

# NASA ADVISORY COUNCIL

## ASTROPHYSICS SUBCOMMITTEE

October 22-23, 2015

Goddard Space Flight Center  
Greenbelt, MD

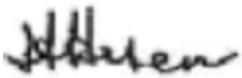
### MEETING MINUTES



11/11/15

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B. Scott Gaudi, Chair



11/17/15

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Hashima Hasan, Executive Secretary

*Table of Contents*

Introductions and Announcements	3
Goddard Space Flight Center (GSFC) Director Welcome	3
Astrophysics Division Update	3
Exoplanet Program Analysis Group (ExoPAG) Decadal Survey Report	7
Physics of the Cosmos PAG (PhysPAG) Decadal Survey Report	7
COPAG Decadal Survey Report	8
Working lunch (Discussion of Decadal Survey Reports)	8
JWST Update	9
Other ExoPAG Business	10
Other PhysPAG Business	10
Other COPAG Business	11
Preparing for JWST Cycle 1 Observations	11
Public Comment Period	12
Discussion	12
Opening Remarks	14
Astronomy and Astrophysics Advisory Committee (AAAC)	
Proposal Pressure Study Report	14
SMD Education Update	15
Imaging X-ray Polarimetry Explorer (IXPE) Update	16
Polarimeter for Relativistic Astrophysical X-ray Sources (PRAXyS) Update	16
SPHEREx Update	16
Public Comment Period	17
Big Data Task Force	17
Discussion	18
Recommendations, Actions	19
Adjourn	19

*Appendix A- Attendees*

*Appendix B-Membership roster*

*Appendix C-Presentations*

*Appendix D-Agenda*

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Thursday, October 22, 2015

Introduction and Announcements

Dr. Joel Bregman, Vice Chair of the Astrophysics Subcommittee (APS) of NASA's NASA Advisory Council (NAC), opened the meeting by welcoming the Subcommittee members and noting that there was a full agenda.

Goddard Space Flight Center (GSFC) Director Welcome

Dr. Colleen Hartman, Deputy Director of Sciences and Exploration at GSFC, welcomed APS. The Subcommittee members were to tour GSFC to see activities relating to the James Webb Space Telescope (JWST) the next day. Other GSFC astrophysics projects have been proceeding well.

Astrophysics Division Update

Dr. Paul Hertz, NASA Astrophysics Division (APD) Director, presented an update on Division activities.

*Science Highlights*

Dr. Hertz discussed some of the Division's recent science accomplishments. The Hubble Space Telescope (HST) has found that the nearest quasar is powered by a double black hole and has also uncovered clues of the earliest galaxies. The Stratospheric Observatory for Infrared Astronomy (SOFIA) has observed water around a protostar. The Spitzer mission has confirmed the closest rocky exoplanet and provided information about its density. The Kepler 2 (K2) mission has discovered the best analogue thus far to an Earth-size planet orbiting a Sun-like star, though it is not clear if the planet is rocky.

Dr. Hertz reviewed the many activities surrounding Exoplanet Week, which included media interviews and a well-attended lunchtime briefing for Congressional staff. APD continues implementing the 2010 Decadal Survey (DS) as the touchstone document. At the time of the meeting, there was no budget for Fiscal Year 2016 (FY16), only a Continuing Resolution (CR). The President's Budget Request (PBR) sought \$1.3 billion for Astrophysics including JWST, which is flat and keeps the plan going, fully funds JWST, funds Wide-Field InfraRed Survey Telescope (WFIRST) pre-formulation activities, and keeps the operating missions going. SOFIA will not be going to the 2016 Senior Review (SR).

APD could have as many as four launches in the next year. These include the European Space Agency's (ESA's) Laser Interferometer Space Antenna (LISA) Pathfinder, the Japanese Space Agency's (JAXA's) ASTRO-H, NASA's Neutron-star Interior Composition Explorer (NICER), and the International Space Station (ISS) Cosmic-Ray Energetics and Mass investigation (CREAM). Progress is being made in moving toward the next DS, with NASA initiating large mission concept studies as input. The mid-decade review is underway, with the report expected in May 2016.

Dr. Joel Bregman asked about implementation of SOFIA oversight. Dr. Hertz replied that the Program is standing up a SOFIA advisory committee. The mission's Program Commitment Agreement (PCA) has been revised to respond to review recommendations. Instead of having a flight hour requirement, the SOFIA team will be asked to do as much science as they can. There has also been a call related to the next generation of instruments in order to upgrade the SOFIA instrument suite. NASA is increasing funding to SOFIA general investigators substantially. The mission has maintained a high flight rate recently due to the low cost of jet fuel. Dr. Hertz said that he felt the threat of having to go to an SR made the SOFIA team think very hard about these issues.

The FY15 Fort Sumner balloon campaign included two engineering flights, one student flight, and one Earth Science Division (ESD) flight. Upcoming suborbital launches may include up to six in White Sands, NM, a Long Duration Balloon (LDB) campaign in Antarctica in FY16, and an Ultra Long Duration Balloon (ULDB) campaign in New Zealand.

For the upcoming SR, HST and the Chandra mission will have separate reviews to look at operations and make suggestions. Six operating missions will go to the SR: XMM, Spitzer, Swift, Fermi, K2, and the Nuclear Spectroscopic Telescope Array (NuSTAR). Suzaku, SOFIA, and LISA Pathfinder will not be reviewed, while SOFIA, ASTRO-H, NICER, and the Transiting Exoplanet Survey Satellite (TESS) may go into the 2018 cycle. Due to a budget shortfall, APD may need to terminate a mission or find some other solution after the SR. This may result in a funding shift.

Dr. Bregman said that he had participated in a number of SRs and it seems like the missions are left to own devices when planning to go into extended operations. Some have been exceptional, and others have not. He wondered if NASA could play a larger role in asking missions how they might get to a suitable extended mission cost phase. Software seems to be a big issue. Dr. Hertz said that APD does not manage missions at that level. The teams know their budgets will go down, they are motivated, and they talk to other missions. He was not worried that they are missing lessons learned. Dr. Bregman said that he was not convinced that the lessons learned are being adopted. At every SR, the panel sees a mission where the investigators are missing something.

#### *Education and Communications*

NASA's current education efforts target grades K-14, while social media, public affairs, and similar strategies fall under communications. This APS meeting was to feature a presentation about Science Mission Directorate (SMD) education efforts. Missions run communications through NASA centers, which coordinate with the principal investigators (PIs) and also fund these efforts. Each mission now develops its communications plans during Phase B. The PIs remain the key spokespersons, issuing updates, providing content, and coordinating with the centers. Science results are not communications. Dr. Hertz was not sure whether the centers now receive extra funding for communications, but he did know that the communications costs are no longer applied to the mission cost caps.

Dr. Kenneth Sembach asked about the role of SMD compared to the role of the NASA Office of Education (OEd). Dr. Hertz replied that it is tightly integrated and includes some co-funding. SMD education activities use the content of missions and science to advance science, technology, education, and math (STEM) education. OEd manages internships, student and teacher support, museums, etc. There has been a lot of continuity since the education contracts have been rebid. Some of the Cooperative Agreement Notice (CAN) contracts are for 3 years, and some are for 5 years, all with possible extensions. Missions will provide the interface with the CAN winners, as has been done all along. However, the policy and practice document is not yet complete. Every mission organizes itself very differently.

#### *Missions in Development*

Missions in development include LISA Pathfinder, ASTRO-H, NICER, TESS, JWST, and Euclid. CREAM is the first project to shift from a suborbital platform to the ISS. LISA Pathfinder will be the next to launch, in early December. This is an ESA project using the NASA ST7, and it will test some key technologies required for a laser interferometer gravitational wave observatory. The mission will take 2 months to cruise to L1, after which there will be a 6-month prime mission and the option of 6-month extended mission. The latter would be an ad hoc decision that ESA can make without NASA.

JAXA planned to launch ASTRO-H in November, and the call for cycle 1 Guest Observers (GOs) would follow in the spring. NICER has begun its final payload integration, and plans are to launch in summer 2016. TESS, the next exoplanet mission, will launch in late 2017. The mission just completed its Critical Design Review (CDR) and has some open items the team was trying to close out by the end of 2015.

Euclid is in its implementation phase. Due to a delay of almost 2 years in completing the detector engineering phase, NASA will not deliver the sensor systems later than planned. ESA announced a launch delay from early 2020 to late 2020. APD selected three Small Explorer (SMEX) missions to go into pre-formulation. The Phase A reports are due in summer 2016. APD will then review the missions and likely select one in January 2017. APD also selected two Missions of Opportunity (MOs).

#### *WFIRST and Athena*

NASA has made tremendous progress on WFIRST over the past 2 years and is now responding to the National Research Council (NRC) review and science definition team (SDT) studies. The coronagraph is on track in terms of technology development, and the wide-field detector technology development is on schedule. This mission will proceed as rapidly as funding allows. At the time of the meeting, the House of Representatives and Senate appropriations committees and direction were not in sync, so APD could only await the final budget. The mission is likely to launch in the mid-2020s. About 80 percent of the funds spent thus far have gone toward technology development. Dr. Hertz reviewed the technology milestones. As the various technologies progress toward Technology Readiness Level (TRL) 6, an external review committee checks them.

NASA did an internal cost estimate, then had Aerospace Corporation review the project and do its own cost assessment, which was roughly comparable to NASA's. When APD adopted the 2.4-meter telescope from the National Reconnaissance Organization (NRO), the assumption was that this would be cost neutral, which Aerospace confirmed. The coronagraph is an upgrade from what the DS proposed. The mission concept review is planned for December, when APD plans to announce the science team selections as well. The Division is engaging industry in studies for their roles; these studies will inform the acquisition strategy.

NASA continues to refine its contribution to ESA's Athena mission. The Agency will provide the sensor array for the X-ray integral field unit and is reviewing a proposal to contribute to the wide-field imager. NASA is also discussing with ESA the possibility of doing calibration at the Marshall Space Flight Center (MSFC). The response to an open call last year asking for hardware interest generated only one response on each of two instruments. Therefore, APD is working with those teams and will do sole source acquisitions.. Athena will have an APD budget line when it goes to Key Decision Point A (KDPA), but the funds are currently in the Physics of the Cosmos (PCOS) SR&T budget.

#### *Budget*

Dr. Hertz reviewed the budget process, noting that NASA has submitted its proposed FY17 budget with the Office of Management and Budget (OMB). As APD spends less on JWST in the next few years, that will open funding availability for WFIRST. It is a high priority to start WFIRST as early as possible in order to maximize overlap with JWST. Dr. Hertz presented the budget in more detail, by project and by function. Missions cost less after launch, and about half of the annual budget is spent on mission development.

If directed increases in funding for WFIRST are not fully funded through an increase in the Division's top line budget, it may be necessary to take \$20-35 million out of the rest of APD, depending on the final FY16 budget. The Division has done its best to optimize each year's spending. When JWST flies, the budget for General Observer (GO) spending will increase substantially.

The Division is now planning to a recommendation of four Explorer Announcements of Opportunity (AOs) per decade. There will be a Mid-sized Explorer (MIDEX) AO late next year, after which they will occur every 2 to 3 years. APD no longer includes the launch vehicle in the cost cap. The highest launch

rates were in the late 1990s/early 2000s. In 2004, the Explorer budget was halved and it has not yet recovered in inflation-adjusted dollars.

In addition to WFIRST, technology development expenses related to DS recommendations, including precursor science, encompass the Technology Demonstration for Exoplanet Missions (TDEM) element of Strategic Astrophysics Technology (SAT). The WFIRST coronagraph and competed technologies account for 80 percent of APD's technology development spending. Inflation Probe technology development is ongoing. Research and Analysis (R&A) has grown 22 percent in real year dollars since the DS was issued. The R&A proposal selection rate varies, with many areas around or just above 20 percent. Dr. Hertz noted that one of APD's accomplishments is that all of the 2015 selections were announced within 155 days of proposal submission.

Dr. Patricia Boyd observed that the NASA Earth and Space Science Fellowship (NESSF) program had a particularly low rate. Dr. Hertz explained that a high fraction of R&A programs fund graduate students, primarily through specific projects, while NESSF funds graduate students who are independent. This program operates across SMD, and each division decides how to handle it. APD is neither the smallest nor the largest. APS was welcome to advise APD on its allocation.

Dr. Hertz next discussed the APD investments in maturing intermediate technologies, as well as the suborbital balloon program. The budget for the latter has been increasing APD is buying a recovery plane for Antarctica.

#### *Astrophysics Division Update continued*

After a short break, Dr. Scott Gaudi, APS Chair, reviewed the Federal Advisory Committee Act (FACA) rules. These include that the meeting is open to the public; Subcommittee members should not reveal proprietary information; only public sessions can form the basis of recommendations to NASA; members should declare conflicts of interest; non-members can speak only when called upon by the chair; and the agenda included a public comment session for both days.

#### *Upcoming Missions and the 2020 Decadal Survey*

Dr. Hertz said that the large missions recommended by the DS have been excellent, which makes it important to prepare for the next DS. Even assuming a flat budget, there will be missions after WFIRST in the 2020s, and the DS committee members should have the background information they need in order to make recommendations for these missions. Therefore, Dr. Hertz believed that APD should study a number of large mission concepts for the DS. He had previously asked the Program Analysis Groups (PAGs) for input on these studies, and they were to report later during this meeting. The suggested missions are:

- Far IR Surveyor
- Habitable-Exoplanet Imaging Mission (HABEX)
- Large UV/Optical/IR Surveyor (LUVOIR)
- X-ray Surveyor

For gravitational wave studies, NASA plans to partner with ESA on an L3 mission, though the Agency's role has not yet been defined. ESA is moving forward on this concept, however, and NASA will not need to do concept studies. Another mission that has generated interest is the Inflation Probe. The current DS advised waiting for the mid-term report before taking action, and that is what APD is doing.

Once the large missions have been identified, APD will appoint science technology definition teams (STDTs) and a study office at a center. The Division will put out a call for self-nominations for the STDTs, vet the nominations, select the members, and charter the teams. The STDTs will develop the

science case, translate that to mission requirements, vet technology gaps, and make decisions about cost and capabilities versus science trades in order to find the optimum investments. Each study will be unique and will start in 2016, with reports due in 2019 as input to the next DS. If the reports can be done earlier, a condensed timeframe could be an option.

Regarding input to the 2020 DS in the area of probes, Dr. Hertz proposed three options:

- Real mission concept studies, which are thorough but expensive and lack a budget line.
- Paper mission concept studies; and,
- Self-selected, self-funded white papers submitted to the DS team.

Dr. Hertz would like the DS to suggest science concepts that are medium-sized, like a probe AO, similar to the Planetary Science Division (PSD) New Frontiers missions. This would provide flexibility to NASA and the PIs to determine the mission architectures. This “probe line” would use some of the available funding for strategic missions, which would slow down the large mission cadence after WFIRST.

Dr. Hertz proposed the following for APS feedback:

- Concept A: Fund about 10 paper mission concept studies, to be selected through the Research Opportunities in Space and Earth Science (ROSES) process and subject to a NASA cost assessment.
- Concept B: Concept A, plus a detailed study and better cost assessment of a few probes as additional exemplars.
- Concept C: Fund three full mission concepts.

#### Exoplanet Program Analysis Group (ExoPAG) Decadal Survey Report

Dr. Gaudi presented ExoPAG’s response to Dr. Hertz’s charge in regard to large missions. Dr. Hertz had asked the PAGs to solicit community input on the proposed large mission concepts, including the addition or subtraction of concepts. The three PAG Executive Committees met in April and there was further and substantial communication among them and, especially, the PAG chairs thereafter. The PAGs came to agreement on the primary conclusions.

The PAGs agreed that all four large mission concepts should be studied, as there was strong community support for moving these concepts forward. This agreement was predicated on the assumption that the 2010 DS priorities will be realized. All the PAGs expressed strong support for maturing the four mission concepts via science and technology definition teams (STDTs). The ExoPAG and COPAGs also agreed that the exoplanet and cosmic origins science capabilities should be baselined for both the LUVOIR and HabEx missions. Dr. Gaudi noted the ExoPAG preferences for the structure of the STDTs; these preferences were not shared in their entirety by the other PAGs. Finally, the PAGs find that there is community support for a line of probe-class missions within the Astrophysics Division mission portfolio.

ExoPAG expressed support for WFIRST with a coronagraph and a starshade. ExoPAG supports a line of probe class missions, specifically a starshade for WFIRST, a transit characterization mission, and an astrometry mission.

ExoPAG developed exoplanet science topics for all four missions, but this community is most interested in HabEx and LUVOIR. While these two missions are on a continuum together, there are obvious break points. HabEx is more focused, searching for habitability in a handful of Earth-like planets, while LUVOIR is a more general purpose mission like HST and would search for habitability on large number of systems, as well as detecting biosignatures on a small number of habitable systems. ExoPAG members see LUVOIR as likely more capable in every respect. PAG members also believe that costing is very important.

Physics of the Cosmos PAG (PhysPAG) Decadal Survey Report

Dr. James Bock presented the report from PhysPAG. As with ExoPAG, there were many meetings over the past year on the topic of the four large mission concepts. The PhysPAG membership assumes that implementation of JWST and WFIRST will precede these, and also expects NASA to partner with ESA on a gravitational wave mission. The PAG report notes that the Inflation Probe is a probe-class mission and will be developed according to the recommendations of the 2010 DS. PhysPAG advises APD to ensure that the STDTs are interdisciplinary and notes strong community support to study probe missions.

The ESA L3 gravitational wave mission is compelling, and PhysPAG members look forward to seeing this mission fully developed for the 2020 DS. NASA should begin work for this project immediately in order to identify the needed technologies and determine the ESA and NASA capabilities. The two agencies should also develop a range of options and the science cases, in addition to assembling the science team.

While PhysPAG agrees that the inflation probe investigation should be planned as a probe class mission, PAG members want more definitive cost information from NASA. This mission could be an exemplar. The 2010 DS technology program should continue going forward.

PhysPAG assumes the ESA Athena mission will progress with NASA participation and not require review by the 2020 DS. The flagship mission studies should fulfill science objectives broadly, and the STDTs should build on PCOS themes in planning the science capabilities. While HabEx is not very applicable to testing physics, the PAG did find a couple of interesting things about that concept.

PhysPAG received enthusiastic community input on probes and brought forward some new probe concepts. Cost and schedule discipline for the Explorer program is strong, and the PAG advocates for expansion of current Explorers and a category of larger, competed Explorers. PhysPAG also received input on integrating the Explorer missions into the strategic planning process.

COPAG Decadal Survey Report

Dr. Sembach presented the COPAG report on the upcoming DS. All community input was considered and is reflected in the report. A solicitation resulted in 38 white papers, many of which had common science themes or mission considerations applicable to multiple flagship concepts. COPAG also held workshops on the Far IR Surveyor and UV/Visible Space concepts. The Association of Universities for Research in Astronomy (AURA) report was issued; this was a 2-year study on UV/optical /IR optical telescopes.

COPAG agreed with the other two PAGs to look further at the four mission concepts, noting that a Far IR Surveyor would provide significant benefit to the cosmic origins science community. COPAG advised having baseline science capabilities for both LUVOIR and HabEx. A flagship mission offering high spatial resolution, high sensitivity, and access to the full range of wavelengths covered by HST is essential. While the X-Ray Surveyor is an obvious candidate for study, it did not engender much discussion within the cosmic origins community. Dr. Sembach noted that the human spaceflight program has some synergy with the science community, and it might be productive to think about treating future flagship missions as long-lived observatories that can be repaired and improved, as was done with HST. Several of the white papers discussed the assembly of telescopes in space.

While there was a strong sense that the STDTs should share information and cooperate, COPAG members saw no compelling reason to have an independent review team assess the integrity of the science assumptions, at least not in cosmic origins. There is community support for a line of probe-class missions within the astrophysics mission portfolio. COPAG recommends taking this to the DS panel as bridging a mission-capability gap. There was no consensus on how to develop probe mission concepts.

Additional considerations were to have NASA engage industry early on in order to tap the great expertise that the Agency needs. The private sector can help guide discussions on what is and is not possible. COPAG also urges more cross-PAG collaborations, as well as proactive engagement of the international science community.

Dr. Hertz thanked the PAGs for these reports.

Working lunch (Discussion of Decadal Survey Reports)

Dr. Gaudi said that the primary conclusion of the three PAG reports was that there should be studies of each of the four missions. Dr. Hertz noted that each program office has a fixed amount of funds to support these studies. The process of arranging these studies with the centers is ongoing, and he planned to report on this at the next APS meeting, in March 2016.

Dr. Rachel Somerville asked about the trades between HabEx and LUVOIR. Dr. Hertz explained that they would require separate studies because they have different drivers. Dr. Gaudi added that it is not yet clear whether LUVOIR would encompass HabEx. ExoPAG wants to maximize the science in light of the constraints – budgetary, political, technology, etc. The members see differences in the science possible between the two missions and advocate having some of the same people on both study teams.

Dr. Jason Kalirai said that he was happy to see a range of sizes proposed. Astronomers have to think of these telescopes in an era in which they have used JWST for more than 10 years. Presumably the HabEx discussion would come with an optimized suite of instruments. Dr. Hertz noted that the DS strongly recommends that NASA bring to the 2020 DS a proposal for a mission capable of imaging exoplanets. If the HabEx STDT decides to broaden the science requirements, they do so at the risk of the DS calling it overly ornamented. On the other hand, APD added a coronagraph to WFIRST without changing the requirements. Dr. Sembach cautioned that if there is no need for a UV capability to image an exoplanet, and therefore no UV capability attached to HabEx, the cosmic origins community will not support it.

Dr. Yun Wang said that it is important to have “habitable planet” in the name, as it excites the public and is easy to explain. Past that, the mission can do other things. That name would help it with Congress as well. Dr. Neil Cornish said that it can be interesting to know what it would look like to focus first on one science goal, then add onto the mission. Dr. Sembach said that a range of science capabilities is essential for a multi-billion-dollar observatory. He fears that a single option would have little chance of selection. Dr. Gaudi suggested that the PAGs recommend that the four missions be studied, predicated on the assumptions outlined in the white paper.

Dr. Hertz said that there is no opportunity to do an inflation probe in this decade. The DS language places the inflation probe in Tier 3 in the event of a low budget, which is what exists. It is a question of applying resources. The budget is fully subscribed through planning, so if something is added, something else must be subtracted.

Dr. Gaudi asked if APS members could agree on the recommendations to Dr. Hertz from the three reports and accept the reports as inputs. Dr. Nathalie Batalha observed that the PhysPAG report lists many x-ray probes. She wondered if there might be a need for an x-ray flagship mission. After some discussion, it was concluded that x-ray missions are very targeted.

Dr. Gaudi suggested that APS state that its recommendation is the joint PAG recommendation, which would include all the specifics and caveats. He reminded the members that he had to present an item on this at the NAC Science Committee meeting. He offered to write a statement that evening for review on the following day. Dr. Gaudi noted that this recommendation is predicated on NASA continuing to

partner on ESA's L3 gravitational wave mission. Dr. Hertz said that NASA's participation in that mission would involve engaging the U.S. science community and NASA technology teams, and making sure that the case is put in front of the DS panel. He would start the APS statement by saying that the assumption is that JWST, WFIRST, and the L3 partnership will go forward. He offered to draft a second statement on probes.

APS voted unanimously to accept the three reports as input, and to give Dr. Hertz the recommendation in the form of the joint summary, adding that they wanted him to consider the other points in the individual reports as well.

#### JWST Update

Dr. Eric Smith spoke about the progress on JWST. The sunshield has been moving forward and there have been additional test of the full-scale engineering model at Northrop-Grumman. Cameras record every critical piece of the assembly and testing, providing information that can be used on the ground after the launch. A team at the Johnson Space Center (JSC) is conducting tests of the pathfinder or engineering telescope set-up and optical ground support. The flight telescope structure is at GSFC.

Watch items include schedule reserve consumption; mid-boom manufacturing; the actuator development; the sunshield membrane manufacturing pace, which has slowed somewhat; and the optical telescope pinned joints, which need to be beefed up and for which new designs are being reviewed. At this point, the mission has 8  $\frac{3}{4}$  months of funded schedule reserve. To have stayed above the plan for 5 years is rather impressive. Funding is holding up as well. The General Accounting Office (GAO) believes this is more than sufficient and is pleased with the mission's management.

Dr. Smith reviewed the high-level milestones and the requirements verification progress, a major element of the current activity. While there had been discussion about moving the Guest Observer (GO) exclusive use period from 12 to 6 months, ESA was opposed to this change and NASA has pulled back for now. The European science community is funded differently than their North American counterparts, and that had to be considered. Therefore, the default exclusive use period remains 12 months in keeping with a Memorandum of Understanding (MOU) that NASA signed with ESA and the Canadian Space Agency (CSA).

The one risk Dr. Smith worries about is another government shutdown, which could affect testing. He was also concerned about the mid-boom repair and the sunshield. The team has already begun talking to the NASA Chief Financial Officer (CFO) about the criticality of keeping the tests going in the event of a shutdown.

#### Other ExoPAG Business

Dr. Alan Boss provided an update on ExoPAG activities. ExoPAG has decided to begin compiling an annual technology gap list similar to what the other two PAGs create, and will begin that process during a winter meeting. Seven Study Analysis Groups (SAGs) within ExoPAG have completed their work. One SAG is dormant; the ExoPAG Executive Committee hoped to close it. There are also two active SAGs, and Dr. Boss presented information on two proposed SAGs.

SAG 12, which is active, addresses high precision astrometry for exoplanet detection and characterization. The members are trying to determine how to identify the giant planet population beyond the ice line, and are also looking at ground-based testing. SAG 13 is focused on exoplanet occurrence rates and distributions, with a special interest in standardization for comparisons of data and studies.

The first proposed new SAG, SAG 14, will study characterization of stars targeted for NASA exoplanet missions. ExoPAG has found that a lot of the work coming in is poorly characterized. This SAG will

bring together experts to identify programs that will benefit TESS and subsequent exoplanet missions in order to ensure their success. ExoPAG was seeking APS approval of this new SAG.

SAG 15 is also new. It will address exploring other worlds, emphasizing observational constraints and science questions for direct imaging exoplanet missions. Not all planets NASA finds will be habitable, but those may be interesting for other reasons. Yet it is not clear what the key questions are, so ExoPAG wants to identify those.

Dr. Boss asked APS to approve dropping SAG 4 and adding SAGs 14 and 15. The vote was unanimous to do so.

#### Other PhysPAG Business

Dr. Bock explained that PhysPAG seeks to understand the nature of the universe, especially dark energy, inflation, black holes, and extreme environments. The PAG has six Science Interest Groups (SIGs) dealing with the inflation probe, gravitational waves, x-rays, gamma rays, cosmic rays, and cosmic structure. Recent activities have focused on the flagship study report. The gamma ray SIG is putting together a roadmap for the next DS, focusing on probes and Explorer concepts. PhysPAG also identified 22 technology gaps.

#### Other COPAG Business

Dr. Sembach said that, like PhysPAG, COPAG has been busy with the flagship mission concepts. The current executive committee membership has a vacancy, and he will be rotating off. He noted that there is no restriction on having industry representatives, and Dr. Hertz added that he could not think of any concerns regarding industry. They know their own conflicts of interest.

There are three SIGs under COPAG: far IR science and technology, which had a workshop in June resulting in a helpful paper; UV/visible cosmic origins science and technology development, with a workshop report pending; and cosmic dawn science, formed recently and still organizing. SAG 8 is active but will close down upon approval of its report on cosmic origins science enabled by the WFIRST-AFTA data archive.

The vote to accept the report and close SAG 8 was unanimous.

#### Preparing for JWST Cycle 1 Observations

Dr. Kalirai explained that JWST will soon be the biggest, most powerful telescope that NASA has ever launched. It will enable new discoveries in both photon and diffraction limited science. Therefore, it is important to prepare the science community.

There are four fundamental science themes associated with the mission: first light, galaxy assembly, exoplanet characterization, and star formation. In Cycle 1 science, JWST spectroscopy will address detailed astrophysics, not just imagery. JWST's resolution and sensitivity in the near IR will be a game changer and answer key questions about star and galaxy formation and characterization. The spectroscopy will characterize physics and chemistry on 10-1000 AU scales, and this will require modeling tools. The near IR and mid-IR imaging will measure stellar-planetary census in star forming regions.

Dr. Kalirai described JWST capabilities in the areas of tracking and characterization. The mission will be transformative, and the complexity of the instruments will create challenges in getting the science out and analyzed. The Space Telescope Science Institute (STScI) is dedicated to enabling the best science from JWST and will also be the mission operations center for the mission.

Science observations will start in spring of 2019. The Guaranteed Time Observers (GTOs) have already won competitions and will use approximately 10 percent of the observing time during the first 2.5 years. Given JWST's efficiency, the remaining time for GOs is still greater than one HST cycle for Cycle 1, and this grows in future cycles as the GTO fraction comes down. At the time of the Cycle 2 Call for proposals, the GO community will still not have much access to JWST non proprietary data. Dr. Kalirai described an Early Release Science program that STScI would execute early in Cycle 1. The ERS program would be selected by the community, would execute early in Cycle 1, and would have no period of exclusive use. Director's Discretionary Time would support it. The teams that receive Early Release Science (ERS) data and funds will have a responsibility to share their products and findings. In addition to scientific excellence, the ERS programs would be required to solve broad technical challenges required to achieve JWST science.

STScI has developed a multichannel communication strategy for JWST science outreach. Dr. Kalirai described efforts to train the community on working with JWST data products.. The team has been developing a range of science topics that go into a workflow. There will be workshops and online materials as well. STScI has a new exposure time calculator and is developing a simulator as a user tool. Some investigators wanted to compare their own simulators to these, which STScI is trying to enable. There is also a spectroscopic simulator that will enable exoplanet transit observations.

Dr. Kalirai suggested that, since JWST will be transformative in astrophysics, APS might want to look at the phasing of the DS in relation to JWST. Dr. Hertz invited the Subcommittee to discuss whether it might make sense to delay the DS.

#### Public Comment Period

The meeting was opened for comments from the public. Dr. Michael Werner of JPL addressed the four potential flagship missions. Regarding LUVOIR, a potential discriminator is the coverage of the telescope. He thought a cold telescope would provide better options than a warm one.

#### Discussion

Dr. Cornish said that if he looks at inputs for the last DS, it seems late already. Dr. Hertz replied that there have not yet been discussions about the optimal time for STDT reports to the NRC. At present, the NRC is fully occupied with the mid-decade review. Dr. Gaudi wondered if there is ever a good time to do a DS, how much the field might learn from JWST in one year, and the extent to which that will affect the DS outcome. The DS might advise against a flagship and recommend only medium and small missions.

Dr. Hertz pointed out that a delay of the Astrophysics DS would have a ripple effect within SMD, delaying the Planetary and Heliophysics Decadal Surveys as well. To comply with statute requiring a DS every ten years,, the DS cannot be delayed by more than 1 year. He will have to give the STDTs their due dates. Dr. Cornish thought that that meant the inputs would be needed in 2018, and Dr. Gaudi agreed that 2019 could be too late. Dr. Hertz said that the funds for the STDTs are not really sufficient, but he will talk to the NASA Centers to see what is possible. All four studies must have deadlines so that their input is relevant to the DS process. The first STDT meetings will take place in the spring, at which point APD will have the FY17 PBR. On the last DS, the panel said that no one proposed anything under \$1 billion, therefore they set no priorities in that area, which would have encompassed probes.

Dr. Gaudi next raised the issue of whether APD should conduct paper mission studies, full mission concept studies, or paper studies with full studies of select missions, some of which could be exemplars. Dr. Sembach said that they first needed to define the purpose of these studies. For example, did they want the DS to select the probe, or state that there should be a probe line growing from the natural AO process? If it were the latter, he thought a joint PAG statement might obviate the need for studies. Similarly, a joint PAG statement could define science areas for probes. After Dr. Hertz explained that the DS will decide

whether to recommend probes or a probe line, Dr. Sembach said that he found the paper studies to be of limited use.

Dr. Bock suggested that the DS could make recommendations for medium-class missions, with areas for probes. Dr. Gaudi added that ExoPAG members were frustrated that there is science that could be done in this price area but is not being done due to the absence of a category. ExoPAG also wants at least one mission that has gone through the complete Cost and Technical Evaluation (CATE) process, and they were very interested in specific missions.

Dr. Cornish observed that selecting a subset of missions for further study would point toward a set of priorities. Dr. Boss added that the 2010 DS did consider probes, which Dr. Hertz confirmed. For the past few Decadal Surveys, NASA has told NRC that it wants recommendations in large, medium, and small categories. NASA even defined these categories. Dr. Gaudi asked if there was a sense that the community wants to advocate for a permanent probe-class line. The exoplanet community does. Dr. Sembach noted a perceived need for it. However, he felt that the community has studied the science cases *ad nauseum*, and that the missing information relates to the costing.

Dr. Marshall Bautz said that there is a very strong belief within PhysPAG that a lot of science can be done between the Explorer and flagship missions. Dr. Hertz said that the charter can direct NRC to consider a probe line, and the community can write white papers. In light of the flat budget, this would mean fewer flagship missions. That is what the DS considers when the panel thinks about the balance – what mix will best advance the science. Dr. Somerville suggested offering them a general menu.

Dr. Gaudi was concerned that a probe that is interesting now might not be in 5 years. Dr. Hertz replied that a probe line gets the DS out of the business of trying to cost missions and more into shifting those decisions to NASA. He does not want to see them select 3 out of 10 fully vetted probes. In PSD, the New Horizons model brought in ideas that were later fleshed out in the AO. The community self-organizes. Dr. Gaudi said that it comes down to a question of NASA going wide but shallow or deep and narrow, or an AO that generates concepts that are studied in detail.

Dr. Bock said that people will want to talk about probes at the American Astronomical Society (AAS) meeting in January. Dr. Gaudi said that the PAGs could discuss probes and the DS, and ask the community if they want NASA to study probes, at what level, and the number, and if they should be competed. Dr. Paul Scowen said that it is potentially explosive to select exemplars.

Dr. Hertz said that he would provide APS with additional information about the constraints and what has been done previously. Dr. Bregman added that, historically, APD's larger programs have been tremendous successes. That is also true throughout SMD and at ESA.

#### Adjourn Day 1

Dr. Gaudi adjourned the meeting for the day at 5:12 p.m.

Friday, October 23, 2015

Opening Remarks

Dr. Gaudi opened the meeting by reviewing the FACA rules.

Dr. Scowen asked to revisit NESSF. He suggested that APD should consider increasing the amount spent on this program. Drs. Somerville and Bregman agreed. Dr. Boyd pointed out that while the program can cover 3 years of support, it is so competitive that students often must apply multiple times. Those who succeed therefore receive only 1 or 2 years of support.

Dr. Sembach cautioned against shifting funds from the postdoctoral fellowships. Dr. Bregman noted that no one has analyzed what is best for the field. The more than 70 postdocs offered worldwide each year exceed the number of faculty positions. Dr. Hertz said that if NESSF is to grow, he will have to take the funds from elsewhere in the R&A budget.

Dr. Somerville explained that there is a bias favoring those who already have funding. A shift in funds to a new group would benefit young faculty. Dr. Gaudi recommended that APS ask Dr. Hertz for a presentation on this at the next meeting, to include scenarios of shifting funds to support 20 NESSF recipients per year.

Astronomy and Astrophysics Advisory Committee (AAAC) Proposal Pressure Study Report

Dr. Priscilla Cushman presented the interim AAAC report on proposal pressure. The study team examined data from NASA, the National Science Foundation (NSF), and the Department of Energy (DOE). Dr. Cushman explained that NSF has an extensive database on proposers, NASA data are segregated by competition and do not include demographics, and DOE data are hard to access.

The study group wanted to produce a report on the potential causes of the decline in proposal success across the Federal astronomical science competitions. The interim report was to inform the mid-Decadal process, provide AAAC a document with information for the final report, and inform the community in order to gather comments and advice.

In essence, the number of proposals submitted has gone up and the number of awards has declined. Most of the groups studied now have roughly half the success rate they did in 2004. For example, APD has gone from 30 to 18 percent, and Heliophysics Division (HPD) dropped from 35 to 15 percent. Dr. Bregman noted that life sciences colleagues at his university seem to be under pressure that is similar, if not worse.

Dr. Cushman said that the study team looked at whether individual PIs are submitting more proposals and found that that is not the case. Nor are age and gender factors – the age distributions have not changed, and while there is a slight increase in women among younger proposers, overall there has been no change.

There is also no evidence of change in the type of institutions applying, and the study team did not find that senior faculty are looking to increase their group size or that postdocs are seeking soft money support. The vast majority – up to 85 percent – of the proposals request amounts below what the PIs would earn in salary over the course of 3 months. Dr. Somerville observed that at her institution, grant success is a requirement for promotion.

Dr. Cushman explained that there is an increasing number of unique PIs applying in consecutive years, accelerating the rise in proposal numbers and the falling selection rate. The higher success rate of previous years meant that there were fewer unsuccessful proposers who would reapply the following year. Dr. Gaudi noted that this explained continuation but not cause for the lower selection rates. Dr. Cushman

replied that there are document-clustering algorithms – anti-plagiarism tools – that can detect similarities and “tweaked proposals” that are probably repeats.

When the study team examined whether growth in the community might be behind this, the data were sparse and insufficient to explain the declining success rate. Of more significance were the ratings data. The Very Good (VG) category used to be funded at a much higher rate. The lower rate could mean that valuable science is not being funded. Excellent (E) and VG/E proposal funding remains stable, however.

In summary, the number of proposers is going up, but not disproportionately by age, nontraditional institutions, or gender. VG proposals are not being funded as much as previously. The increase in proposals leads to a greater number of panels and more work for the funders, which comes with a cost. There is also more difficulty in recruiting reviewers.

The study team tried to quantify proposer failure versus success to see if there is a point at which it is no longer worth proposing. Dr. Cushman cited the Matthew Effect, which states that new and unfunded researchers have decreased success rates. However, the study team found that the rate of acceptance for new PIs is close to that for more established PIs.

When the team compared the time spent writing proposals to time spent writing papers, it found that the time spent writing a proposal is equivalent to that spent preparing 0.4 papers. Where success rates are 20 percent, therefore, the time cost to writing a proposal is greater than that of writing two papers. Since the typical astronomy grant results in about eight publications, new researchers with success rates of about 6 percent will spend more time writing proposals than they would writing papers.

At present, there are no clear solutions to this situation. Work will continue, and the final formal report will be issued in March 2016.

#### SMD Education Update

Ms. Kristen Erickson, Director of SMD Science Engagement and Partnerships, explained the current state of SMD education funding. In 2013, the White House sought to consolidate Federal education programs. SMD therefore lost its education funding. Since then, the community, SMD Associate Administrator (AA) John Grunsfeld, and Dr. Hertz have come together to help shape the current SMD program.

The goal of NASA science education is to enable NASA scientists and engineers to engage more effectively with learners of all ages. Objectives include enabling STEM education, improving U.S. science literacy, advancing national education goals, and leveraging partnerships. To this end, SMD posted a Cooperative Agreement Notice (CAN); proposals were submitted in May and selections were announced in late September.

The assumption is for a \$42 million annual budget. SMD selected 27 of 73 proposals (37 percent) for negotiations leading to Cooperative Agreement Awards (CAAs). Fifteen of the 27 are “legacy” institutions with a history of involvement in NASA science education, and three focus on the 2017 total solar eclipse. SMD will do full or partial selections from the proposals, the latter being portions instead of the entire proposal. Awards are planned to be completed by end of 2015.

The awardees will have requirements and baselines. Other opportunities will go through NSPIRES; these are for museums and other institutions that can fill a variety of gaps. There is likely to be another call for proposals to service underserved areas. Although there is some overlap between the NASA Office of Education (OE) and the SMD function, STEM education is SMD’s primary focus.

Regarding the legacy institutions, Ms. Erickson explained that when the funding was removed in 2014, much of the talent went away or became dormant, sometimes finding opportunities elsewhere. Some of the individuals involved are now with SMD's selected organizations, however. Having 44 percent of the selections as new players is exciting. When the 27 selectees begin collaborating, even better ideas will come forth. The framework for that collaboration is the greatest challenge. There has also been an issue in communicating what this is and what it is not. There will be a greater role for the science divisions, though they will not be directing the education projects.

Dr. Kalirai was concerned that OE has not always given sufficient emphasis to science. Ms. Erickson said that there has been a change in leadership in OE and the SMD education group. She meets with her OE counterpart at least twice each week. SMD is the only mission directorate with its own education funding, and OE respects that.

#### Imaging X-ray Polarimetry Explorer (IXPE) Update

Dr. Martin Weisskopf described the IXPE, which has been selected by APD to go into a Phase A study. Several categories of X-ray sources are likely to show significant polarization. The IXPE observatory will provide the sensitivity to measure the polarization degree and position angle of numerous x-ray sources, in many cases as functions of energy, time, or position within a source (for sources resolved by IXPE). Such measurements will expand the observation space to provide new input to add constraints on the current understanding of these astrophysical systems. Dr. Weisskopf explained the mission's hardware and presented multiple polarization-sensitivity maps to show how IXPE will perform imaging polarimetry of pulsar-wind nebulae, supernova remnants, the Galactic Center, and at least one AGN jet. He emphasized how imaging improves the sensitivity for pulse-phase polarimetry of pulsars in extended objects.

For sources that are not spatially resolved, IXPE will still measure x-ray polarization, in many cases as functions of energy and time. Such measurements will characterize the x-ray polarization of pulsars, magnetars, microquasars, and accreting x-ray pulsars, providing unique information on the astrophysics of such sources, as well as measuring fundamental-physics effects of QED birefringence and gravitational Faraday rotation.

The lifetime of the mission depends on the orbit, but it is most likely 2 to 5 years. Available targets can go into the hundreds.

#### Polarimeter for Relativistic Astrophysical X-ray Sources (PRAXyS) Update

Dr. Keith Jahoda described the PRAXyS mission, which has been selected for a Phase A study. Polarization is an essential element in probing exotic physics and is affected by interactions with matter. PRAXyS builds on the design, experience, and lessons learned from the Gravity and Extreme Magnetism (GEMS) mission, a 2008 SMEX that was not confirmed in 2012. Because of that experience, the payload development for PRAXyS is advanced, and the science team has expanded.

Dr. Jahoda described how polarization can provide information on black holes, neutron stars, and magnetars, and explained how this mission helps meet NASA's strategic goals. Essentially, this has not been done before because it is difficult and the measurements are demanding. All prime mission data will be made public once they have been validated. The proposed primary mission will last 9 months, though the actual lifetime could be much longer. The mission will concentrate on black holes, neutron star sources, and subclasses of each.

#### SPHEREx Update

Dr. Bock explained that the SPHEREx mission, which will be selected for a Phase A study, is an all-sky spectral survey. It will explore the origin of the Universe, the origin and history of galaxies, and the origin of water in planetary systems. This is a low-risk implementation that follows the model of NuSTAR.

SPHEREx will address all three of NASA's fundamental science questions, about the origins of the Universe, the creation of galaxies, and the conditions for life outside our solar system. The mission is well-matched to current all-sky surveys and can create some baselines for the WFIRST transient survey. Dr. Bock described the hardware and the resource margins.

Throughout the universe, water appears to exist primarily in the form of ice, in addition to vapor. This mission will measure ices in a range of sources and determine volumes. SPHEREx will also measure extragalactic background light and fluctuation, which encodes the light from the first stars. In the area of inflation, SPHEREx will look for large-volume redshift, making it complementary to Euclid and WFIRST. After Dr. Gaudi pointed out that this mission could help expand upon TESS observations, Dr. Bock said that the team will consider that.

#### Public Comment Period

Members of the public were given an opportunity to speak. None came forward to do so.

#### Big Data Task Force

Dr. Erin Smith described the new Big Data Task Force (BDTF), a NAC advisory group seeking information about what is current, what is needed, and the future of big data at NASA. Committee membership will consist of up to 10 people: a chair with a cyber-infrastructure specialization, one aeronautics representative, two industry representatives with appropriate experience, and six science representatives (two each from Earth science and heliophysics, and one each from astrophysics and planetary science). Dr. Smith will be the executive secretary. Six of the 10 members have been selected and the Committee hopes to have the first meeting in December.

Big data means different things to different groups. Interoperability is a factor in any number of directions, including across agencies. Users can find new ways to employ data and develop new questions. Dr. Smith has been asked by the NAC Science Committee to talk to each subcommittee and identify the big data topics. While the Task Force will not develop tools or algorithms, it does hope to catalogue what NASA does, what the Agency can do better, and what it can incorporate from elsewhere – that will be the first step.

Dr. Cornish said that it would be interesting to have input on how to best gather these insights and developments. Big data happen across all sciences and industry. So rather than each branch reinventing it, he wondered if NASA would want to coordinate and learn the lessons across agencies. Dr. Somerville said that there has been much work and discussion about an international virtual observatory, and she advised tapping into that interface.

Dr. Sembach found the idea interesting, but noted that the university system, government centers, and other institutions are ahead on this in terms of mobilizing. Much work has already been done to integrate NASA data sets. From an astrophysics standpoint, he would urge understanding if the various astrophysics entities are talking to each other.

Dr. Gaudi found this perplexing because it seemed it was being set up without a goal. Dr. Hertz said he could imagine it would be useful to disseminate what is out there for astrophysics. He would want the task force to list what might be useful to SMD, which is a survey task. The survey should include industry and others for ideas. He noted that the initiative goes across NASA and is not just about SMD.

Dr. Gaudi said that APS would recommend finding out what each subfield has as a big data activity, and what they have identified as needs. Dr. Batalha applauded the effort and said that the NASA archives staff should have lots of suggestions.

### Discussion

Dr. Gaudi listed the topics for Subcommittee discussion: MIDEX cost cap; NESSF, which will be reviewed after an APD presentation at the next meeting; probes; proposal pressure; education efforts; and the BDTF. APS had also agreed on what it would say about the DS reports. Dr. Sembach did not see the point in discussing probes any further, suggesting instead that the PAGs confer at the AAS meeting and gather more community input in the meantime. The outcome could then be a joint PAG white paper with thoughts for the DS. Dr. Gaudi agreed, adding that they should determine whether the community wants APS to recommend a probe class line, and what the thoughts are about studies. This would then be something they could present to Dr. Hertz in the spring. In return, it would be helpful if Dr. Hertz were to describe what he can and cannot do. Dr. Hertz agreed to do this.

Dr. Gaudi noted that the joint PAG executive summary contained a statement about probes. The APS membership agreed to leave it in. Dr. Hertz said that while the question about flagship missions was well-focused, the probe issue is a more general question. As for the timeline for input for the DS, mission concept studies take more time than a white paper advocating a probe line. He did not think they were behind, but cautioned that the study teams should receive realistic dates.

As far as showing the DS that probes can be done within the cost range, Dr. Gaudi said that ExoPAG members thought there should be some fully developed probes taken through the CATE process to prove that the cost range is reasonable. However, it was unclear whether they should advocate specific science. Part of the confusion was that they did not know if the DS will be wary of NASA costs that have not gone through the CATE process. Dr. Hertz explained that the charge for the DS is a negotiation between NASA and the NRC. On the previous DS, much of the discussion was about boundaries with other science. The community should do the advocacy.

Dr. Gaudi said that it seemed they had a path forward. APS addressed the BDTF as well as they could. The proposal pressure information presented was from an interim report and it is not clear precisely what is causing the change. It could be that the community is self-correcting. Dr. Somerville disagreed. It was clear to her that there is not enough funding for the amount of meritorious science proposed. She thought it was shortsighted to build facilities under this scenario. Dr. Gaudi agreed, but said that there is a need for clarity about GO funding as well.

Dr. Giovanni Fazio said that he was seeing many 10 percent effects coming together. If that were indeed the case, it would be cumulative and therefore hard to stop. Dr. Boss said that the most deleterious effect is the time people spend writing and reviewing proposals with no science resulting from their efforts. Dr. Cornish said that no single hypothesis worked. Dr. Gaudi added that people are leaving the field and science is being left on the table. Therefore, a more efficient process will not solve the problem.

Dr. Fazio gave the example of the Keck Foundation, which begins with a one-page proposal. The Foundation then tells proposers if they want more. Dr. Boss suggested something similar. Dr. Sembach said that the HST oversubscription rate is as high as 7 to 1, which is the saturation limit. It has been that way for a while and has nothing to do with funding. More data might dilute what the proposal pressure study team is trying to find.

Dr. Bregman suggested that some of the proposal pressure might come from investigators who were on missions that have ceased operations. Dr. Gaudi said that APS was hypothesizing and thought the Subcommittee should suggest that the proposal pressure team consider funding from GOs and ask if

cumulative effects might explain the result. After further discussion, it was agreed that APS would recommend that NASA and AAAC work together to provide some additional data. Dr. Boyd volunteered to be the liaison.

Dr. Bock expressed concern about the upcoming SR and what might happen if all of the missions are considered meritorious. Dr. Hertz explained that he asks the SR panel to assess and rank the missions, along with the budgets proposed. He tells them his entire budget for extended missions. APD then acts on the report. It was determined that there was nothing for APS to do on this.

Recommendations, Actions

Dr. Gaudi reviewed the writing assignments.

Adjourn

The meeting was adjourned at 4 p.m.

**Appendix A**  
**Attendees**

Subcommittee members

B. Scott Gaudi, Ohio State University, *Chair, Astrophysics Subcommittee*  
Nathalie Batalha, NASA Ames  
Marshall (Mark) Bautz, Massachusetts Institute of Technology  
James J. Bock, NASA JPL  
Alan Boss, Carnegie Institution for Science  
Patricia Boyd, NASA GSFC  
Joel Bregman, University of Michigan  
Neil John Cornish, Montana State University  
Giovanni Fazio, Harvard Smithsonian Center for Astrophysics  
Jason Kalirai, Space Telescope Science Institute  
Paul Scowen, Arizona State University  
Kenneth Sembach, Space Telescope Science Institute  
Rachel Somerville, Rutgers University  
Yun Wang, California Institute of Technology  
Beth Willman, LSST-University of AZ (via telecon)

NASA attendees

Paul Hertz, NASA HQ, *Director, Astrophysics Division*  
Mansour Ahmed, NASA GSFC  
Dominic Benford, NASA HQ  
Peter Bertone, NASA MSFC  
Joan Centrella, NASA GSFC  
Debbie Chipouras, NASA GSFC  
Julie Crooke, NASA GSFC  
Jeanne Davis, NASA HQ  
Shawn Domagal-Goldman, NASA GSFC  
Kristin Erickson, NASA HQ  
Dan Evans, NASA HQ  
Matt Garhouse, NASA GSFC  
Jonathan Gardner, NASA GSFC  
Michael Gorey, NASA HQ  
Shahid Habib, NASA HQ  
Kate Hartman, NASA GSFC  
Hashima Hasan, NASA HQ, *Executive Secretary, APS*  
Dave Herr, NASA HQ  
Steven Horowitz, NASA GSFC  
Ann Horscheimer, NASA GSFC  
Keith Jahoda, NASA GSFC  
Michelle Johnson, NASA Ames  
Louis Kaluzienski, NASA HQ  
Joe Kittle, NASA GSFC  
Norman Lacey, NASA GSFC  
Alan Lamale, NASA GSFC  
Janet Larson, NASA HQ  
Dave Leisawitz, NASA GSFC

Carolyn Mercer, NASA HQ  
Susan Neff, NASA GSFC  
Deborah Padgett, NASA GSFC  
Rob Petri, NASA HQ  
Aki Roberge, NASA GSFC  
Wilton Sanders, NASA HQ  
Kartik Sheth, NASA HQ  
Martin Sly, NASA HQ  
Eric Smith, NASA HQ  
Erin Smith, NASA HQ  
Robin Stebbins, NASA GSFC  
Michael Werner, NASA JPL

Non-NASA Attendees

Francisco Bordi, Aerospace  
Ethan Burbridge, UMD  
Matt David, UMD  
Martin Frederick, Northrup Grumman  
James Lochner, USRA  
Gary Melnick, SAO  
Elizabeth Sheley, Zantech

Webex/Telecon

Mitzi Adams, NASA  
Matthew Ashby  
Randy Baggett, NASA MSFC  
Louis Barbier, NASA Goddard  
Michael Bicay, NASA Ames  
Heather Bloemhard, The American Astronomical Society  
Matthew Bolcar, NASA GSFC  
Jay Bookbinder, NASA  
Eugene Churazov  
Mark Clampin, Goddard  
Alberto Conti, Northrop Grumman  
Priscilla Cushman, U of MN  
Ettore Delmonte, IMAS  
Elaine Denning, NASA  
Mark Devlin, University of PA  
Shawn Domagal-Goldman, NASA  
Jeanette Domber, Ball Aerospace  
Rebecca Doroshenk, NASA  
John Dyster, Orbital  
Ron Elsner, NASA Marshall  
William Fischer, NASA  
Martin Frederick, Northrop Grumman  
David Gallagher, JPL  
Michael Garcia, NASA  
Matt Giorgio  
Kathy Hartman, NASA  
Sally Heap, NASA Goddard

NAC Astrophysics Subcommittee Meeting Minutes, October 22-23, 2015

Brian Hicks, NASA Goddard  
Keith Jahoda, NASA  
Hussein Jirdeh, Space Telescope Science Institute  
Mary Beth Kaiser, Johns Hopkins University  
Louis Kaluzienski, NASA  
Victoria Kaspi, McGill University  
Kiranmayee Kilaru, NASA  
Chryssa Kouveliotou, George Washington University  
Joseph Lazio, JPL  
Dan Leone, Spacenews  
John Lewis  
Charles Lillie, Lillie Consulting  
Herman Marshall, MIT  
Anthony Mastalski, MSC - NASA  
Carolyn Mercer, NASA  
Kevin Miller, HPD  
Alison Noret, Lockheed Martin  
David Oberg, Orbital ATK  
Stephen O'Dell, NASA  
Bruce Pham, NASA  
Ronald Polidan, Northrop Grumman  
Juro Poutanen  
Bill Purcell, Ball Aerospace  
Tom Roellig, NASA Ames  
Rita Sambruna, NASA  
Wilton Sanders, NASA HQ  
Douglas Scharz, NASA  
Denise Smith, Space Telescope Science Institute  
Karl Stapelfeldt, NASA  
Jean Swank, NASA Goddard  
Doug Swartz, NASA  
Allyn Tennant, NASA  
Volker Tolls, Smithsonian Center for Astrophysics  
Stephen Unwin, NASA JPL  
Martin Weisskopf, NASA Marshall  
Stu Wiens, Lockheed Martin

**Appendix B**  
**NAC Astrophysics Subcommittee Members**

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

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

Natalie Batalha  
NASA-AMES

Marshall (Mark) Bautz  
Massachusetts Institute of Technology

James J. Bock  
Jet Propulsion Laboratory

Alan Boss  
Carnegie Institution for Science

Patricia Boyd  
Goddard Space Flight Center

Joel Bregman  
Department of Astronomy  
University of Michigan

Neil John Cornish  
Department of Physics  
Montana State University

Giovanni Fazio  
Harvard Smithsonian Center for Astrophysics

Jasonjot (Jason) Singh Kalirai  
Space Telescope Science Institute

Paul Scowen  
Arizona State University

Kenneth Sembach  
Space Telescope Science Institute

Rachel Somerville  
Department of Physics and Astronomy  
Rutgers University

Yun Wang  
IPAC  
California Institute of Technology

Beth Willman  
LSST/Steward Observatory  
University of Arizona

**Appendix C**  
**Presentations**

1. *Astrophysics Division Update*, Paul Hertz
2. *ExoPAG: Preparing for the 2020 Decadal Survey*, Scott Gaudi
3. *PhysPAG Decadal Survey Report*, James Bock
4. *COPAG Decadal Survey Report*, Ken Sembach
5. *JWST Update*, Eric Smith
6. *ExoPAG Update*, Alan Boss
7. *NASA's Physics of the Cosmos Program*, James Bock
8. *Cosmic Origins Program Analysis Group*, Ken Sembach
9. *Preparing for JWST Cycle 1 Observations*, Jason Kalirai
10. *AAAC Proposal Pressures Study Group Interim Report Summary*, Priscilla Cushman
11. *SMD Science Education Restructuring Strategy and Selections*, Kristen Erickson
12. *The Imaging X-Ray Polarimetry Explorer*, Martin Weisskopf
13. *PRAXyS*, Keith Jahoda
14. *SPHEREx: An All-Sky Spectral Survey*, James Bock
15. *Ad Hoc Task Force on Big Data*, Erin Smith

**Appendix D**  
**Agenda**

**Astrophysics Subcommittee Meeting**  
**October 2-23, 2015**

**Thursday, October 22, 2015**

9:00 a.m.	Introduction and Announcements	Scott Gaudi
9:05 a.m.	GSFC Director Welcome	Colleen Hartman
9:10 a.m.	Astrophysics Division Update	Paul Hertz
11:00 a.m.	Break	
11:15 a.m.	ExoPAG Decadal Survey Report	Scott Gaudi
11:30 a.m.	PhyPAG Decadal Survey Report	James Bock
11:45 a.m.	COPAG Decadal Survey Report	Ken Sembach
12:00 p.m.	Break	
12:15 p.m.	Working Lunch (Discussion of Decadal Survey Reports)	APS members
1:40 p.m.	JWST Update	Eric Smith
2:20 p.m.	Other ExoPAG Business	Alan Boss
2:35 p.m.	Other PhysPAG Business	James Bock
2:50 p.m.	Other COPAG Business	Ken Sembach
3:05 p.m.	Break	
3:20 p.m.	Preparing for JWST Cycle 1 Observations	Jason Kalirai
3:50 p.m.	Public Comment Period	
4:00 p.m.	Discussion	APS Members
5:00 p.m.	Adjourn Day 1	

**Friday, October 23, 2015**

11:00 a.m.	Opening Remarks	Scott Gaudi
11:10 a.m.	AAAC Proposal Pressure Study Report	Priscilla Cushman
11:50 a.m.	SMD Education Update	Kristen Erickson
12:20 p.m.	Break	
12:35 p.m.	Working Lunch	
1:00 p.m.	IXPE Update	Martin Weisskopf
1:20 p.m.	PRAXyS Update	Keith Jahoda
1:40 p.m.	SPHEREx Update	James Bock
2:00 p.m.	Public Comment Period	
2:10 p.m.	Break	
2:20 p.m.	Big Data Task Force	Erin Smith
2:40 p.m.	Discussion	APS members
3:30 p.m.	Recommendations, Actions	Scott Gaudi
3:45 p.m.	Brief to Hertz	Scott Gaudi
4:00 p.m.	Adjourn	