find it. He described the selections of exoplanet proposals as done jointly within SMD, in the integrated review as opposed to kicking them out to individual divisions. All the divisions are pleased with this. APD is moving exoplanets that were competed in other elements into XRP, as is PSD. There will be a single program. Dr. Gaskin asked about the selection rates, and Excellent (E) and Excellent/Very Good (E/VG) proposals that are not funded. Dr. Hertz said that APD could provide data on selections by ratings. For most programs, it is usually 100 percent of the Es, close to 100 percent of the E/VGs, 50 percent of the Very Good (VG)s, and a small fraction of the remainder.

LISA Update

Dr. Ira Thorpe provided an update on the Laser Interferometer Space Antenna (LISA) mission, led by ESA with NASA participation. It will be the first gravitational wave observatory in the millihertz band, with tens of thousands of various sources and wide applications throughout astrophysics. One area of study will be the mergers of massive black holes and their origins. LISA will also look at potential electromagnetic counterparts, extreme mass-ratio inspirals to probe high-mass demographics and dynamics of nuclear clusters, and ultra-compact binaries in the Milky Way. The mission will have guaranteed MMA sources. LISA will conduct all-sky monitoring with no pointing, with both transient and persistent sources. NASA will be able to participate in the science, and the Agency's likely contributions will include both hardware and science. For the LISA consortium, ESA typically has both international and member state contributions, including payload and science. The structure is well-developed. Individuals and research groups can apply for a number of slots. The interfaces with NASA and the U.S. community are being developed.

LISA is now in formulation, ESA's Phase A equivalent. Dr. Thorpe showed the timeline to mission adoption in 2023, with a launch date planned for 2034. He noted recent progress, including an increase to the ESA science budget. The NASA LISA Study Office comprises three NASA locations and the University of Florida. This will evolve into a formal NASA project office in 2021. Near-term NASA goals include collaboration with partners (ESA, LISA Consortium) on formulation activities, assessment of potential NASA contributions, technology development, consolidation of final roles and responsibilities, and an MOU prior to adoption.

LISA is a single instrument distributed across a constellation of spacecraft, which makes the system engineering critical to success. NASA is supporting activities by LISA and the consortium, and is doing internal reviews. Dr. Thorpe showed the NASA technology development investments in five enabling technologies. The Agency seeks to demonstrate technology readiness prior to mission adoption, and demonstrate key driving requirements to reduce mission risk. The Study Office will coordinate the various development efforts, harmonize the NASA efforts with LISA requirements, develop contribution scenarios, and manage cost, schedule, and technical risk. Dr. Thorpe confirmed that NASA could invest in enabling technologies. The Study Office maintains a set of potential options. Currently, the primary candidates are:

- Telescope, for which there is an RFP out now;
- Laser system, which has to be quite stable;
- Charge management device;
- Phasemeters, for which inflight results have been published and which is being scaled up for LISA – the main driver is getting the channel count; and,
- Microthrusters, which need to be very secure.

The telescope, laser, and charge management device are the highest priorities for NASA, based on ESA input and internal NASA assessments. While they remain viable candidates, the microthruster and phasemeters are being funded at lower levels.

In the science activities area, NASA continues to support ESA-led activities via the Science Study Team, task groups, and planning efforts. NASA also supports consortium-led activities, U.S. community activities, and Science Core Team activities. Dr. Thorpe described the NASA LISA Study Team (NLST) and listed its members. New tasks from NASA are to describe the science value of data products and outline the science returns for various models. Domestic hosting of a data archive is under discussion. For the upcoming DS, the team produced science white papers, RFI responses, and other information. Preparatory science grants are managed by NASA as part of ROSES, not the NASA LISA Study Office.

LISA's Science Ground Segment (SGS) is an essential part of the instrument. This consists of the algorithms, computing infrastructure, etc. needed to deliver the mission science objectives. ESA, ESA member states, and NASA will all contribute. NASA's role in SGS is under development, with the expectation that the Agency's science support will be in addition to its hardware contribution. This is all still being defined. NASA will also take steps to allow the U.S. science community use of LISA data and science. Among the considerations here are data access rights, and the fact that the U.S. and European communities have different models for science support. The expectation is that NASA will have a contribution to the SGS.

Dr. Woodward asked about the expectations for data rights and access. Dr. Thorpe explained that there is a range of thought within ESA and among its partners. While ESA is closer to NASA, there are differences among the member states, concerns about restricted access, interest in getting the data out, and differing expectations. He wants decisions to be made based on the science. Dr. Meyer noted that recent and developing ESA missions have a diversity of models. Dr. Thorpe said that the expectations are similar to ESA's Gaia mission, which has global fit and periodic releases. There will be other considerations, however. Dr. Meixner noted that making things public quickly is advantageous to LISA. Dr. Thorpe described the output. The next step will be to do the global fit, which will be done by the consortium rather than ESA. The product will go back to ESA, which will send it out to the archive.

Dr. Meyer asked about the preparatory science program, which Dr. Thorpe said had had one round thus far. Headquarters would probably make the decision about additional rounds. Regarding a notional timeline for identifying NASA's technology development, that is still evolving. The milestone is mission adoption in 2023. ESA will need to know the international contributions at that time. Dr. Meyer asked if there were any dual-use technologies from the technology gap list that might help set priorities. Dr. Thorpe replied that the focus is on the application of LISA. Dr. Woodward asked about the channel count of eight on the prototype. Dr. Thorpe explained that the mission will need multiple panels and a multiplicity of systems, plus redundancy. That led to the channel count. This is the type of systems engineering challenge that arises when dealing with multiple partners.

SOFIA Update

Dr. Naseem Rangwala described recent science highlights from SOFIA, including an investigation of the dimming of Betelgeuse, and mapping water on the moon. These two examples highlight a more aggressive and strategic the increased use of director's discretionary time. APAC had requested information from the mission in response to the operational and science reviews of SOFIA. Changes since the reviews address science selection, science execution, and productivity. The first change will be to give more time to legacy programs in Cycle 8. These will account for 25 percent of the observing time, to go up to as much as 50 percent in future cycles. The mission team hopes to organize workshops to support these increases. Joint proposals include reserved time for JWST and ALMA in Cycle 9, and joint calls for other proposals. The mission is also implementing shorter flights, of 8-hour duration. Those are most useful between May and October. The team created more winter observing opportunities by consolidating maintenance periods. The southern deployment is being extended.

Cycle 8 proposals were selected with an orientation to likely publication. Dr. Woodward pointed out that this pivots away from high risk. Dr. Rangwala agreed, stating that the team wants to make it useful to the community. They are doing a "compressed 4" mode for the southern deployment, which will be with a single instrument and lead to 28 flights over 7 weeks. Proposers will be alerted to the block scheduling for Cycle 9. The project is looking at increasing 'high-value' observing opportunities.

The SOFIA team implemented major initiatives to significantly improve efficiency, reduce staff stress, and build robust mission operations, which allow more flexible reactions to weather. The preflight preparation time is now automated. There is less time needed for instrument swaps, as most instruments have been demonstrated. The project changed the policy for Priority-2 (P2) observing programs: once these are started, they will be completed, thus boosting the completion rate. Previously, the P1 programs would be transferred to a new schedule, and the P2s were pushed aside. P1s and P2s constitute 75 percent of the observing program.

Cycle 9 planning is going on now, which is an opportunity to make big changes. The team is considering doing 2-year observing cycles to allow longer campaigns, more flexibility, and fewer instrument swaps. These will lead to more publications, and the team wants to make it easier for the community to publish. If data are not archived within 15 working days, the team will be notified. The data will be released as they are analyzed rather than waiting for the whole series with a given instrument.

A major change was the reorganization of the SOFIA project in Fall of 2019. This led to a workforce reduction of 10 percent. Dr. Rangwala explained the new sustainable operations model for SOFIA at lower cost that still maintains or sustains the flight rate (4 flights/week), weekend support for maintaining the observatory and an annual Southern Deployment. In the previous two years, there were additional funds available to staff up to sustain the flight rate of 4 flight/week and to develop new

instrumentation. In addition, the team wanted to implement as many of the recommendations as possible during this reorganization, and many were cost-neutral. The rest were evaluated in terms of science impact. Dr. Woodward said that he understood SOFIA to be a development platform for instrumentation, and asked if that is being deemphasized. Dr. Rangwala said that, in the near term, they want to focus on science from the existing instruments (plus HIRMES that is in development). In the long-term, they can do another exercise for development of new capabilities. Dr. Cooray asked if the reorganization responds to the recommendation to break up the integrated observatory model. Dr. Rangwala said that the Project did not break up the integrated model as recommended by the SOMER review, which was explained Project's written response submitted to the APAC. Dr. Jones pointed out that the response was SOMER and FMR reports were heavily redacted and thus the reasoning behind this recommendation is not known.

Dr. Rangwala explained that the panel for the SOFIA Operations and Maintenance Efficiency Review (SOMER) looked at aircraft operations, but SOFIA is an observatory, and the observatory systems are fully integrated in the aircraft. Dr. Hertz said that the charter was not aircraft operations. Dr. Gaskin asked why operations were separated. Mr. Shane Dover explained that SOMER was asked to look at the aircraft operations to determine if there were efficiencies possible. In the initial phases, it made sense to couple the two. As the mission went into operations, the operations team should have focused on meeting metrics and providing capabilities for the customer. It created confusion about quality assurance, inspections, etc., and it was hard to extract actual operations costs. The recommendation was then to have metrics and management devoted to efficient aircraft operations. The team thought that would be best done via a customer/provider model. The reviewers felt the failure to manage it as an operational asset versus a developmental asset led the program to operate as if it were a developmental asset and resulted in a lack of metrics for measurement.

Dr. Rangwala explained that the science and mission operations also went through a reorganization. They are hiring more postdocs as a result. She then presented historical data on the southern hemisphere campaign. There is a higher publication rate associated with southern hemisphere work. There are limits on staff, however, as they are away from home for too long. The team wants to compress the flights and make the deployments shorter. The team looked at options for longer deployments and local hiring, and even wrote a proposal on this. The panel accepted the proposal but also encouraged them to look at other southern hemisphere locations. They can get high-quality observations in the northern hemisphere as well, but the southern hemisphere work is strong. They have not yet done a detailed study of long-term deployment in New Zealand. The issue is finding the right people locally in New Zealand to work on SOFIA. Dr. Jones noted that the balloon program office deploys people for 9 months of the year on a $40 million budget. Dr. Gaskin asked how the SOFIA team concluded they could not support the deployments. Dr. Rangwala explained that another set of staffing for crew rotation would carry costs. Dr. Meyer advised looking at a new model instead of thinking about doubling the staff. They would not need to stand down everyone.

Dr. Cooray asked the reason for the reduction from 32 to 28 flights. Dr. Rangwala explained that the team identified funding for 24 nights in the southern hemisphere and they have sufficient proposals to fill that. However, it took a while to reduce the workforce, and the team could not promise more than 24 flights. They are doing a swap between northern and southern hemisphere flights to get to the 28. There is also extended maintenance that cannot be shifted.

Dr. Rangwala next presented the metrics for high-quality observing time on altitude and water vapor analysis, which the team wanted to investigate further. There are seasonal variations in water vapor

that appears due to weather along the flight path. Once the analysis is complete, the data can be used in a variety of ways. They are still waiting for this report to be completed. Dr. Thomas Roellig said that there is a water vapor monitor on the aircraft, and there has been extensive work to correlate those measurements with independent measurements. This is complicated, and the understanding is quite lacking. It has less useful than anticipated, and better results might come from satellite data.

Dr. Rangwala noted that the overall demand is very high and SOFIA is getting good proposals. The mission can fund all E, E/VG, and VG proposals. The legacy programs are for 2 years, and this is an annual call. P1 PIs get their funding right away. P2 funding is released soon, and P3 activities are funded as they fit in. P1s do not have to repropose if they lose their flight time, and there is a simple process for P2s to initiate a second opportunity. If they do not fly at all, however, they must repropose. Dr. Woodward asked how the team arrived at the goals for impact and greater return. Dr. Rangwala said they reflect that the team accepted the recommendation.

Dr. Cooray asked how the mission planned to increase publications from 30/year to 100/year. Dr. Rangwala replied that that is a stretch goal, which should be achievable with archival research. Dr. Brenneman asked about the fraction of high-priority programs resulting in publication. Dr. Woodward thought it indicated a latency problem. Dr. Rangwala said that the mission has several initiatives to increase high-quality data, and has moved to coordinate with other infrared archives to bring in multi-wavelength data for research and publication. The team is working on getting data to users in 15 working days. Dr. Galeazzi asked about the typical timeline between data delivery and publication. The 40 percent for Cycle 3 is low. Dr. Rangwala said there would be a white paper on that. Dr. Gaskin asked for data on unique PIs versus multiple proposers, which Dr. Rangwala promised to provide.

Dr. Cooray pointed out that Cycle 4 was 4 years ago and has a low rate of publication. He also doubts the ability to get publication rate up to 100 papers/year. Dr. Rangwala said that the Cycle 4 completion rate was poor. The team is looking at unpublished data to see what could lead to publication. The publication rate of 100 papers/year is a stretch goal that includes archived data through ADAP grants. Dr. Cooray said that it would be hard to make old data compelling in a review panel. Dr. Rangwala countered that in the most recent ADAP call, five proposals using SOFIA archival data were selected. ADAP seems like the better option.

Dr. Jones asked about the make-up of the proposed external operations advisory group. Dr. Rangwala said that they want that group to be integrated, and to include some scientists on it. Regarding the High Resolution Mid-InfrarEd Spectrometer (HIRMES) instrument, the plan is to make it available by Cycle 10. Dr. Woodward said he would like the team to return to discuss HIRMES and the availability of instruments.

Public Comment Period

The meeting was open to the public for comment, but no one came forward.

Discussion, Recommendations, Actions

Continuing the SOFIA discussion, Dr. Gaskin said would be good to get the data on unique new PIs, and to better understand what it would take to get additional crews. Dr. Galeazzi also wanted data on publications. Dr. Jones was concerned about the lack of metrics and wanted to know if that meets the review recommendations. Dr. Meyer pointed out that other missions have the clear line of operations being separated, and it is puzzling why the SOFIA team has not figured this out. Dr. Meixner noted that the panels were separated, and they recommended separating management. Then the project came

back and said it was integrated. Dr. Hertz explained that the aircraft review took place first, and several members of the first review were on the second review.

Dr. Woodward said it would be helpful to address Dr. Jones's call out on the lack of metrics. APAC will invite the SOFIA team back to discuss HIRMES, at which time they can also address publication and other tracking issues. Dr. Gaskin was concerned that the publication goal is not realistic and urged that it be reconsidered. Others agreed. Dr. Walkowicz observed that realistic goals reflect a project's ability to self-monitor. Dr. Hertz reminded APAC that this is not the first time SOFIA has been put up for termination. Dr. Brenneman said that that makes feasible goals even more important. Dr. Meixner thought the criteria and the context might have a disconnect. Dr. Woodward said that undebatable delivery of performance is paramount at this stage, which makes it important that they have realistic goals they can build. Dr. Gaskin said that they will be assessing against the stretch goal, so why not have something more attainable? Dr. Rangwala said that the steps are in a range. Dr. Mahadevan was not sure about the programmatic balance among the legacy programs, the P1s, and finishing the P2s that are begun. Dr. Woodward said that the timeframe is another issue. The messaging is important. Dr. Meyer said that the pending launch of Webb will be a distraction from any further SOFIA work, and suggested use of JWST to stir enthusiasm. Dr. Rangwala said that Cycle 9 will include JWST collaborations.

Dr. Woodward turned to WFIRST and the coronagraph. Since it is post-KDP-C, and they had adequate assurances that it will not deflect the mission, he moved discussion along to Artemis. Dr. Galeazzi said that while astrophysics can propose observations, the program does not clearly lend itself to the discipline. Dr. Meixner said that Artemis is developing launch capabilities that astrophysics could use. Dr. Meyer wondered if they were being creative or aggressive enough. Dr. Hertz said that when he looks at strategic priorities from the community, he does not see many suggestions for ideas that can best be done from the moon. If they come up, it is an option. There are science projects and concepts that the advocates think are best done on lunar surface, and those white papers were submitted to the DS.

Dr. Woodward summarized the meeting, saying that this had been a productive conversation, and APAC was excited about WFIRST and encouraged by the DAPRs. The PI Launchpad conversation was useful, and APAC wants follow-up. The Committee was encouraged by the status of Webb, especially the team's high confidence level. APAC will be interested in a reassessment after the summer activities. The meeting discussed the PAGs. It will be helpful for them to talk to one another, especially regarding technology exchange. Development of the rideshare opportunities is helpful to the community. APAC will need further conversation about data management. Part of that is what goes into proposals and how this works in a coding environment. APAC would find it useful to learn more about launch vehicle certification, and it will be best for it to conclude early with WFIRST. It was also useful to hear that the Astrophysics Data Service (ADS) fulfills some of the desires to get PI publications into public fora in a meaningful way.

APAC received its first detailed presentation on LISA. The Committee would like more on the evolution of the data archive and the ground system once there is more consensus on how to use the science products in the U.S. community. They would also like to review the full LISA report. Dr. Hertz took an action to get the status on that report and its likely availability.

Dr. Gaskin said that the Pioneers Program hit a lot of what she has heard in the community as a need. It is important to get it right. She would like the timeline and, if possible, would like APAC to make comments on a more finished draft. Dr. Hertz explained that APD cannot show APAC the draft

solicitation before it is released. Members cannot help write it unless they recuse themselves from proposing. It is a procurement activity, and he does not think that would be good for APAC. Members can comment as individuals, and they can talk to others as individuals, but not as committee members. APD hopes to get the draft out in April and the final report in June, before the next APAC meeting.

Dr. Woodward said that the formal acceptances of PAG actions will be in the letter. The Committee was asked to formally approve the MMA SAG, close SAG 19 and SIG 1, and approve SIG 3. There were no objections in the vote to approve all of those.

The letter would recommend that the chairs of both SOFIA reviews give an assessment on the response at the next APAC meeting. Dr. Woodward asked members to consider topics for the June meeting. They would receive the formal letter for review in the next few days. The SMD gap summary should be completed by then.

Adjourn

The meeting was adjourned at 3 p.m.

Appendix A
Participants

Committee members
Charles Woodward, University of Minnesota, *Chair, Astrophysics Advisory Committee*
Laura Brenneman, Harvard University
John Conklin, University of Florida
Asantha Cooray, University of California, Irvine
Massimiliano Galeazzi, University of Miami
Jessica Gaskin, NASA Marshall Space Flight Center
Kelly Holley-Bockelmann, Vanderbilt University (via telecon)
William Jones, Princeton University
Suvrath Mahadevan, Penn State
Margaret Meixner, Space Telescope Science Institute
Michael R. Meyer, University of Michigan
Leonidas Moustakas, NASA JPL (via telecon)
Lucianne Walkowicz, Adler Planetarium (via telecon)

NASA attendees
Paul Hertz, NASA HQ, *Director, Astrophysics Division*
Lucien Cox, NASA HQ
Mike Garcia, NASA HQ
Hashima Hasan, NASA HQ, *Executive Secretary, APAC*
Stefan Immler, NASA HQ
Patricia Knezek, NASA HQ
Jeff Kruk, NASA GSFC
David McAllister, NASA AFRC
David McBride, NASA AFRC
Michael New, NASA HQ
Mario Perez, NASA HQ
Naseem Rangwala, NASA Ames
Rita Sambruna, NASA HQ
Evan Scannapieco, NASA HQ
Kartik Sheth, NASA HQ
Eric Smith, NASA HQ
Linda Sparke, NASA HQ

Non-NASA attendees
Raphaelle Haywood, Harvard University
Ryan Hickox, Dartmouth College
Elizabeth Sheley, Electrosoft
Ana Wilson, Electrosoft

Webex/Telecon
David Adler
Gabriel Adler, NASA
Jaya Bajpayee, NASA
Matthew Beasley, SW Research Institute

Dominic Benford, NASA
Teresa Brandt, NASA GSFC
Monique Brewer, NASA
Brice Burgh, Lockheed Martin
Stephen Clark, Space Flight Now
Dan Clary
Michael Davis, SW Research Institute
Patricia Daws, NASA
Monty DiBiasi, L. DiBiasi Associates
Tammy Dickenson, Science Matters Consulting
Shane Dover
Daniel Evans, NASA
Richard Fischer, NASA
Jeff Foust, Space News
Jonathan Gardner, NASA
Timothy Gehringer, USAR
Colleen Hartman, NASA
Phillip Horzempa, Lemoyne College
Pat Hosfacker, Aero Space America
James Jackson
Teresa Jensen, Space Dynamics Laboratory
Jonathon Krazel, NASA
Lilly Larson, Ball Aerospace
Bill Latter, NASA
David Leisawitz, NASA
Charles Lillie, Lillie Consulting
Sara Lipscey, Ball Aerospace
James Lochner, USRA
Jennifer Lu, NASA
Eric Mamajek, NASA JPL
Guido Marducci
Stephan McCandliss, JHU
Gary Melnick, Harvard University
Matthew McDigman, Ohio State University
Jon Morse, Boldly Go Institute
Elia Perez, NASA
Rob Petre, NASA GSFC
Graca Roca, JPL
Thomas Roellig, NASA ARC
Martin Ruzek, USRA
Ken Sembach, STScI
Ryan Sims, NASA
Evan Skanape, Echo
Eric Smith, NASA
Marcia Smith, Space Policy Online
Ed Stanton
Karl Stapelfeldt, JPL
Will Thomas, AIP

James Thorpe
Steve Thompson, Millennium Space Systems
Ashlee Wilkins, AAS
Alexandra Witze, Nature Magazine

Appendix B
Astrophysics Advisory Committee Members

Charles Woodward, APAC Chair
University of Minnesota

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

Laura Brenneman
Harvard University

John Conklin
University of Florida

Asantha Cooray
University of California, Irvine

Massimiliano Galeazzi
University of Miami

Jessica Gaskin
Marshall Space Flight Center

Kelly Holley-Bockelmann
Vanderbilt University

William Jones
Princeton University

Suvrath Mahadevan
Pennsylvania State

Leonidas Moustakas
Jet Propulsion Lab

Margaret Meixner
Space Telescope Science Institute

Michael R. Meyer
University of Michigan

Lucianne Walkowicz
Adler Planetarium

Appendix C
Presentations

1. *Astrophysics Division Update*, Paul Hertz
2. *ROSES Update,* Stefan Immler
3. *Engaging in Global Issues as a Sagan Fellow,* Raphaelle Haywood
4. *ExoPAG Report*, Michael Meyer
5. *PhysPAG Report*, Graca Rocha
6. *COPAG Report,* Margaret Meixner
7. *Astrophysics Pioneers Program*, Michael Garcia
8. *WFIRST Update*, Jeff Kruk
9. *Science Data Management Working Group Report,* Patricia Knezek
10. *Webb Update,* Eric Smith
11. *LISA Update,* Ira Thorpe
12. *SOFIA Update,* Naseem Rangwala

Appendix D
Agenda

Agenda
Astrophysics Advisory Committee
March 5 – 6, 2020
NASA Headquarters, Washington D.C., Rm. 5H42

Thursday March 5

8:30 a.m.	Meeting Room Open	
9:00 a.m.	Introduction and Announcements	Charles Woodward/Hashima Hasan
9:10 a.m.	Astrophysics Division Update	Paul Hertz
11:10 a.m.	ROSES Update	Stefan Immler
11:40 a.m.	Discussion	APAC members
12:00 p.m.	Lunch	
12:15 p.m.	Engaging in global issues as a Sagan Fellow	Raphaelle Haywood
1:00 p.m.	ExoPAG Report	Michael Meyer
1:30 p.m.	PhysPAG Report	Graca Rocha
2:00 p.m.	COPAG Report	Margaret Meixner
2:30 p.m.	Break	
2:45 p.m.	Astrophysics Pioneers Program	Michael Garcia
3:15 p.m.	WFIRST Update	Jeff Kruk
4:15 p.m.	Public Comment Period	
4:20 p.m.	Discussion	APAC Members
5:00 p.m.	Adjourn Day 1	

Friday March 6

8:00 a.m.	Meeting Room Open	
8:30 a.m.	Opening Remarks	Charles Woodward
8:40 a.m.	Science Data Management Working Group Report	Pat Knezek
9:10 a.m.	Webb Update	Eric Smith
10:10 a.m.	Discussion	
10:45 a.m.	Break	
11:00 a.m.	LISA Update	Ira Thorpe
12:00 p.m.	Lunch	
1:00 p.m.	SOFIA Update	Pat Knezek/Naseem Rangwala
2:00 p.m.	Public Comment Period	
2:05 p.m.	Discussion, Recommendations, Actions	APAC members
2:45 p.m.	Brief to Hertz	Charles Woodward
3:00 p.m.	**Adjourn**	