

# ASTROPHYSICS ADVISORY COMMITTEE

July 23-24, 2018  
Washington, DC


## MEETING MINUTES



8/28/2018

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Feryal Ozel, Chair



8/28/2018

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Hashima Hasan, Executive Secretary

NAC Astrophysics Advisory Committee Meeting Minutes, July 23-24, 2018

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*Prepared by Elizabeth Sheley  
Electrosoft*

Monday, July 23, 2018

*NASA Headquarters*

Introduction and Announcements

Dr. Hashima Hasan, Executive Secretary of the NASA Astrophysics Advisory Committee (APAC), opened the meeting by welcoming the Committee members. Dr. Hasan then reviewed the Federal Advisory Committee Act (FACA) rules. She noted that a number of APAC members had conflicts of interest (COIs) with specific topics on the agenda, and those would be noted at the time of the presentations. Any questions related to ethics should go to her; she would convey them to the NASA attorneys if necessary.

Dr. Feryal Ozel, APAC Chair, welcomed the Committee members. She noted that the agenda was full, but there was nothing overwhelming. She then turned the meeting over to Dr. Paul Hertz, Director of NASA's Astrophysics Division (APD).

Astrophysics Division Update

Dr. Hertz welcomed the APAC members. All of NASA's programs, including those within APD, align with key questions about the origins of the universe, its cosmic evolution, and whether there is life beyond Earth. APD is seeking an Astrophysics Program Scientist as part of a long-term effort to have more civil servant scientists.

Science highlights included the use of the Hubble Space Telescope (HST) to refine the distance ladder, raising the question of whether there are new physics involved and what scientists have not yet figured out. A long Chandra study determined that tens of thousands of black holes exist in the center of the Milky Way, with implications for stellar evolution. HST and Spitzer studies of the TRAPPIST-1 system revealed that the planets are likely rocky planets, and some have thin atmospheres. The Neutron star Interior Composition Explorer (NICER) identified an x-ray pulsar with a rapid orbit.

Dr. Hertz reviewed the APD structure for the benefit of the newer APAC members. Strategic Missions include NASA-led flagship missions and probes, and some contributions to partner-led missions. Principal Investigator (PI) -Led missions are competed, and include Explorers and some contributions to partner-led missions. Supporting Research and Technology (R&T) encompasses Research and Analysis (R&A), technology development, suborbital investigations, cubesats, and investigations attached to the International Space Station (ISS). Finally, there is Infrastructure and Management. Dr. Hertz provided examples for each category and showed the APD Fiscal Year 2018 (FY18) of \$1.38 billion as allocated among the major areas. Two thirds of the development funding is for the James Webb Space Telescope (JWST); APD will always spend a large portion of its budget building the next great observatory. Much of the mission operations area funding goes to the Guest Observer (GO) program.

Major accomplishments since APAC's previous meeting include the launch of the Transiting Exoplanet Survey Satellite (TESS), which is in commissioning. The Stratospheric Observatory for Infrared Astronomy (SOFIA) is in science operations following extended maintenance. The Galactic/Extragalactic Ultralong-Duration Balloon (ULDB) Spectroscopic Terahertz Observatory (GUSTO) just completed system requirements review. The Wide Field InfraRed Space Telescope (WFIRST) recently passed Key Decision Point B (KDP-B) and has begun the preliminary design phase (Phase B). Balloon campaigns launched in Texas and Sweden, and APD launched its first cubesat, HaloSat, which will study the hot galactic halo. The Imaging X-ray Polarimetry Explorer (IXPE) completed Preliminary Design Review

(PDR), and NASA submitted the JWST replan. The near future will bring the beginning of TESS science, more balloon campaigns, Decadal Survey (DS) activities, and the APD Senior Review.

The FY18 budget was effectively reduced by \$10 million to accommodate directed spending, and Congress has not yet approved NASA's operating plan. The FY19 President's Budget Request (PBR) proposes a reduction in spending, from FY18's \$1.38 billion total to \$1.185 billion, which comes to 14 percent. The PBR places JWST in APD's budget; it had been outside the Division for a number of years. The PBR also terminates WFIRST. In Congress, both the House and Senate have marked up the budget, which has yet to be passed by either house and must go through reconciliation after passage. The House gives APD \$1.33 billion, and the Senate allocates \$1.55 billion. The JWST replan will be submitted as part of the FY20 budget request in February 2019.

The House has allocated \$150 million to WFIRST, which would keep it even with FY18, and directs \$20 million for work on a starshade. The Senate funding is for \$352 million, which is consistent with the funding profile required to stay on schedule. Both cap WFIRST at \$3.2 billion. Other mark-ups and language include the House stating that SOFIA should not go through the Senior Review and the Senate stating that it should. The House introduces \$10 million for technosignatures to search for signs of intelligent extraterrestrial life, and the Senate wants APD to spend \$15 million on search-for-life technology. Overall, the House reduces the budget for the rest of APD by 3 percent, and the Senate by 1 percent.

The JWST cost cap of \$8 billion covers the mission through commissioning and does not include operations. Congress requires NASA to seek Congressional approval to reauthorize if JWST exceeds that amount for development. The cost cap prior to the replan was \$8.6 billion including operations. Dr. Hertz does not anticipate risk to the upcoming Small Explorer (SMEX) call. R&A funding is marked up as requested; APD does not use R&A to balance out shortfalls elsewhere. Historically, differences in mark-ups have emerged from reconciliation in the direction of whichever house holds the stronger opinions. The language in the mark-ups sometimes indicates this.

Dr. Ozel reminded APAC that they had previously determined that they want a review of SOFIA, whether it is through the Senior Review or otherwise. Dr. Hertz said that NASA is seeking a means of review, but nothing has been determined. If SOFIA is not in the Senior Review, APAC and others have said that it is appropriate to review the mission, and NASA will have to determine a path forward. The House and Senate strongly disagree with each other on this. Dr. Hertz presented a chart showing the notional planning budget for the next 5 years, in which the top line serves as guidance. The chart had not been updated with the JWST replan. The R&A budget has had steady growth and will continue to grow in the flat notional budget, with the addition of a \$5 million cubesat every year. This did not come from the reduction in named fellowships.

Dr. Hertz next turned to mission updates. With the launch of TESS, there are seven missions in development across a range of sizes. TESS commissioning is ongoing and has an extensive, ground-based follow-up program to confirm exoplanet candidates, identify false positives, characterize host stars, and determine planet mass. A space-based follow-up program will address the detection of atmospheres, as well as molecule detection and atmosphere characterization. The Guest Investigator program for TESS has completed Cycle 1 selections for the southern hemisphere. Cycle 2 will be for the northern hemisphere. Science data will begin coming in soon.

Euclid is a European Space Agency (ESA) dark energy mission scheduled to launch in 2022. NASA has a number of contributions to the mission, including 20 characterized Near InfraRed (NIR) sensor chip systems. The detectors are in ESA characterization testing, but NASA has had to redesign and test the sensor chip electronics. Dr. Hertz did not know the cost of the sensor chip redesign at the moment but

would find out. The Euclid chips are a version of the JWST chips, but Euclid has a different readout scheme and a different operating temperature, so the redesign uses wirebonds for the readout.

The Japanese Space Agency (JAXA) recently renamed the X-ray Astronomy Recovery Mission (XARM); it is now the X-Ray Imaging and Spectroscopy Mission (XRISM) because JAXA wanted to remove the word “recovery.” XRISM is scheduled to launch in 2022 and the NASA contribution is now in Phase C. NASA will contribute a microcalorimeter, being built at the Goddard Space Flight Center (GSFC), and will also provide an x-ray mirror assembly. The Canadian Space Agency (CSA) recently joined the NASA team. U.S. scientists will be selected for the Guaranteed Time Observing (GTO) teams and will be eligible for the General Observing Program. XRISM’s “Resolve” microcalorimeter is a copy of the SXI instrument NASA furnished for the lost Hitomi mission, though Resolve might have a bit better spectral resolution.

Both an Independent Review Board (IRB) and a Standing Review Board (SRB) re-evaluated JWST and issued reports. The IRB and SRB are in agreement that the JWST science is compelling. Technical complexities greatly affected the mission’s development schedule, as did human errors. NASA has accepted the IRB recommendations and, along with Northrop Grumman, the primary contractor, has initiated process controls and corrective actions. The revised schedule and cost are at the 80 percent confidence level, with reserves. Dr. Hertz emphasized that there are no instruments that need to be rebuilt. The IRB estimated that a 29-month extension would be necessary, equal to about \$1 billion in additional costs. This replan breaks the Congressional cost cap. The total lifecycle baseline, set in 2011, was for \$8.835 billion, and the new baseline is \$9.663 billion, while the launch date commitment shifted from October 2018 to March 2021. The additional funding will be needed in FY20 and FY21. Dr. Hertz was not sure if there will be impact on the FY19 budget. Development had been set at \$7.998 billion and is now estimated at \$8.803 billion. The required Congressional reauthorization will likely come through an authorization or appropriation, and Congress can refuse to do this, though that is unlikely. NASA will need about \$490 million for JWST above planned budgeting for JWST in FY20 and FY21 as a result. This is likely to affect the APD budget, though, as he said previously, Dr. Hertz will protect the R&A and Explorer programs while applying DS priorities.

Dr. William Jones, participating remotely, asked about the launch vehicle. Dr. Hertz replied that it is being supplied by ESA, which has said it will not be an issue. Dr. Mark Bautz asked how this will affect the working budget for the DS panels. Dr. Hertz replied that the replan budget will be part of the FY20 PBR, and so it will be submitted in February of 2019, at which point it will become public. This is commensurate with the time when he will be briefing DS. He will discuss realistic, optimistic, and pessimistic assumptions with the DS panel.

In 2017, NASA conducted the WFIRST Independent External Technical/Management/Cost Review (WIETR), which led NASA to reduce WFIRST’s cost and complexity, while also making the coronagraph a technology demonstration. WFIRST is currently in Phase B, but the FY19 PBR zeroes out the mission. If Congress were to go along with that, there could be an additional competed mission for APD, but the mark-ups from both houses of Congress indicate that there will be WFIRST funding, though the level of that funding is yet to be decided.

APD has reorganized its program offices. There will be two flight program offices: Astrophysics Strategic Missions at NASA Headquarters, and Explorers at GSFC. Everything else goes under Supporting R&T Programs: R&A, Physics of the Cosmos (PCOS) and Cosmic Origins (COR), Exoplanet Exploration (EXEP), and balloons. Sounding rockets are managed by the Heliophysics Division (HPD). SOFIA will go under strategic missions. NASA participation in ESA’s Athena and Large Interferometer Space Antenna (LISA) missions will move to flight programs once the missions are under KDP-A. Project offices are at the NASA centers and program offices are generally at Headquarters.

A number of Explorers are in competitive Phase A. The plan is to have four Explorers per decade. Proposals to contribute to ESA missions would be allowed in the PI-managed Missions of Opportunity (MoOs). APD intends to solicit smallsats in the MoOs. Smallsats are Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) ring missions. As a first step, NASA will conduct funded SmallSat mission concept studies (via ROSES) in advance of the 2019 SMEX AO. The Division received 38 proposals for funded concept studies; these are in the peer review process. The selected PIs will have 6 months to conduct their smallsat concept studies. The SMEX Announcement of Opportunity (AO) will come at least 1 day after that deadline. The first APD cubesat, HaloSat, just launched, and there are three more cubesats in development.

The Athena and LISA missions are in pre-formulation at NASA. While NASA plans to contribute to both, ESA is now accelerating the missions' timelines, which will have budget implications for NASA, especially on the LISA mission. Technology maturation is another concern, as it is not clear whether NASA can get the technology to Technology Readiness Level 5 (TRL5) in time for LISA's earlier launch date. ESA wants the synergy of flying Athena and LISA at the same time, though the timeline will be affected by any development issues that arise. ESA must also obtain additional funding in order to do this. While Dr. Hertz could not commit to the NASA contributions, he did note that NASA is working on five technologies of interest for LISA.

SOFIA's new instrument is the High-resolution Airborne Wideband Camera-plus (HAWC+). Next will be the High Resolution Mid-Infrared Spectrometer (HIRMES), and a call is out for another instrument. SOFIA Cycle 6 started late due to the extended maintenance. A more complete mission update was on the APAC meeting agenda. The 2010 DS assumed there would have been a Senior Review of SOFIA by now, and Congress is at odds with itself over whether NASA should have one. NICER launched a year ago and is working flawlessly, resulting in some discoveries. The data are now public and papers are coming out. It will be in the Senior Review since the prime mission is almost over. There will be a gap between the end of the prime mission and the beginning of FY20, so APD is assessing its progress now, and will give the mission the bridge it needs to continue operating through the Senior Review.

Next, Dr. Hertz presented the Senior Review schedule, with draft and final calls for proposals in 2018 and the panel meetings in 2019. Dr. Brenda Dingus asked about Cosmic-Ray Energetics and Mass for the International Space Station (ISS-CREAM) investigation. Dr. Hertz replied that NASA is still working toward getting science from its data, and it does not have an end-to-end science pipeline. APD has provided additional resources to the PI, including a mission manager and a data manager outside of the grant. The prime mission was approved for 1 year with a possible extension up to 3 years. APD will do a continuation review at the end of summer to determine the path forward. It will not be part of the Senior Review because it was funded with a grant and not managed like a flight project.

Every DS has recommended space observatories that have changed the science. Dr. Hertz said that his highest aspiration for the next DS is that it recommend a program for NASA that continues this history of launching visionary missions that rewrite the textbooks. The timing of the DS had been a question, with a 2-year delay under consideration. Dr. Thomas Zurbuchen, Science Mission Directorate (SMD) Associate Administrator, spoke to APAC about this at the last meeting. JWST will not have launched before the DS work begins, and the WFIRST budget will be in question, which led to the question of how to do a strong DS in that context. APAC did a very good survey of the community, and the National Academy of Sciences (NAS) also put together a group to analyze this issue. They formally recommended that the APD DS stick to the existing schedule. Therefore, it is moving forward.

A substantial amount of planning is preceding the DS panels. There are flagship and probe studies going on, which involve four Science and Technology Definition Teams (STDTs) and 10 PI-led studies. All

four STDTs have submitted interim reports to NASA, each containing an “Architecture A.” Dr. Hertz has asked them to provide an “Architecture B” in the final reports. Each STDT said they planned on doing that already. He does not expect the teams to choose one or the other, but rather to submit both to the DS.

The NAS Committee on Astronomy and Astrophysics (CAA) is reviewing the balloon program roadmap, the evolution of data centers, smallsats, a study of in-space servicing and assembly, and technology development on segmented telescopes to see if more needs to be done in these areas. NASA is finalizing a Statement of Task for the DS between NASA, NAS, the National Science Foundation (NSF), and the Department of Energy (DOE), while NAS is preparing a proposal to the agencies. NASA and NSF have funding for this if there is a proposal by September 30. Once the funding is sent forward, NAS can assemble the panels, determine the structure, etc. There will be a roll-out to the community at the January 2019 American Astronomical Society (AAS) meeting. The DS should be delivered by early 2021. APAC was welcome to advise on anything else NASA can do to prepare. Dr. Hertz noted that the STDTs and balloon roadmap group are under APAC. NAS will solicit white papers for the DS, but Dr. Hertz did not know the timing. The CAA will determine whether the STDTs will need to submit white papers. If there are concerns, the STDTs should email the CAA co-chairs.

Dr. Hertz next reviewed the APD response to APAC’s recommendations from the April 2018 meeting. Most had been closed out. Of the remainder, the response status is below:

- Recommendation: APAC suggested that the Senior Review subcommittee be populated with the membership of the "rest of missions" panel to insure balance and fairness.
  - This will be a discussion topic at the next APAC meeting.
- Recommendation: APAC suggested that SOFIA undergo a comprehensive review like a Senior Review, and seeks input into the terms of reference for that review.
  - Response: NASA is awaiting clarification from Congress.
- Recommendation: APAC recommended that Dr. Michael New continue to work with the NASA centers to learn about the pathways taken by successful women PIs, and how to increase the pool. APAC urged Dr. New to communicate directly with Center Division Directors and Branch Heads/Lab Chiefs, as these individuals directly influence the make-up of project teams.
  - Response: APD will ask Dr. New to present at a future APAC meeting.

In addition, NASA continues work on High-Risk/High-Reward (HR/HR) programs, and will respond to the SMD committees when it is completed.

#### *Discussion*

Dr. Ozel thanked Dr. Hertz. Dr. Bautz said that he was pleased to hear of the intent to protect R&A and Explorers. He asked that APAC’s letter include a statement to that effect.

Dr. Paul Scowen asked if the JWST situation would affect the Congressional mark-ups. Dr. Hertz replied that these mark-ups are for FY19, and the JWST budget is adequate for that year. The mission will need more funds than originally planned for FY20 and FY21, but he does not anticipate putting in a revised request for FY19. However, the Congressional committees do know about the replan, and NASA Associate Administrator Steve Jurczyk had already testified about it. The House Science Committee was to hold hearings in a few days, with testimony from NASA Administrator James Bridenstine, the Northrop Grumman CEO, and IRB Chair Tom Young. There had been briefings on Capitol Hill as well. It could be that the final budget language will include some direction and/or comments. The cost increase as stated is necessary. JWST has been manufactured and therefore it cannot be redesigned. Testing is essential; to do otherwise would be foolish. So there are no alternatives to completing the mission according to the replan. Dr. Victoria Meadows asked about mitigation of the impact on science, like with TESS data, for example. Dr. Hertz thought this was a great question that warrants serious thought. NASA ought to assess the options. He asked that APAC’s letter request that APD identify the impacts.

### Webb Telescope Update

Dr. Eric Smith, JWST Program Scientist, explained that the replan is at the 80 percent confidence level for a launch date of March, 2021, and the Program will implement the Independent Review Board (IRB) recommendations. Recent acoustics testing revealed loose hardware from the sunshield membrane covers, introducing a delay of about 5 months, which is factored into the IRB report. If everything were to go perfectly, which never happens in any space program, JWST could launch sooner. The project aims to move quickly, but mission success is the most critical thing now.

The Optical Telescope element/Integrated Science (OTIS) payload functional testing is complete, and the team has performed deployment post-cryogenic testing, with one more deployment test to go. The General Observer (GO) call will be re-issued in late 2019/early 2020. The Space Telescope Science Institute is using lessons learned from the run-up to proposal submission. There are a lot of ground segment tests and rehearsals. One of the most gratifying things about the IRB report, which is online, was the recognition of the promise JWST has for science. The fact that the science payload is complete indicates that it will meet that promise, but the remainder of the mission must match it. This is a big, complex mission, and the Integration and Testing (I&T) schedule was optimistic. Small problems can have major schedule and cost impacts.

The team is working on the IRB recommendations. Dr. Smith presented a chart of the recommendations, with responses by NASA, Northrop, and both. He explained that an “embedded problem” is something buried in the system that will only be uncovered later, such as loose hardware. The IRB cited the need to look at the various procedures at Northrop, which had staffing issues leading to errors. Dr. Ozel observed that the IRB identified a number of Northrop staff-related issues, and asked whether they related to procedures, clarity, corporate culture, or something else. Adding more paperwork will not fix the problem. Dr. Smith gave an example of a procedure that assumed something that should have been made explicit. It is impossible to eliminate human errors, but the procedures can be made more robust. That is happening now. Not all of the issues relate to procedures, however.

Before the topic of the science community was discussed, Dr. Hasan asked Dr. Scowen to leave the table due to a COI. Dr. Smith then addressed the IRB request to restore communications with the Science Working Group (SWG) to what it had been. He explained that after delivery of various instruments, particularly OTIS, the SWG meetings became less frequent, people became less engaged, and communications fell off. The team is now ramping back up to a higher cadence in order to keep the community engaged. He also presented links to the online reports, including the IRB report and the NASA response.

Dr. Alan Boss asked for an explanation of the staff morale situation at Northrop, which was cited by the IRB. Dr. Smith explained that this primarily refers to the fact that the work was going 24/7, and some workers were burning out as a result. The schedule now comprises two 10-hour shifts, plus a voluntary third shift to help out other workers. In addition, some staff lost sight of the bigger picture, specifically why they are doing this work. Therefore, the team will have scientists go through and talk to them about the impact and context of why they are working so hard.

Regarding hardware and technical issues, the team is trying to maintain schedule performance. There were also issues with membrane cover repair, OTIS mirror stability, and the Near InfraRed Camera (NIRCam) pupil wheel. The membrane covers sit on the sunshield membranes during launch. Once the covers roll back, they tuck under the sunshield. The mechanism includes battens, about 2 percent of which came loose during acoustics testing, which is approximately twice as intense as what is likely to occur during launch. The team removed all of the screws, placed them back on, and did some additional work. More practice is necessary, and the team is looking at whether to add a bumpers to the battens. The



cover is not the same as the membrane; the membrane is the sunshield itself, while the bolts are on the cover, which must survive the launch without damage. The team will deploy this mechanism at least two more times in testing prior to launch.

There were three OTIS Problem Failure Reports (PFRs), which Dr. Smith described. These were either closed or near closing. There were thermally induced stresses and communications equipment, the former requiring modifications and re-assessment. Work on a NIRCam element move failure was ongoing, but there are three other ways to address the error. This is a redundant path issue, so the team may employ alternative ways to move the module. Dr. Smith listed the remaining I&T activities. Northrop has to deploy a secondary mirror support structure on the science payload. In addition, the spacecraft will require acoustics, vibration, and thermal vacuum testing, to be followed by I&T of the combined payload and spacecraft element.

The Space Telescope Science Institute (STScI) is rehearsing mission operations, and there is a back-up center at GSFC to address spacecraft issues, if needed. In answer to a question, Dr. Smith explained that the NIRCam pupil wheel functions with optical elements. Dr. Scowen pointed out that the IRB calls attention to a cultural problem at Northrop with sticking to the schedule and doing the job right. The report states that workers should be able to halt activities if needed. He asked about the likelihood of lurking issues that were not addressed sufficiently due to schedule pressure. Dr. Smith replied that the team is trying to determine if all of the complex items were sufficiently tested, and where issues might arise in subsequent tests. If anything is found, there will be additional tests. This has to work. The IRB wants NASA and Northrop to focus on mission success.

Dr. Laura Brenneman asked about staffing at the STScI mock-ups. Dr. Smith said that there is a small staff except for during rehearsals, when it expands. Dr. Ozel said that JWST is the highest visibility mission at NASA, and the screw problem sounds like a design flaw. Instead of stating that, however, the technical personnel seem to have solved the problem at their level. She asked if they reported this back as a design flaw that they addressed. Dr. Smith said that the designs go back to the Responsible Design Engineers (RDEs). Sometimes these individuals move on within the company, resulting in years-long gaps between design and discovery of the problem. The Project is bringing them back into the process per the recommendations of the IRB.

Dr. Fischer asked about the fraction of remaining work, and whether items are going into storage. Dr. Smith said that the science instrument and telescope are complete, and the science payload meets its requirements. The team will be doing testing, and making sure it stays clean via a very thorough contamination protocol. Dr. Leonidas Moustakas asked whether RDEs will stay on programs into the future. Dr. Smith said that this is a good lesson learned, and any long-duration mission will have this concern. That is why this falls to Northrop, so they will keep such people around. The flight software is being rehearsed at STScI, which will use the extra time for additional review. The Institute has been the star of the program and has kept to its milestones. NASA has another organization checking the software on various dimensions, including hacking. The Agency is doing all it can to make sure the mission stays on track.

Dr. Boss asked if the SRB should have caught some of these things. Dr. Smith said that the IRB did not look at this. The SRB meets at a certain cadence, and the JWST team had lower-level reviews with relevant SRB members. Dr. Kelly Holley-Bockelmann said that many of the mistakes seem attributable to Northrop, and wanted to know if the company was passing the cost back to NASA, resulting in Northrop being paid to fix its mistakes. Dr. Smith said that NASA pays the company what it takes to produce the product. Any time there is a change in a program like this, the contract must also change, and that probably involves lawyers. The new launch date has a new launch cost, and now NASA will go into

negotiations with Northrop. Dr. Hertz added that the amount being quoted encapsulates costs to all parties, plus reserves. Northrop does not get all of that, and it is being negotiated.

*Lunch Presentation – Cosmic Accelerators: Gamma Rays and Neutrinos*

Dr. Regina Caputo gave a lunch-time science report for APAC members. It was not part of the official meeting.

GPRAMA Guidelines

Ms. Jennifer Kearns of SMD provided background on the Government Performance and Results Act Modernization Act (GPRAMA), which requires each Federal entity to provide a strategic plan, an annual performance plan, and an annual performance report that evaluates the progress made in key areas. In SMD, the performance measures address milestones for missions and development. There are also measures of science progress, Annual Performance Indicators (APIs), that call for an external expert review. This is a function that APAC provides for APD. It is a very high-level assessment based on achievements, and it is not an advocacy exercise. The document should cite accomplishments that represent growth.

There are three APIs in NASA's FY18 Annual Performance Plan against which APAC was being asked to assess progress:

- API AS-18-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.
- API AS-18-2: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.
- API AS-18-4: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life

In determining NASA's success in meeting the performance goals related to astrophysics, APAC was free to evaluate anything that occurred during the last year, though they were only to consider items funded in whole or in part by NASA. That funding did not need to come from APD specifically. Dr. Hasan had sent APAC members a document with items they could consider, though they were not bound to using those examples. The only requirement for the APAC material was that it be sufficient to back the conclusions.

The key requirement was for a color rating, as follows:

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

APAC was being asked to include three or four examples per API to support the color rating. These should be brief and written for the intelligent layperson. The use of links was encouraged.

GPRAMA Discussion

Dr. Ozel led the discussion of the ratings and examples. She suggested that each APAC member write up a candidate example, with the goal of creating a working draft on the second day of the meeting. Dr. Hasan, who had sent out a document with some possible examples, thanked Dr. Rita Sambruna for her contributions to the piece. Dr. Ozel reiterated that the examples should be written for the intelligent layperson rather than for scientists. Ms. Kearns explained that the APAC should assume readers who hold a college degree in something other than science.

The first API was AS-18-1, to demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity. Under that category, the first proposed example was “NASA’s NICER Mission Finds an X-ray Pulsar in a Record-Fast Orbit.” While the members agreed that this warranted inclusion, Drs. Holley-Bockelmann and Asantha Cooray thought it belonged in the second category, AS-18-2. Dr. Ozel suggested that APAC review additional candidates and return to this one.

The next example in Dr. Hasan’s document was “NuSTAR Probes Black Hole Jet Mystery.” Drs. Brenneman and Moustakas advocated inclusion, since jets are still largely unknown and the discovery raises interesting questions. Dr. Brenneman volunteered to write this example. Several APAC members suggested that the third example, “X-rays Reveal Temperament of Possible Planet-Hosting Stars,” was more applicable to the API dealing with exoplanets. However, since it could go into either, it was decided to include it last under AS-18-1 as a segue. Dr. Fischer agreed to write this one. APAC was unanimous in thinking that “NASA Missions Catch First Light from a Gravitational-Wave Event” should be first under AS-18-1. Dr. Holley-Bockelmann took it. She suggested combining it with the example of galaxies without dark matter and the one on the tens of thousands of black holes in the Milky Way’s center.

Dr. Ozel asked if APAC could offer five examples. Ms. Kearns said that while the writing team prefers approximately three for each API, there is some flexibility. In addition, the APAC could combine related items in a single paragraph, increasing the amount of material covered by providing links for the reader. Dr. Ozel noted that it has been a particularly exciting year. Dr. Hasan added that there is a requirement that examples include references to a published paper.

The vote on AS-18-1 was unanimous, for a rating of Green.

Next, APAC discussed API AS-18-2, to demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe. Dr. Ozel noted that APAC had moved one item to this category. The next candidate was “SOFIA Observations Help Unravel Mysteries of the Birth of Colossal Suns,” which was determined to be a good example. Following that was “Hubble Finds Substellar Objects in the Orion Nebula.” There was also a SOFIA result about the Horsehead Nebula; this one was eliminated during further discussion. Dr. Holley-Bockelmann thought there should be some galaxy results here, such as the previously discussed galaxies without dark matter, and super-massive black holes outpacing galaxy growth. Dr. Boss was concerned that there was some controversy in that one, and others agreed. Other options were “Astronomers See Distant Eruption as Black Hole Destroys Star” and “Kepler Solves the Mystery of Fast and Furious Explosions.”

Dr. Ozel reviewed the candidates: the SOFIA result on the birth of massive stars; substellar objects in Orion from HST; distant eruption; Kepler; and light from a gravitational wave event. Everyone liked the Kepler result. Dr. Holley-Bockelmann also liked the black holes outpacing galaxy growth. She thought this might tie in with another result, on red nuggets, which she would find for the Committee. It was agreed to remove the Orion topic, and to move x-ray activity impact on stars from AS-18-1 to AS-18-2. Dr. Holley-Bockelmann emailed another potential example to the APAC members, thinking it could replace Astronomers See Distant Eruption as Black Hole Destroys Star. The SOFIA example on the birth of massive stars did not survive voting. It was noted that the next GPRAMA will probably have a lot from SOFIA. It was agreed to keep the article on the distant eruption as a black hole destroys a star, as well as the Kepler result.

The vote was unanimous for Green.

The third API, AS-18-4, was to demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life. The first example was “NASA Finds a Large Amount of Water in an Exoplanet’s Atmosphere.” Dr. Meadows thought it could be combined with another example for a general “characterization” paragraph. Next were “Hubble Detects Exoplanet with Glowing Water Atmosphere” and “New Clues to TRAPPIST-1 Planet Compositions and Atmospheres.” Dr. Meadows agreed to work on these and find pictures for TRAPPIST. The final example was “NASA Releases Kepler Survey Catalog with Hundreds of New Planet Candidates,” which all of the members wanted to include.

The vote was unanimous for Green.

Dr. Ozel asked the APAC members to work on their assignments. During discussion on the second day of the meeting, they would settle on which examples to keep and their order.

#### Ground Based Support for TESS and Other Missions

Dr. Fischer explained that the detection of biosignatures will rely on direct imaging spectroscopy, and transiting planets will be further away by definition. She then presented a schematic of anticipated TESS results compared to Kepler and non-Kepler sources. Investigations should be able to control for which planets have Radial Velocity (RV) measurements. She showed graphs of transiting planets in the Habitable Zone (HZ) and RV-detected planets in the HZ, and presented data on RV precision and telescope aperture. While some spectrographs have been decommissioned, many more are coming online during the next 5 years, and more than half of those are accessible to U.S. astronomers.

The EXtreme PREcision Spectrograph (EXPRES) was designed to reach a higher level RV precision. Dr. Fischer explained the stability of the spectrograph and the testing that is being done. New instruments coming online are a great start but insufficient to fully address discovery and mission support. There is a need for moderate (3-meter) to large (10-meter) telescopes in order to obtain the desired precision. The niche for RV is key to the NASA strategic vision, which involves finding the Earths around nearby stars. EXPRES, Europe’s Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations (ESRESSO), and the NEID observatory could lead the next wave of exoplanet detection. TESS, JWST, and WFIRST are among the upcoming missions targeting exoplanets. Together, these missions represent an eco-system – pull out one of them and the strategic path forward is stressed. All will need ground-based RV support. Measuring RVs is time intensive, resulting in only 10-15 stars observed per night. Longitudinal coverage and high cadence are necessary, as are spectrographs for characterizing the stars, and RV detections and turning radii into densities.

The United States and Europe approach the issue of public access differently. Along with ESA, Europeans have the European Southern Observatory (ESO), as well as the science organizations for the individual countries. In the United States, NSF is the default manager of all ground-based facilities, and its budget is insufficient. If there were an independent way to fund ground-based facilities, it might help, but ground-based observation seems to have no good home in the United States. The existing facilities are good as far as they go, but most U.S. investigators are confined to data mining. The additional \$800 million that JWST needs would build six ground-based telescopes. Dr. Fischer is more concerned about hardware than software, but it is not clear how to support innovative instrumentation in this field. It is in NASA’s best interest to have the instruments that investigators need in order to fully characterize discoveries. All of NASA’s upcoming missions will require ground support.

Dr. Boss said that he and Dr. Meadows participate in the NAS Astrobiology Science Strategy committee, which has also discussed this issue and will produce a report this fall. It was not clear which funds should be shifted to this area, if any. Dr. Ozel asked what APAC or APD might do. Dr. Fischer replied that there is a problem with underestimating how long these detections take. All of the upcoming missions will

require RV follow-up, but they do not acknowledge it because to do so would grow their budgets. Dr. Hertz said that the DS is the right place for the community to provide input on an integrated plan for the relative priority of ground and space observations. The astrobiology study should cover this, and the community should write white papers if the study does not.

#### WFIRST Update

Drs. Dingus, Holley-Bockelmann, and Conklin were the only APAC members who were not conflicted on WFIRST. All other members left the table.

Dr. Jeff Kruk explained that WFIRST was the top recommendation from the 2010 astrophysics DS. It is distinguished by its field of view and addresses four broad categories of science: dark energy and the fate of the universe; wide-field infrared surveys of the universe; technology development for exploration of new worlds; and full distribution of planets around stars. The mission will provide a robust GO program that will account for a minimum of 25 percent of observing time over the 5-year baseline mission and 100 percent in the following years. It will be a serviceable mission that will also provide a robust archival research program with access to all data from the mission. WFIRST will measure both the cosmic distance scale and the growth of expansion. For microlensing, this mission will complete the census of exoplanets, building on what has been done by Kepler. WFIRST will survey nearby galaxies 100 times faster than HST, and at the same resolution. The coronagraph will be a technology demonstration. The telescope aperture is 2.4 meters and will be compatible with future starshade missions. The surveys will not be decided for a while, but Dr. Kruk gave some examples of the kinds of work that could be done.

While the FY19 PBR seeks to terminate the mission, the WFIRST team will continue work until they are told to stop. Congress is deliberating, and the preliminary indications are that there will be full funding. The systems requirement review and mission definition review were passed in late winter, and the mission is now in Phase B. There have been some notable changes to keep WFIRST within its cost cap. The integral field channel has been descoped due to budget constraints. The Phase A-E lifecycle costs remain at \$3.2 billion at the 50 percent confidence level. The project will study options for reducing the coronagraph costs, with a report in November. The international partnership contributions have not yet been formalized; they will probably come to about \$50-100 million.

The team was trying to take an expansive view of “technology demonstration” with the coronagraph, as it is felt that the best way to demonstrate that the technology works as desired is to do science with it. However, a comprehensive science program would require more filters than the budget will allow. Therefore, the baseline is the minimum set for a demonstration and starshade compatibility. The potential science will still inform the mask and filter options. The model is similar to a PI-class instrument. It is also possible that the coronagraph could go from a Class C to a Class D instrument.

All observing time will be selected competitively, starting close to launch and periodically afterwards. All data will be public immediately, and archival research will be funded on par with GO programs. The science priorities will be updated as needed throughout the mission. The project team is thinking about how to allocate time and organize teams. This is not a pure survey mission, and there are Level 1 requirements to execute certain science investigations, so teams will need to be able to define the surveys. There will also be funding for teams to develop the needed software. Dr. Kruk described a number of ways this might work. There are plans for community working groups, the first of which will address planning deep fields. A workshop will be held at the end of August on this topic.

Dr. Holley-Bockelmann asked what the demonstration goals are for the coronagraph. Dr. Kruk said that a demonstration will require some science, and there is a wide range of what could be done. He gave the example of contrast on dust and debris studies. Regarding the integral field channel and supernova science: the combination of high-quality imaging from space and ground-based spectroscopy has long

been considered to be a viable backup plan, and some in the supernova community have actually preferred that to an integral field channel-based approach. Dr. Holley-Bockelmann asked how the microlensing will compare with the ground-based the Large Synoptic Survey Telescope (LSST). Dr. Kruk said that while some microlensing is done from the ground, it is not part of the LSST observing plan. WFIRST will be able to seek smaller planets. It was noted that a ground-based telescope has limited sensitivity, where a space-based telescope has greater sensitivity and precision, along with larger numbers. Dr. Holley-Bockelmann said that LSST is looking at this, so there might be some interesting synergy. Dr. Dingus asked how much money might be saved from eliminating the coronagraph. Dr. Kruk replied that the 2017 estimate was \$400 million, which might have changed. None of the international contributions are essential, and many relate to the coronagraph.

#### Public Comment Period

The public was provided an opportunity for comment, but no one came forward.

#### Discussion

Dr. Ozel said that one of the items left over from the previous meeting had to do with the possibility that a private entity might take over running Spitzer. Dr. Hertz reported that some parties had wanted the mission to operated until JWST flew, but as of now they have not raised the additional funds to take it beyond its projected end date. In addition, Spitzer is becoming less efficient due to its orbit. Dr. Kartik Sheth later reported that Spitzer is now at 48.5 degrees and will pitch to 52.5 degrees.

Dr. Moustakas wondered about the extent to which APD collaborates with other divisions on various opportunities, giving the example of the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO). This mission is funded by the Planetary Science Division (PSD), and Dr. Cooray wondered if PSD would actually want APD to be involved. At a lower level, Dr. Boss noted that the Exoplanet Program Analysis Group (ExoPAG) has decided to interact more with PSD PAGs. There was some speculation about the best way to approach collaborations, whether to take it to the NAC Science Committee, the PAGS, or something else. Dr. Hertz said that the MoO call in the spring will include new science with existing spacecraft, including from PSD's New Horizons program, among others.<sup>1</sup> Dr. Meadows said that the community should be aware of this opportunity. There was also discussion of a town hall, or another survey through the PAGs. Dr. Ozel pointed out that other divisions and mission directorates offer possible synergies, as does inter-agency collaboration.

Dr. Hertz said that he wants to hear about any research opportunities that are missing from the program, because he wants to avoid having gaps. Ideas ought to be proposable. There are no rules against scientists collaborating across disciplines. For example, he is willing to fund a heliophysicist who proposes successfully. Dr. Boss said that the exoplanet program at the Jet Propulsion Lab (JPL) is working on a gap list, will be relevant for future Exoplanet Research Program (XRP) proposals. Some of those proposers are unclear about whether to go to APD or PSD. Dr. Hertz said that this is a known issue that NASA is trying to resolve before issuing the Research Opportunities in Space and Earth Sciences (ROSES) 19 call. The gap list is about things NASA needs to know, not things the Agency funds or solicits.

Dr. Ozel liked the idea of identifying the topics that are not covered and determining what fraction of the community is concerned. She wondered if a community survey might be the best way to proceed, and if so, whether it should go through the PAGs. Because the PAGs would not go beyond astrophysics, they might start by asking if astrophysicists are covered sufficiently. Dr. Meadows suggested talking to the other discipline's AGs or interest groups, maybe even having them present to APAC. Dr. Hertz noted that they are all organized differently, and the Earth Science Division (ESD) does not have any. Drs.

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<sup>1</sup> Subsequent to the APAC meeting, a decision was made not to offer New Horizons in the upcoming Explorers AO.

Moustakas and Ozel returned to the idea of asking the astrophysics community if they felt anything was missing, then have speakers to APAC. Dr. Scowen emphasized the need to have a very clear question. Dr. Hertz advised APAC to go to the other divisions' advisory groups, not their AGs. This could be done through the Science Committee or chair-to-chair calls.

Dr. Meadows pointed out that Dr. Aki Roberge, an astrophysicist, is a member of the Planetary Science Advisory Committee (PAC), and she herself is a planetary scientist. Dr. Ozel said that it is important that the discussions about possible missing opportunities result in action. Dr. Bautz asked whether it was known or just suspected that there is a need for this. Dr. Moustakas replied that it is the former with XRP. Dr. Bautz wondered if the exoplanet community might be different. Dr. Scowen said that APAC would need to verify interest on the part of the other divisions. Dr. Hertz said that this is an excellent topic if there are specific ideas. He would like to know if the other communities perceive gaps and whether SMD needs to do better in this area. He would fix any concrete issues right away if they were brought to him.

Further discussion led APAC to determine that they should identify any astrophysics issues before reaching out to other committees. Examples might help. Dr. Dingus gave gamma-ray burst detectors as a case of something that is hard to get flown. Dr. Meadows cited exo-Venuses, noting that it would be helpful to know about Venus in studying Venus-like exoplanets. Dr. Hertz asked that APAC distinguish between flight projects and R&A. Instruments on missions are a different topic. Dr. Ozel said that there should be a balance between thinking across boundaries and proposers who were unable to get funding because they fell outside of a clear, existing category. Dr. Holley-Bockelmann thought it would be useful to know what succeeded despite programmatic issues.

Dr. Ozel said that the proposal was to develop a question to take to the community on the issue of existing attempts to do interdivisional science. The purpose is to identify those areas, determine whether investigators have obtained funding, and learn if there are areas they want to expand into but do not because it is unclear where to go. APAC would examine the responses, take them to Dr. Hertz, and possibly reach out to other NASA science advisory committees to discuss gaps and the potential for collaboration. Dr. Hertz added that APD hopes to be able to bring something on XRP collaboration to the next APAC meeting. Dr. Dingus suggested hosting a AAS session. She was concerned about the question being too vague to result in useful information.

Dr. Scowen said that at the next meeting, he wants to hear more about technology prioritization across APD. Dr. Hertz said that there could be a presentation from the program managers on how they will do the technology prioritization report next year. Dr. Ozel noted that she was keeping a running list of agenda items for the next meeting.

#### Wrap up for Day 1

Dr. Ozel closed the meeting for the day, reminding everyone of the location for Day Two.

Tuesday, July 24, 2018

*Capitol Holiday Inn*

#### Opening Remarks

Dr. Hasan opened the second day of the meeting by reviewing the FACA standards and the requirements for Special Government Employees (SGEs). For the Nexus for Exoplanet System Science (NExSS) presentation, Dr. Moustakas had a COI and would recuse himself.

#### R&A Update

Dr. Stefan Immler, R&A lead, listed APD's four R&A areas: supporting R&T, mission science and instrumentation, data analysis, and separately solicited. He then described each area. A new ROSES element, LISA Preparatory Science (LPI), received 30 proposals. Another new ROSES solicitation, for smallsat studies, resulted in 38 proposals. The Astrophysics Theory Program (ATP) will solicit next in 2019. The TESS Guest Investigator (GI) program received 33 Cycle 1 proposals. After NICER completes its prime mission, there will be a new ROSES element for a NICER GO program. APD also created a code of conduct for reviewers and chairs.

Dr. Immler reviewed the ROSES 2018 elements and listed upcoming calls. He explained the difference between "exoplanets" and "habitable world." The former is detection, and there is some planetary interest. The latter is cross-divisional with PSD and HPD. HPD might join the exoplanet area, as well; this is still under discussion. Great observatories such as HST and Chandra are not under ROSES, but instead run their own solicitations. Dr. Immler discussed the time it takes to notify PIs, which is sometimes a matter of timing among solicitations and reviews, and might also reflect the status of the Federal budget, clarification, topic complexity, and program scientist workload.

Dr. Ozel pointed out that the selection rate for the NASA Earth and Space Science Fellowship (NESSF) program is at 5 percent, which is a concern. Dr. Immler said that APD wants this award to be a privilege. The Division provides an average of eight of these awards per year. As it has no separate funding line, it must be funded out of other lines. Dr. Hertz added that, given APD's fixed R&A budget, APAC should consider whether to fund graduate students directly or through their professors. He welcomed the input. Dr. Ozel agreed that that is a consideration. However, when the success rate falls below a certain level, the selection process becomes very difficult, making differentiation of the students a matter of splitting hairs. Dr. Hertz agreed. Dr. Immler cited the high level of student participation in some R&A programs. Dr. Cooray said it would be helpful to see if the students with fellowships have had successful careers. Dr. Brenneman urged caution in defining success. Dr. Hertz said that determining the level of graduate student funding through PIs would take some analysis.

APD's Theoretical and Computational Astrophysics Networks (TCAN) program supports coordinated efforts in fundamental theory and computational techniques, with an emphasis on collaborations across institutions and regions. ROSES 2017 included a TCAN call with a \$1.5 million allocation. Of the 32 proposals received, 3 were selected, for a selection rate of 9 percent. Dr. Immler described proposal pressure over the last 15 years. The slope of the proposal rate is higher than that of the funding, while the selection rate has stabilized. The notional budget is a 28 percent increase over next 5 years, including cubesat funding.

The Internal Scientist Funding Model (ISFM) is a NASA initiative to fund research from the civil servant workforce, unduplicated with the rest of the community and capitalizing on specific center capabilities. The program solicits proposals internally. Dr. Immler reviewed the packages selected for FY18 and FY19. All went through external, written peer reviews, and three would have been submitted as 10 separate proposals under the previous system. The peer review process used the forms and criteria from a face-to-face review. This is not like a solicitation. Rather, it is an ongoing discussion in which APD tells center management to offer new ideas. There is then a dialogue and an agreement to submit a small set of proposals. Dr. Jones observed that if all of the proposals are accepted, it sends the review stage to the centers. Dr. Immler explained that APD had very complex discussions with the centers, which initially presented too many ideas. Dr. Bautz asked if the themes were agreed to in advance. Dr. Hertz explained that ISFM criteria require that the research be substantive and best done at a center. The science themes are from the DS and reflect center expertise. That leads to fewer topics. Dr. Immler added that the centers ask for the funding they feel is adequate, and the parties negotiate from there. The number of civil servant proposals has gone down, which was one of the goals. Almost all x-ray mirror development at NASA is under ISFM now, for example. Non-NASA sources typically do not propose for these areas. While



community members are not discouraged from proposing for these topics, they seldom did so even before ISFM.

The R&A code of conduct, which was developed for panelists and chairs, is now placed on posters at all peer reviews. Dr. Immler reviewed the code highlights, stating that APD hopes it will spread across SMD. The Division continues to have a program scientist present for all panels. They do not weigh in on the review, but they do follow the discussions. This is something that each SMD division handles differently; APD feels this is a balanced approach. Dr. Ozel agreed. Dr. Moustakas asked about a double blind experiment being conducted for the HST GO program. Dr. Immler said that APD is curious to see the outcome and will evaluate it.

Dr. Immler next showed the FY18 and FY19 manifests for the balloon program, which has four launches in the queue for Antarctica. He also presented the APD sounding rocket launch manifest for mid-2017 through 2020. SMD expects to have a facility ready in Australia in 2020. Cubesats are being solicited via ROSES, through the Astrophysics Research and Analysis (APRA) program. Over the past several years, APD has selected four cubesats. Dr. Immler showed a photograph of a cubesat that is about the size of a shoebox. APD will fund cubesats at \$5 million per year starting in FY19, and plans to select one annually via APRA. While science return is a requirement, the size limits the science. On the other hand, these cannot be pure technology demonstrations. Student participation is among the criteria, and NASA will provide a free launch. Dr. Hertz added that PIs are welcome to draw on SMD and Ames Research Center (ARC) capabilities, but they must take the initiative. APD has pointed PIs to these sources in order to enable cost savings, etc.

Dr. Immler described an APD Request for Information (RFI) that sought to pull in ideas for high-priority astrophysics science projects funded at \$10-35 million. The RFI also asked for advanced mission concepts for which “significant” investments in instrument and/or platform technologies would be required, without budget constraints, in order to inform future solicitations. There were 55 responsive replies. A smallsat solicitation will select up to 10 proposals for 6-month studies, timed to allow completion prior to the release of the 2019 SMEX/MoO. A large number of students are participating.

Dr. Dingus said that it would be helpful to have the demographics of the PIs. Dr. Hertz explained that NASA is not allowed to collect this data, by law. APD can only infer gender, for which there is limited actual data. However, as Dr. New reported previously, SMD is studying the career paths of successful women PIs. To obtain additional data would require an Office of Management and Budget (OMB) waiver. The NASA Chief Scientist has such a waiver, but APD and SMD do not. Dr. Hertz welcomed a discussion leading to a recommendation that notes the data desired, the ways to collect it, and how the data might be used productively. The data from inferring gender based on first names indicate that the fraction of females selected is equal to the percentage of females who proposed. Some programs’ proposal rates reflect community data on gender, though not all. Dr. New is looking at that as well. NASA is not allowed to ask PIs about the gender of their students. AAS can collect that, but not the government. Dr. Immler added that R&A tries to have diverse panels, and the percentage of female panel members is higher than the percentage of proposers. Dr. Ozel added that Dr. New’s previous presentation was very useful, and while the data are not as good as directly collected data, he did show what Dr. Hertz described. He will be presenting to APAC at a future meeting, probably in the spring of 2019.

It was noted that cubesats are part of the suborbital program through APRA, and both the science and technology maturation matter. However, the score has to be good, and proposals focused on only one area tend to not be selected. Dr. Conklin said he was concerned about where to propose technology demonstrations with cubesats. The Space Technology Mission Directorate (STMD) is more focused on nuts and bolts. He asked if STMD would bring in astrophysics help to review a proposal on focal plane

devices, for example. The reply was that they do that already, but almost all cubesats have new detector technology.

#### High End Computing Support and Plans

Dr. Tsengdar Lee explained that SMD manages High End Computing (HEC) for the Agency at ARC and GSFC. He described the systems and storage. NASA is doing a modular expansion at ARC. Half of that facility's capacity goes to SMD, and APD receives about one quarter of the SMD allocation. GSFC HEC is primarily for ESD, with some for APD. The HEC program provides user support services and products, including the online resources. A user survey rated the help desk services very highly, the best among all of the services. This service operates 24/7 and can help on any kind of request. Dr. Lee showed some interesting results from simulations run on HEC Capability (HECC) resources.

One of the issues that has arisen is allocation to investigators. In FY18, astrophysics requested 64 million Standard Billing Units (SBUs). The target was 60 million, and with various reserves and other allocations, only half of the total resource had been used as of June 30. Dr. Lee projected use of only about 65-70 percent of the allocation by the end of the fiscal year. This means that there are wasted resources. Each SBU is worth about 16 cents. If 20 million SBUs are wasted, that is \$3.2 million in wasted funds. ESD has a similar issue, though PSD and HPD do not. This is not the historical pattern; this is new. In the past, SMD did not have sufficient resources, and what was there was fought over. This year is different. Dr. Jeffrey Hayes said that investigators going through HPD waste about 50 percent of their allocation, and the Heliophysics Advisory Committee (HPAC) is pondering the best means to address the situation. This only covers R&A, as well. Mission needs comes in differently, as do Explorers. Investigators funded through both APD and HPD have discovered that large simulations can now be done, whereas before NASA lacked sufficient capacity. Using only 60 percent of the allocation is inefficient. There needs to be a better algorithm. HPAC thought about having a monthly communication with the PIs, which will require some work at NASA Headquarters. Some of the simulations are too large for the allocations, taking as many as 2 million SBUs.

Dr. Ozel wondered if a large projects panel might be necessary. She added that she self-censors when she applies for computing time, and the fact that others waste it is annoying. Dr. Holley-Bockelmann agreed that this is very frustrating for someone like her, who exercises restraint. She noticed a lot of homogenous purchases and asked about specialized purchases. Dr. Lee said that when SMD tried that, there was little utilization. Absent a large request, the HEC program will stay on the current path. Dr. Hayes added that SMD is also discussing whether to purchase or rent infrastructure. Dr. Lee said that long queue times operate on a default of first-in, first-out, with some adjustments as needed. HECC does not let the code consultants get into a situation of being overworked. Each of the 12 will help about one project per year. Dr. Ozel observed that it could be useful to manage this even at the proposal level. Dr. Lee replied that scheduling is an ongoing area for which SMD will take input. The challenge is that the requests exceed capacity, and SMD knows that investigators are self-censoring. HECC wants to allocate time when the project is selected, and continues to establish allocation targets and insert the requests into the panel review process.

He described what is being done to increase capacity and capabilities, with focus on a modular super computing facility. SMD has been collecting information related to ROSES for each program element, to determine the number of requests and the SBU's requested. He showed the projected APD demand, targets, and known requests to date through 2024. This will be provided to program scientists when the Division sends out a call. Among the top challenges are how to treat computing time compared to telescope time; how to establish program-level targets; how to determine project-level allocations at selection; and how to identify and solicit reviewers with supercomputing expertise. This needs to be part of the ROSES review process, and for that Dr. Lee sought APAC input.

Dr. Ozel said that this is the right direction. With the increasing number of highly computational projects, merging the estimation of computing time into ROSES would be a good pilot project, and she recommended starting with ATP. Her concern was the need to have review panelists qualified to address the HEC issue. Dr. Meadows asked if there were a backfill queue or some other means of addressing the wasted time. Dr. Lee said that if a division does not use its share, the resource will go elsewhere. The computing is fully utilized, but it would be wasted from the division standpoint. SMD is about halfway into analyzing the challenges and processes. They know how much time ATP receives, for example, and might be able to set a target in another year. He is aware of the self-censoring of PIs like Drs. Ozel and Holley-Bockelmann, who do not request time because they feel they will not get it. Dr. Dingus asked about lessons learned from other sources. She is familiar with DOE and Los Alamos, and suggested talking to them. Dr. Lee replied that he meets with an interagency working group monthly. DOE has a program that SMD might work with but for size and code issues.

Dr. Ozel asked what would be helpful from APAC. Dr. Hayes said that spreading the word that there are issues due to inherent inefficiencies would be useful. APAC can assist in educating users, and the users are going to have to help. Codes are growing faster than the capacity, and access is becoming problematic. It might help to think about how the community polices itself. All four SMD divisions are struggling with this. Dr. Ozel wondered about holding a townhall on HEC at an AAS meeting or something. Dr. Hayes said that might be worthwhile, adding that some of the missions now require more computing time, which will be a factor in Senior Reviews from now on. Dr. Holley-Bockelmann asked about whether missions might go into a separate pool. Dr. Hayes said that that is possible. He would like to see data use in AO responses. Dr. Ozel said that APAC can acknowledge the current situation, state that they look forward to cloud computing, and address efficiency, then weigh in on the community aspect of users doing better, and the allocation element that may lead to a separate group on this. This could be addressed in panels, with some panels weighting it more than others, as needed.

Dr. Lee said that he has visited JPL as part of this effort. Discussions with other agencies are ongoing, but inter-agency work requires a lot of coordination and goes slowly. Some of what he suggested comes from other agencies lessons learned, but other things might not be appropriate for NASA. For example, DOE has large projects for which allocation is done by the computer scientist, not the program scientists. NASA also tried a computational call, which did not go well. SMD does not want a two-step process, preferring a single call to allocate resources. Nor does SMD have the resources to have a competition for improvements in codes, though this might be considered if the need arises, and APAC can recommend it. Currently, NASA relies on self-selection and self-censorship, which may not be helpful in the future.

#### Discussion

The topic of R&A gender diversity came up for additional discussion, but both Dr. Hertz and Dr. Ozel advised waiting for Dr. New's report in the spring. Dr. Hertz noted that it was possible to collect data on the numbers of graduate students supported. Dr. Fischer wondered about the value of NESSF, since the selection rate is so low. It was agreed to consider this at the spring meeting, as well. Dr. Dingus noted that NSF also has graduate fellowships with low success rates. Dr. Hertz added that this is similar to the NSF fellowship program. NSF has data on the career paths of those selected and those almost selected. Dr. Dingus thought that would be a good example to study. Even when students are turned down, they are writing proposals. She was not sure that it is always in the students' best interest to get these fellowships, as students benefit from having advisors. Dr. Ozel suggested discussing this and the data APAC would like to see in the spring. Dr. Fischer said that NSF funds 12 percent of fellowship applicants across the organization; she did not have data specific to astronomy. Dr. Scowen added that NSF has a lot of planetary fellowships. Dr. Hertz said that SMD is not uniform; ESD funds many fellowships. Dr. Ozel reiterated that APAC wants to know the funding that goes to graduate students from APD-funded, PI-led proposals. Dr. Hertz said that it would be helpful to get community input on the pros and cons of having

their graduate students apply to the NESSF program. Drs. Jones and Conklin both had that information and said they would provide input.

#### ExoPAG/PhysPAG/COPAG Updates

##### *COPAG*

Dr. Scowen explained that the Cosmic Origins Program Analysis Group (COPAG) has been very active. He noted the Executive Committee membership and status, and explained that COPAG has representatives on all four of the STDTs preparing reports for the upcoming DS. The group for the new Study Analysis Group (SAG) on great observatories is coming together. The window for submissions to the DS is January 14-18, 2019, which will be a factor. COPAG sought community input on the possible delay of the DS; all three PAGs used the same survey. The joint report, issued in May, was used by NAS in its report, and is on the three PAG websites. The recommendation was for no delay, which was the decision. The responses were overwhelmingly to have the DS now. This goes across all axes of analysis.

COPAG has one open SAG, three open Science Interest Groups (SIGs), and one open Technology Interest Group (TIG). All groups have plans to prepare for the DS, to organize and coordinate input but not direct it. The Far InfraRed (FIR) SIG website is now at the Infrared Processing and Analysis Center (IPAC), and a review on FIR science was submitted for publication. The SIG is coordinating white papers for the DS. There is also an ongoing webinar series covering science and mission topics. FIR SIG is still working on its newsletter and preparing for a 2019 winter AAS session, will continue with Origins Space Telescope (OST) white papers, and work with the FIR community, with a possible fall workshop.

The UV Visible SIG is setting up a leadership council and hopes to have white paper teams on ambitious science. There has been no activity in SIG 3 due to some changes in personnel. The Great Observatory SAG is moving forward, with cross-PAG leadership, and preparing for the January AAS meeting. Membership will be about 30 or 40 rather than the 10 listed in the PowerPoint presentation. The TIG had limited second quarter activity but met informally by teleconference, and is seeking access to the redstar database at the Marshall Space Flight Center (MSFC) for technical information. The TIG is advancing a suggestion to expand its scope beyond technology for flagship missions, to include smaller missions.

COPAG was requesting no actions from APAC. Future activities are teleconferences, ongoing STDT support, white papers, community feedback to NASA on relevant issues, and identifying new Executive Committee members. Diversity along many axes is a priority with the Committee.

##### *ExoPAG*

Dr. Meadows gave the ExoPAG update. The PAG has three active SAGs in sundown phases, and she was requesting closeout on SAG16, for which she had provided the final report. The other two will close out at the next APAC meeting. Recent activities include a letter to the JWST Users Committee (JSTUC) to make the case for large multi-cycle legacy proposals to support community-led proposals. The ExoPAG18 meeting was planned for the following week in Boston, at the Cool Stars 20 conference, as part of an effort to visit a range of meetings beyond AAS. ExoPAG was funding four students to travel to that meeting. ExoPAG provided feedback on the science gap list and sought member input on the DS delay idea. The SIG2 charter had been drafted, as well. An in-person virtual NExSS workshop in 2016 had extremely broad community participation to address science questions on how to enhance science return from NASA exoplanet characterization missions, resulting in five papers.

SAG16, which addressed exoplanet biosignatures, produced a published paper. Dr. Meadows described its goals, objectives, and membership. ExoPAG wanted to close out the SAG now that its work was done. SIG2, on exoplanet demographics, was still determining membership. The SIG will build on prior demographics, synthesize survey information, and provide yield comparisons to be used by mission

concepts. Future activities include the meeting prior to Cool Stars 20, continued teleconferences, work on the gap list, completion of work on the two remaining SAGs, and initiation of SIG2. ExoPAG will also participate in the Great Observatories SAG with COPAG and the Physics of the Cosmos PAG (PhysPAG). Dr. Meadows asked APAC to close out SAG16 and initiate SIG2. In discussion, there was some questioning of the timing of the technology gap assessment, which ExoPAG has always done a bit differently than the other two PAGs. This was addressed later in the meeting.

#### *PhysPAG*

Dr. Conklin gave the PhysPAG update, starting with a review of what the PAG covers. Physics of the Cosmos (PCOS) represents 54 percent of all respondents to a recent community survey. Currently, the main effort is the Multi Messenger Astrophysics (MMA) SAG, inspired by the Fermi and LIGO/Virgo detection of a binary neutron star merger, and approved at the last APAC meeting. The SAG includes multiple disciplines and has members from COPAG. It is inspired by, but not specific to, gravitational waves. MMA SAG hoped to have a steering committee that includes all of the significant disciplines, but it is organized in a traditional manner. The outcome will be at least one white paper delivered to APAC in mid-2019, along with input to the DS. MMA SAG will not advocate for a particular mission, focusing instead on existing missions and facilities. After announcing the SAG to the full PhysPAG and COPAG email lists, 59 astronomers have signed up, and 34 dialed in for the first full MMA SAG teleconference. A substructure will be in the form of source teams, which will try to get around some of the silos created by observation methodology. The team leads will organize their own communications. PhysPAG has nominated a representative for the COPAG Great Observatory SAG. Dr. Conklin briefly described the activities of PhysPAG's SIGs and listed past and upcoming meetings. One of the latter will occur at the January AAS meeting.

#### Public Comment Period

The meeting was opened for public comment. Dr. Ozel asked if there were any members of the public who wished to speak, but no one came forward. Dr. Meadows read part of an email she received clarifying the issue on technology gaps. This will be done officially in 2019, but ExoPAG is already preparing for it.

#### Discussion

APAC returned to discussing GPRAMA. Dr. Ozel had sent out the latest draft. For the first API, AS-18-1, APAC had voted green. Below are the examples:

1. NASA Missions Catch First Light from a Gravitational-Wave Event. Dr. Holley-Bockelmann was to edit this.
2. Hubble Constant Mystery Keeps Growing. This was a placeholder title, and Dr. Moustakas was writing it.
3. NASA's NICER Mission Finds an X-ray Pulsar in a Record-fast Orbit, Dr. Ozel took on the editing.
4. NuSTAR Probes Black Hole Jet Mystery. Dr. Brenneman took this one.
5. New Study Uncovers Tens of Thousands of Black Holes Exist in Milky Way's Center.

Dr. Cooray agreed to write the summary on the second API, AS-18-2. The examples still under consideration were:

1. Kepler Solves the Mystery of Fast and Furious Explosions.
2. Astronomers See Distant Eruption as Black Hole Destroys Star. There was lingering debate on this one. Dr. Holley-Bockelmann thought it was being swapped out for red nuggets and intermediate black holes, and Dr. Fischer preferred having a press release, as the description was too scientific for the audience. Dr. Ozel suggested adding the shredding star information.
3. SOFIA Observations Help Unravel Mysteries of the Birth of Colossal Suns. Dr. Ozel had concerns about this one, as it was one of two SOFIA results, and not very exciting as written. Dr.

Fischer agreed. Dr. Scowen thought it could be restated to be more interesting, and Dr. Fischer found some additional information to boost that element of the example. However, it was pointed out that there will be further results on this topic. APAC tentatively agreed to remove it.

4. X-rays Reveal Temperament of Possible Planet-Hosting Stars. Dr. Fischer took this one.

Dr. Fischer also took on the summary for the third API, AS-18-4. The examples are:

1. NASA Releases Kepler Survey Catalog with Hundreds of New Planet Candidates. Dr. Boss checked this one for a conflict with a previous result. Since there was none, APAC decided to keep it.
2. A: NASA Finds a Large Amount of Water in an Exoplanet's Atmosphere; B. Hubble Detects Exoplanet with Glowing Water Atmosphere. Dr. Meadows said she would combine A and B.
3. New Clues to TRAPPIST-1 Planet Compositions, Atmospheres. Dr. Meadows was already working on this one, with information from three papers. She would provide the references.

Dr. Ozel said that she would send the sections for final review. There was no need for another vote.

### SOFIA Update

Dr. Harold Yorke, Director of SOFIA Science Mission Operations, presented selected recent science results from the mission, starting with discoveries about the magnetic field in the Galactic Center. This has led to questions about the impact and role of the magnetic fields, particularly regarding black holes. The galactic region is an ideal lab for testing star formation theories in extreme environments. Dr. Yorke showed locations of three clusters of massive stars and of isolated massive stars, stressing that far IR observations are necessary to find forming massive stars during earlier phases. A Spitzer FIR image close to the Galactic Center was overexposed and could not find massive protostars; a SOFIA far IR example with a short exposure of this bright region found several. Further out, looking at a mini-starburst in the nearby LMC galaxy, far IR reveals intense star-forming activity. The magnetic lines seem to be evidence of a Parker Instability. Magnetic fields in active galaxies raise the question of whether plasma controls fields, or fields control plasma.

Dr. Yorke also discussed the HAWC+ dust emission photometry of a distant galaxy, which helped separate contributions from Active Galactic Nuclei (AGN) and starbursts to the total energy observed. Several dozens of bright-lensed galaxies could be similarly analyzed using SOFIA. For the nano-starburst of Orion Trapezium Cluster, SOFIA used multi-wavelength studies to untangle the role of magnetic fields in star-forming regions. The magnetic field structure shows an analogous hourglass shape seen in other views.

The [C II] serves as tracer for star formation and it measures molecular cloud mass not found by carbon monoxide. It determines bulk kinematics and turbulence of this gas, and quantifies photo-electric heating efficiency over a wide range of UV fields. Where there is strong [C II], there is also strong heating. The large area [C II] velocity-resolved map of Orion shown by Dr. Yorke would have taken 2,000 hours of observation time on Herschel, but only 40 hours on SOFIA. A similar map of [C II] in M51 was shown, clearly delineating spiral structure distinct from the carbon monoxide spiral structure. High-resolution spectroscopy was also used to examine oxygen in the planet-forming zone of HL Tau, which is presumably in an advanced stage of planet formation. Investigations like this at even higher sensitivity will be the focus of HIRMES, a future SOFIA instrument. Dr. Yorke reviewed its capabilities. HIRMES will enable detection of the distribution of oxygen, water ice, water vapor, etc. There are a number of other applications related to water detection. For example, SOFIA observations of water on Mars indicate that the atmosphere has not been replenished by surface water for the past 2 giga-years.

Summarizing, SOFIA focuses on three science objectives: the birth of stars and planets; the path to life, by detection and analysis of water, organics, and dust; and the role of extreme environments in starbursts

and AGN. Since it is not a space mission, SOFIA can perform hardware repairs/upgrades and can accommodate much more complex state-of-the-art instruments. The mission is in Cycle 6 through April of 2019, with 24 flights having occurred and more than 80 others planned. For Cycle 7 there are two calls for observing proposals: 200 hours in a new two-year legacy program for large proposals and 400 hours available for smaller U.S. queue programs. The thesis-enabling program will be continued. Dr. Yorke notes that SOFIA over-accepts proposals in order to have a sufficiently large target pool. Regarding coordinated measurements among missions, it is always important to ensure that they are measuring the same thing, but a multi-wavelength approach is indeed necessary for many topical areas of study. There is an open ROSES solicitation for the next generation science instrument for SOFIA. Dr. Sheth said that this solicitation is being driven by legacy program science. The data for all legacy programs will be immediately public.

#### NExSS Update

Dr. Natalie Batalha, presenting remotely, described NExSS as a Research Coordination Network (RCN), a term used at NSF. This RCN is dedicated to the study of planetary habitability and the search for life on exoplanets. It is also a NASA cross-division initiative bringing together astrophysicists, planetary scientists, Earth scientists, and heliophysicists to yield a “systems science” approach to the subject. The science objectives relate to habitability. Goals address planet diversity; interaction of planet history, geology, and climate; architectural context of planets; experience of the solar system; and where NASA should invest. A graphic illustrated the many considerations and indicators of habitability. NExSS has the strategic objectives of exploration of exoplanets; cross-division common goals; leverage of existing SMD programs; and creation of a mechanism to break down the barriers. The pilot program from 2015 sought to create an inter-divisional group to look as ROSES awards and the CANs to identify what could be part of the effort. There were seven teams with overlap among them. Activities include white papers, workshops, etc. As an example of a highlight, Dr. Batalha described the exo-mineralogy activities within NExSS. They involved three NExSS groups with complementary expertise: geophysicists, geochemists, and astronomers. The goal was to determine the size and composition of dust from the planets orbiting certain stars, and to compare this to the dust grains expected to be shed from disintegrating planets, based on surface petrology and dust condensation models.

NExSS has produced white papers addressing science and technology gaps, resulting in a list of six topics resembling a technology gap list. There were also some workshops on a range of topics. The technosignatures workshop reflects directed spending from a Congressional budget, and will take place at the end of September. Dr. Batalha described the results of workshops on exoplanet biosignatures and habitable worlds. Public awareness is important. The January issue of Nature included commentary highlighting the need for this systems science approach.

An early question was about JWST and how to help. The JWST Advisory Committee (JSTAC) was working on an early release science program, so NExSS came together to consider what would be needed. Regular teleconferences led to an Early Release Science (ERS) proposal, which currently has 104 team members and was the highest ranked proposal. Dr. Batalha also noted allocation levels and measures of success. Some of the NExSS white papers will be submitted to the APD and PSD DS panels. The habitable worlds program covers astrobiology, Mars exploration, outer planets research (all in PSD), and exoplanet research (APD). There is now official language encouraging individuals to participate. In addition, habitability was specified in the Space Authorization Act (SAA). APD and PSD program scientists are identifying potential members. NExSS has been inexpensive and has no deliverables, as it is a grass roots effort. The group is working for more transparency and considering how to leverage its efforts over the longer term.

Dr. Ozel explained that APAC discussed interdivisional science, of which NExSS is an example. The Committee was concerned about gaps that do not fit into an existing SMD division, as well as whether

there is sufficient funding. In that context, she wanted to know whether the review panels were told about NExSS in the pilot program. Dr. Batalha said that that was not the case. The pilot program was initiated after the fact. Dr. Ozel confirmed that these are proposals that would have been funded anyway. She asked if there are still areas that would not have gone through. Dr. Batalha said that few of these activities would have happened without NExSS, but the research funding is completely independent. Those teams are selected individually. Some are pulled in through the CANs. Planetary habitable worlds is intrinsically interdisciplinary. It is difficult to fund interdisciplinary teams, as there are few resources for that. Dr. Boss said that in 1986, the Origins of the Solar System (OSS) program was first funded, and it was interdisciplinary, but that particular program no longer exists. Dr. James Green, NASA Chief Scientist, said he viewed it more as rearranged. Dr. Fischer asked if there is any thought of building a bridge between NExSS and the NASA Exoplanet Science Program (NEXSci). Dr. Batalha said that the NEXSci archives are phenomenal, and there needs to be an interface.

#### SMD Science Activation Program

Ms. Kristen Erickson, the SMD Director for the Science Engagement and Partnerships Division, explained that the Science Activation program was formerly known as SMD Science Education. However, in 2013, the funding for education was removed from SMD. She held regular meetings with the science discipline Division Directors (DDs), including Dr. Hertz, to determine how to maintain SMD leadership in science education. SMD identified its contributions: subject matter expertise, content, and authentic experiences. All four DDs determined that science education and literacy were still important priorities within SMD, so SMD began talking to stakeholders, including a review of the Decadal recommendations and hosting a workshop at the National Academies. SMD started treating science education with the same rigor as science. SMD also issued a Cooperative Agreement Notice (CAN). SMD identified potential connections and the next generation of science standards. It was decided to meet learners where they are, while being as efficient as possible. The result was 27 agreements, 4 of which are tied directly to APD. Awardees include a space science badge progression for Girl Scouts, and the SOFIA Ambassadors program. The Universe of Learning shifted the model of delivering astrophysics content to be more effective. There is a lot of relationship building, with independent evaluation. The 2017 total solar eclipse brought in many partners and broadened the effort. The nimbleness of the CAN enabled increased responsiveness. The CAN included a 5-year base agreement with a 5-year option.

SMD is expanding this initiative through existing community partners. The Division plans to partner more fully with the Office of Science, Technology, Engineering, and Math (STEM) Engagement as well. The SMD Science Activation model has not changed. It is a simple input/output model, with NASA's unique capabilities lying in its expertise. But the hard part in managing such an extensive program is focusing and keeping complexities simple. Ms. Erickson described a number of outcomes, such as enabling STEM education, improving science literacy, etc. SMD wants to be active in moving toward these objectives, while leveraging partnerships and advancing national education goals, which will officially involve Mr. Bridenstine, as the co-Chair of this Administration's strategy.

The Science Activation providers are where the interface occurs with the community and learners. Ms. Erickson described some of the toolkits and exhibits using astrophysics expertise. The SMD collective relationships are multi-faceted, and Dr. Hasan is the Astro Lead. The model includes content, dissemination, and audiences, as well as infrastructure. Ms. Erickson described digital access and the free resources within the infrastructure. An input/output model is used, and Ms. Erickson showed how it applies to the Universe of Learning agreement. A nice, unexpected result is the rapid response. There is still a lot to do in the middle of the country, even in the areas with low populations, for that is where the "dark skies" areas offer opportunities for science. Ms. Erickson gave the link for the science resources and listed upcoming opportunities. Her Division is asking astrophysicists to participate in the American Geophysical Union (AGU) conference this year, at which SMD will have an exhibit. In 2019, NASA will commemorate the 50th anniversary of the Apollo moon landing. Earth and space 2019 toolkits are



available for training and activities. Even those researchers who are not selected can access much of this online.

Regarding efforts to increase diversity among the Ambassadors, SMD has an Ambassador with access to a number of Native American tribes. He has held two conferences with them thus far. It is important to understand their needs rather than make assumptions. Another Ambassador has worked with tribal leaders in Alaska. For the upcoming APD DS, the Science Engagement and Partnerships Division has identified gaps in its models, and a group will conduct an assessment over the next year. The Division is informing the DS panels through the Space Studies Board.

#### Recommendations, Actions

Dr. Ozel said that APAC was in good shape with GPRAMA, which she would organize and send out for comments and edits. APAC decided not to say anything about the budget or markups in its letter to Dr. Hertz. Regarding JWST, it was noted that earlier in the meeting, Dr. Hertz had said he was going to look into whether there would be operational changes as a result of the replan, and Dr. Meadows had asked if there was anything that the community should be doing as a result of the delay. Dr. Hertz now said that the first step is to think about what the community might do to minimize the impact of the delay. Dr. Ozel asked if that was in terms of what JWST might need or if it referred to data that other missions had planned to take simultaneously with JWST. Dr. Meadows explained that there are target selection issues that the JWST team might address. She was taking the question to ExoPAG and polling the community. Dr. Bautz recommended that the PAGs all do this. Dr. Boss said that STScI might have a revised plan for review by the APAC at the fall meeting.

Dr. Ozel asked about reaction to the IRB report. Dr. Boss recommended thanking Dr. Smith for being transparent and thorough, and thanking the IRB for their work in a difficult situation. Dr. Dingus noted that there will be hard budget decisions ahead in FY20 and FY21, and she was concerned. Dr. Hertz explained that APD will follow DS priorities and protect Explorers and R&A, and there will be impacts on the rest of the program. Dr. Ozel said that APAC would thank Dr. Smith for a transparent and thorough presentation, and acknowledge the Committee's concerns. It was suggested that this statement also cover support for the DS, the need to consider international partnerships, and the need to propagate new lessons learned into the future as best practices. It would be ideal to have the lessons learned by January in order to meet the DS panel timeline for input.

Dr. Dingus asked if APAC could recommend anything on WFIRST since they did not have an unconflicted quorum. Dr. Conklin said that he would note that the work continues despite budget uncertainties. There was discussion clarifying that the coronagraph technology demonstration would require some science to be done as part of the demonstration. Dr. Hertz explained that the items driven by science usability have been descoped. Dr. Holley-Bockelmann remained concerned about the supernova survey and found it worrisome to have this happen so late. Dr. Hertz explained that the astrophysics community has been talking about WFIRST as a concept for a very long time, but actual activities have not been occurring during all of that time and NASA just recently nailed down the requirements. Spectroscopic observations of supernovae are now to be made on the ground, and while those must be paid for, they are cheaper. The project went through a cost-cutting exercise and the requirements can be met by the combination that saves dollars. The science impact was acceptable.

Dr. Dingus thought it might be helpful to have a presentation on the science capabilities that are going forward. Dr. Hertz recommended phrasing for the request, which Dr. Ozel included in her discussion summary. She said that the members present were pleased with the continued progress under this circumstances. Those members noted the reduction in instruments and want a presentation on how the science requirements flow down to the mission and instrument requirements.

It was determined that there was nothing to be said about LISA. Dr. Ozel said that the letter would state that APAC heard about NICER and acknowledges that it is going well, and that there is a plan for a 6-month GO program to the bridge gap between the primary mission and the Senior Review. APAC also completed GPRAMA. Dr. Ozel sent APAC members a blurb to review on cross-divisional science. There was debate about whether to give examples when surveying the community. Dr. Hertz thought the examples would prevent people from thinking further. Dr. Conklin suggested having check boxes for the other divisions with which astrophysicists might want to work. Dr. Ozel thought there would need to be a text box as well, which would then require some analysis to identify clusters. Dr. Meadows suggested putting the text responses in an appendix, an idea that other APAC members liked. Dr. Bautz thought the PAGs might design this, another suggestion that received broad agreement. Dr. Conklin asked whether the survey should include other NASA directorates, but it was decided to start with SMD divisions and see if other directorates were mentioned in the comment box. Dr. Meadows pointed out that funding sources for projects that straddle divisions might be an issue.

For the technology gaps presentation at the October meeting, APAC was to ask the technologists to present. On the R&A update, Dr. Ozel said that the letter would commend APD for establishing the code of conduct for panel reviews. APAC would also seek more information about graduate fellowships at one of the next two meetings. This should include the success rates from NSF and other agencies if possible, and the amount of PI funding that goes to graduate students through other R&A programs. Dr. Hertz said that the Committee could get a first look in October to ensure that the information at the spring meeting is what APAC wants. Dr. Ozel said that Dr. New will report back in the spring with his data.

For HEC, at least five different things came up as suggestions, some of which were in the presentation. APAC was asking for more on the following:

1. The growing need for a long-term plan, and any details that can be shared.
2. More efficient management of existing resources and the queues, along with plans on how to allocate resources.
3. User education, community education, and a townhall to discuss HEC and its use.
4. Potential changes in the selection process, including having a large project panel.
5. The possible test of a “use it or lose it” allocation of funds to be used only for computing, in order to reduce the unused computing time. This method would allow PIs to return unused time, buy from cheaper sources, etc.

Dr. Meadows said that for Option 5, PIs could go outside NASA. Dr. Ozel explained that there is no obligation to use full capacity. In this method, an investigator who does not use the funds will return them. Dr. Dingus questioned whether APAC was the right group to decide this, instead of the users. Dr. Ozel said that these were things to think about. Dr. Moustakas wondered about the efficiency of the cloud via SMD instead of the money going to individuals. He did like that they were taking the challenges to the community and wanted to encourage that. Others agreed.

Dr. Ozel said that the letter would also note the PAG updates and the SOFIA science that is coming in. Dr. Meadows asked APAC to respond to her request to close SAG16. The vote to do so was unanimous, as was the vote to initiate SIG2. On the science activation talk, Dr. Ozel found it impressive that they took science teaching to many different learning environments. She asked that any further thoughts be added when members reviewed the letter. NExSS was tied into the cross-divisional discussion. The Committee would thank Dr. Batalha for that presentation. Dr. Dingus added that it was amazing what they have accomplished with little funding.

#### Brief to Division Director

Dr. Hertz said that the previous discussion served as the briefing, and he looked forward to the letter.

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Dr. Hasan thanked the APAC members and other participants. The members applauded Dr. Ozel for her first meeting as Chair.

Adjourn

The meeting was adjourned at 3:55 p.m.

**Appendix A**  
**Participants**

Committee members

Feryal Ozel, University of Arizona, *Chair, Astrophysics Advisory Committee*  
Marshall (Mark) Bautz, Massachusetts Institute of Technology  
Alan Boss, Carnegie Institution of Science  
Laura Brenneman, Harvard-Smithsonian Center for Astrophysics  
John Conklin, University of Florida  
Asantha Cooray, University of California, Irvine  
Brenda Dingus, Los Alamos National Laboratory  
Debra Fischer, Yale University  
Kelly Holley-Bockelmann, Vanderbilt University  
William C. Jones, Princeton University (via teleconference)  
Victoria Meadows, University of Washington  
Leonidas Moustakas, NASA JPL  
Paul Scowen, Arizona State University

NASA attendees

Paul Hertz, NASA HQ, *Director, Astrophysics Division*  
A.F. Barghouty, NASA  
DaMara Belson, NASA  
Dominic Benford, NASA HQ  
Regnia Caputo, NASA GSFC  
Kimberly Ennico Smith, ARC  
Kristen Erickson, NASA HQ  
Mike Garcia, NASA HQ  
Thomas Hams, NASA HQ  
Hashima Hasan, NASA HQ, *Executive Secretary, APAC*  
Jeffrey Hayes, NASA HQ  
Stefan Immler, NASA HQ  
W. Vernon Jones, NASA HQ  
John Karcz, NASA  
Jennifer Kearns, NASA HQ  
Patricia Knezek, NASA HQ  
Jeff Kruk, NASA GSFC  
Tsengdar Lee, NASA HQ  
Diamond McCoy, NASA HQ  
Mamta Nagaraja, NASA HQ  
Susan Neff, NASA Goddard  
Mario Perez, NASA HQ  
Rob Petri, NASA Goddard  
Rita Sambruna, NASA HQ  
Kartik Sheth, NASA HQ  
Ryan Sims, NASA OCFO  
Eric Smith, NASA HQ  
Michael Werner, JPL  
Eddie Zavala, NASA Ames

Non-NASA attendees

Mary Floyd, ElectroSoft

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Robert Frey, Successful Proposals Strategies  
Elizabeth Sheley, Zantech  
Denise Smith, STScI  
Nicholas White, USRA  
Harold Yorke, USRA

### Webex/Telecon

Lynn Bowman, NASA Langley  
John Callous, JPL  
Joan Centrella, NASA  
Stephen Clark, Space Flight Now  
L. Curtis, Aura Astronomy  
Patti Daws, NASA  
Jeff Foust, Space News  
Richard Griffiths, University of Hawaii  
Jason Kalirai, STScI  
Bill Latter, NASA  
Sara Lipscey, Ball Aerospace  
Aquila Maliyekkao, House of Representatives  
Eric Mamajek, JPL  
Court Manske, Space Foundation  
Julie McHenry, NASA Goddard  
Connie Meinke, STScI  
Rachel O'Connor, Ball Aerospace  
Joshua Pepper, Lehigh University  
Thai Pham, NASA  
Marc Postman, STScI  
Naseem Rangwala, NASA Ames  
Rita Sambruna, NASA  
Wilton Sanders, retired  
George Sarver, NASA Ames  
Ryan Sims, NASA  
Karl Stapelfeldt, JPL  
Eric Tollestrup, NASA  
Stephen Unwin, JPL  
Ryan Wakefield, House of Representatives  
Al Wooten, MRAO

**Appendix B**  
**NAC Astrophysics Advisory Committee Members**

**Feryal Ozel**, APAC Chair  
University of Arizona

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

Marshall (Mark) Bautz  
Massachusetts Institute of Technology

Alan Boss  
Carnegie Institution of Science

Patricia Boyd  
Goddard Space Flight Center

Laura Brenneman  
Harvard-Smithsonian Center for Astrophysics

John Conklin  
University of Florida

Asantha Cooray  
University of California, Irvine

Brenda Dingus  
Los Alamos National Laboratory

Debra Fischer  
Yale University

Kelly Dr. Holley-Bockelmann  
Vanderbilt University

William Jones  
Princeton University

Victoria Meadows  
University of Washington

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Leonidas Moustakas  
Jet Propulsion Lab

Paul Scowen  
Arizona State University

Beth Willman  
University of Arizona

**Appendix C**  
**Presentations**

1. *Astrophysics Division Update*, Paul Hertz
2. *James Webb Space Telescope*, Eric Smith
3. *GPRAMA Annual Performance Evaluation*, Jennifer Kearns
4. *The Role of PRVs to Enable and Support NASA Discoveries*, Debra Fischer
5. *WFIRST Update*, Jeff Kruk
6. *R&A Update*, Stefan Immler
7. *NASA High-End Computing Program and Its Support of Astrophysics*, Tsengdar Lee
8. *COPAG Report*, Paul Scowen
9. *ExoPAG Report*, Victoria Meadows
10. *PhysPAG Report*, John Conklin
11. *Science in the SOFIA Era*, Harold Yorke
12. *NExSS: The Nexus for Exoplanet System Science*, Natalie Batalha
13. *SMD Science Activation Program*, Kristen Erickson



**Appendix D  
Agenda**

**Astrophysics Advisory Committee  
July 23-24, 2018  
Washington D.C.**

**Monday, July 23, 2018**

**NASA Headquarters**

8:30 a.m.	Introduction and Announcements	Hashima Hasan/Feryal Ozel
8:40 a.m.	Astrophysics Division Update	Paul Hertz
10:45 a.m.	Break	
11:00 a.m.	Webb Telescope Update	Eric Smith
12:00 p.m.	Working Lunch – <i>Cosmic Accelerators: Gamma Rays and Neutrinos</i>	Regina Caputo
1:00 p.m.	GPRAMA Guidelines	Jennifer Kearns
1:10 p.m.	GPRAMA Discussion	APAC members
2:10 p.m.	Ground Based Support for TESS and Other Missions	Debra Fischer
2:40 p.m.	Break	
2:50 p.m.	WFIRST Update	Jeff Kruk
3:20 p.m.	Public Comment Period	
3:25 p.m.	Discussion	APAC Members
4:30 p.m.	Wrap up for Day 1	Feryal Ozel

**Tuesday, July 24, 2018**

**Capitol Holiday Inn**

8:30 a.m.	Opening Remarks	Feryal Ozel
8:40 a.m.	R&A Update	Stefan Immler
9:10 a.m.	High End Computing Support & Plans	Tsengdar Lee
9:40 a.m.	Discussion	APAC members
10:30 a.m.	Break	
10:45 a.m.	ExoPAG/PhysPAG/COPAG Updates	Victoria Meadows/ John Conklin/Paul Scowen
11:30 a.m.	Public Comment Period	
11:35 a.m.	Discussion	APAC members
12:00 p.m.	Lunch	
1:00 p.m.	SOFIA Update	Harold Yorke
1:30 p.m.	NExSS Update	Natalie Batalha (via telecon)
2:00 p.m.	SMD Science Activation Program	Kristen Erickson
2:30 p.m.	Break	
2:45 p.m.	GPRAMA Discussion (cont'd.)	APAC Members
3:45 p.m.	Recommendations, Actions	Feryal Ozel

NAC Astrophysics Advisory Committee Meeting Minutes, July 23-24, 2018

4:00 p.m.

Brief to Division Director

Feryal Ozel

4:15 p.m.

Adjourn