NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

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NASA Headquarters
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MEETING MINUTES

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Bradley Peterson, Chair	Rita Sambruna, Executive Secretary

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Welcome and Conflict of Interest

Dr. Rita Sambruna, Executive Secretary of the Astrophysics Subcommittee (APS), welcomed the members and introduced the new APS Chair, Dr. Bradley Peterson. Dr. Peterson asked the members to introduce themselves and to note any conflicts of interest.

Mandatory Ethics Training

Katie Spear, representing NASA's Office of General Counsel (OGC), presented the mandatory annual ethics training session to the Subcommittee members.

APD Update and Q&A

Dr. Paul Hertz, Director of NASA's Astrophysics Division (APD), welcomed the new APS members, then presented an update of APD activities.

Mission updates

Dr. Hertz started his presentation with a review of APD missions.

The Nuclear Spectroscopic Telescope Array (NuSTAR) was successfully launched on June 13, and thus far it is working well, though it is still in the calibration phase. The Kepler mission continues to make intriguing discoveries like the Kepler-36 system, where two planets go around the host star with very similar orbits affecting each other's motion. The inner planet is 1.5 times the size of Earth, while the outer is like a small version of Neptune, and both lie inside the habitable zone of the star. The recent senior review extended the Kepler mission.

The Hubble Space Telescope has shown that the Milky Way is destined to collide with the Andromeda galaxy in 4 billion years, when the cores of the two galaxies will start to merge. Collisions between stars are unlikely during this collision because of the large space between stars in a galaxy's halo. Meanwhile, the Fermi mission has detected the highest energy light from a solar flare.

The Galaxy Evolution Explorer (GALEX) is now operating under a new paradigm. CalTech, led by APS member Dr. Chris Martin, is operating GALEX with private funds and may continue to do so for up to 3 years. The annual operating budget is about $110,000 per month, and CalTech is funding GALEX on a month-to- month basis. NASA and CalTech signed a Space Act Agreement (SAA) in which NASA loans the spacecraft to Caltech. Under the SAA, NASA retains long-term liability and is responsible for decommissioning and re-entry of the satellite. Dr. Martin applauded NASA for its commitment to enable the SAA. As noted by Dr. Hertz, the GALEX SAA with Caltech provides a model for future missions that are terminated in Senior Review.

Gravity and Extreme Magnetism (GEMS)

After confirmation review of the Gravity and Extreme Magnetism (GEMS) mission NASA decided not to confirm the project, as based on the finding that it could not be completed within an acceptable cost and schedule. There were significant cost risks in completing the optical boom, along with concerns about avionics, the schedule, and cost estimates. The project cost exceeded the Announcement of Opportunity (AO) cost cap as well. Though GEMS

was proposed and selected with three telescopes, it had already been descoped to two telescopes, and there were not many acceptable descope options left to save money any further.

A post-cancellation review of GEMS was held by NASA to assess lessons learned and mistakes that occurred. Dr. Hertz explained that the purpose of the review is to determine how to avoid making some of the same mistakes in the future, as well as preserving the work done so far, such as the design and technology work, enabling a better proposal to be resubmitted again. Upon a question from a member of the committee, Dr. Hertz recounted that a year ago NASA conducted a general examination of its technical evaluation practices, including Technical, Management, and Cost (TMC) assessments. The review also studied what the TMC process might have missed that could have been foreseen. The results enabled NASA to change its course of actions. A major finding was that TMC reviews would develop a lot of findings about technology readiness, but there was no follow through by NASA or the project. This technology heritage review has been now extended to all AO-selected missions to prevent falls-out between the TMC review and the handoff. The heritage reviews are underway, and results will be forthcoming.

Dr. Hertz explained that Congress requested a review of the Science Mission Directorate's (SMD's) decision process in terminating GEMS. However, since Public Law 112-55 requires that NASA provide Congress 15 days of notice before termination and fund reallocation, until the report is provided to Congress, the GEMS project officially continues. Once termination occurs, the funding planned for GEMS will go back to the future Explorer budget to enable selections from the Explorer AO and to enable acceleration of future Explorer AOs. Functionally, this allows APD to avoid a delay of the next full mission and the next Mission of Opportunity (MO). The GEMS team can resubmit their proposal in future Explorer cycles.

Following a question from the committee, Dr. Hertz explained that the independent cost review is an established part of the confirmation process. After the project finishes Preliminary Design Review (PDR) and NASA has a plan to move forward, the Agency conducts independent cost and confidence assessments to evaluate the ability of a project to move forward to completion. This is standard practice. Cost estimates are usually conducted by the standing review board through the SMD contract with The Aerospace Corporation (Aerospace), to help identify when projects might fall behind with cost and schedule.

The cost estimates for GEMS were both consistent and transparent. The budget required the project to be successful with 70 percent confidence, and those estimates were consistent, though there were some differences between external cost estimates and Goddard Space Flight Center's (GSFC's) estimate at the 50 percent confidence level. Standard practice is to have a discussion where project and cost estimators share assumptions and review discrepancies. While this process is not expected to result in consensus, the purpose is to help avoid significant discrepancies. The process is not based on rigorous, quantitative criteria but relies on the expert opinions of the participants.

Dr. Hertz cautioned against conflating the independent cost estimates for SMD with the TMC reviews for completion. The AOs contain a section noting whether and under what conditions Aerospace can be used as a proposer. If Aerospace is a proposer, the company is not used for TMC, and if Aerospace wants to do the TMC, the company must recuse itself from partnering. The AOs state which role Aerospace and NASA have agreed the company will fill. There are clauses in the Federal Acquisition Regulations (FARs) prohibiting any contractor from responding to proposals on which it has worked. On the contract side, NASA has set up appropriate firewalls. Dr. Hertz did not know if the GEMS team was contracting with Aerospace, but if they were, NASA has firewalls to keep the people independent. Goddard does something similar.

Dr. John Nousek pointed out that Aerospace is a nonelected, nongovernmental entity that has a great say in all of the decisions that are made. He did not want to imply that there is anything improper or untoward in this, but stated that the heavy dependence on the company troubled him. Dr. Hertz acknowledged his concerns, and explained that when

NASA does TMC reviews, Aerospace is one of three entities that may be involved, which mitigates the company's influence. In addition, Aerospace is a Federally Funded Research and Development Center (FFRDC). FFRDCs exist because the government needs on-call expertise in an organization that is non-conflicted. NASA set up firewalls that allow Aerospace to participate on either side. Dr. Hertz was previously involved in a 1.5-year process to work out the contract with Aerospace and is comfortable that NASA has done more than is required and everything necessary to ensure that Aerospace does not have too much influence or a conflict of interest. These terms are reviewed with every AO. There are other organizations that have the technical expertise to provide these services to the government when needed. NASA's Office of General Counsel and Procurement Office are also involved. NASA's goal is to design and launch projects that achieve the best science. The Agency also wants to have believable, untainted, and reliable technical advice.

Dr. Nousek remarked that the TMC contractors may be biased in favor of the TMC process, from which they gain. On GEMS, their performance was not satisfying. A substantial amount of money was invested in GEMS, which now will not launch. Dr. Hertz replied that there are many reasons and contributing factors for the termination of GEMS, and the dominant reason is not necessarily related to the performance of the TMC. There are multiple, substantial factors that will be considered.

Related to this discussion, Dr. Martin wondered if NASA was becoming too conservative to take risks for enabling the most exciting science. Dr. Hertz thought this would be perfect for the community to discuss. At the time of the competition, NASA thought it was possible for GEMS to be delivered close to the cost cap. There were others the Agency thought would cost the same or more that were not selected. At what point does breaking the cost cap become a concern? At what point does continuing with such a project become unfair to the competition that occurred in the first place? The Small Explorers (SMEX) program allows focused, smallest-size missions, but does that mean that cost growth is unimportant? NASA's stakeholders in the Administration and in Congress do not support the view that the science justifies the cost growth. They expect NASA to assess what the science is worth and what it costs, and they want the Agency to take that seriously. NASA has tried to improve its ability to deliver missions within cost and is launching a number of missions within cost commitments. The GEMS decision was difficult. There were reasons to go either way, and no one wants to cancel projects.

Stratospheric Observatory for Infrared Astronomy (SOFIA)

The recent Stratospheric Observatory for Infrared Astronomy (SOFIA) instrument selection resulted in the choice of two upgrades to a first generation instrument, the High-resolution Airborne Wideband Camera (HAWC), instead of selection of a new instrument. The HAWC Polarization (HAWC-Pol) upgrade gives HAWC the capacity to make polarimetric observations at far-infrared wavelengths. The HAWC++ upgrade provides a sensitive, large-format detector array to the HAWC-Pol investigation, increasing its observing efficiency. The two upgrades will cost about $8 million. APD expects to issue a second new instrument call in 2 years. The program has a slowly growing funding wedge with $30 million through 2018, mostly at $3 million per year. APD has only used the front end of the wedge, to enable easier disboursement of the funds.

SOFIA has building and flying segments. The program is in the building portion of Segment 3, upgrading a lot of components like the avionics and science support software, in anticipation of reaching full operations capabilities by next summer. The early science was successful. Peer review was completed for Cycle 1, a year of observations. Regarding when SOFIA might be subject to a senior review, Dr. Hertz said that the real question is which senior review would be most appropriate after SOFIA has operated for several years with a full complement of instruments. From the budget point of view, SOFIA will transition from development to operations in the summer of 2013. At that point, the Agency program management council will relinquish control and shift it to the SMD program management council. Within 3 years of declaring the program operational, it must meet the specifications requirements in the documentation.

Other mission updates

For ASTRO-H, an X-ray astronomy satellite mission of the Japanese space agency (JAXA), NASA is building a Calorimeter Spectrometer Insert (CSI) that is about to go into functional testing. Very recently, one of the heat switches failed, affecting stability. Dr. Hertz did not yet know the impact of this development. JAXA has not officially confirmed a change in the launch date, although it appears that there will be a delay due to the 2011 tsunami. The Agency will support JAXA should the rumored delays turn into reality.

On the Euclid mission, NASA has come to an agreement with the European Space Agency (ESA) to provide Near Infrared Spectrograph and Photometer (NISP) flight subassemblies that meet ESA's requirements for testing and characterization. The subassemblies each consist of a detector, Application Specific Integrated Circuits (ASICs), and cryo-cable in what is being referred to as a "triplet." These instruments will be delivered to ESA, which will do the integration and test. The risk to NASA for cost overruns is low. If the triplets meet and test to specifications, NASA will be in compliance with the agreement. Both agencies have agreed to a draft Memorandum of Understanding (MOU) that is now going through diplomatic channels for approval. NASA's Jet Propulsion Laboratory (JPL) is working closely with ESA to finalize the lower-level agreements in writing. In answer to a question, Dr. Hertz said that if a subassembly meets the specifications on delivery and later fails, NASA is not responsible. NASA is also providing spares.

ESA will appoint a NASA-selected member to the Euclid science team. The Euclid consortium will appoint a NASA-selected member to the Euclid Consortium Board and up to 40 NASA-selected members to the Euclid Consortium. NASA-appointed consortium members will have same data rights as European members. There are almost 900 members on the consortium, including 500 full members. The budget for this commitment is spread over 10 years. There was no set formula for NASA's percentage of involvement. The Agency has budgeted $50 million for hardware, and the science team will be funded at a similar level over the life of the mission through 2022, so that is close to a 10-percent contribution, though ESA does not count the science team in their calculations. Euclid costs over $1 billion.

The Wide Field InfraRed Survey Telescope (WFIRST) Science Definition Team (SDT) delivered its final report on July 12. Funds exists to allow advance in technology and planning. APD will not be in a position to start a new strategic mission until after the launch of the James Webb Space Telescope (JWST) and assuming that the Division recovers that funding wedge. The JWST launch is set for 2018 and thus a wedge could be opening in the budget around 2017, when JWST development phase starts to fade. APD is in the process of developing a plan to allow a decision of which mission(s) to fund on the long term. Decisions will be affected by the dynamical socio-economical landscape over the next several years. Thus, Dr. Hertz's plan for the next 3 years is to keep options, including WFIRST. A possibility might be to descope WFIRST to a probe-size or select other Decadal Survey (DS) missions. It is premature to speculate what the situation will be in 2015.

The agenda provided time for a more in-depth discussion of the Explorer program later in the meeting, but Dr. Hertz wanted to mention that there will be an AO in the fall of 2012 with a $50-60 million cost cap for a MoO. An AO for a SMEX will be issued in late 2013, with cost caps and dates to be determined, and an AO for an Explorer and MoO will be issued in 2015. Dr. Hertz noted that APD has invested into Explorers more resources than the DS recommended.

The senior review determined that all current missions are delivering compelling science and will be continued. Extending Kepler, Fermi, and Spitzer took funds from other areas, however, as the assumption had been to have only one of the three continue. In answer to a question about the pressure on operating costs for missions that have gone beyond their mission lifetime, Dr. Hertz explained that APD did not reduce funding for Great Observatory

(GO) programs, which were held constant as the Division reduced mission operations costs. In any case, it would not be possible to transfer funds made available by terminating a mission like Fermi, which has an $8 million annual budget, to elsewhere in the system for grants. The Division is committed to consult its adivory bodies (senior reviews, APS, etc.), before making decisions toward balancing APD's science program on the short and long term.

A workshop was held in July 2012 on implementing best practices for NASA science operations centers. The workshop resulted in 38 findings in 7 topic areas, which are posted online at www.stsci.edu/~inr/portals.html. The "stoplight charts" have not changed much. The balloon program stalled due to winds over Sweden, but the operating missions are doing fine. A Kepler reaction wheel failed, and the spare was implemented successfully. It is not possible to do the Kepler science with only two wheels. The concern is to operate in a way that takes the mission to 2016.

Budget

Dr. Hertz reviewed the budget, noting that about 25 percent goes directly to the community. Budget constraints dictate that no new missions other than Explorers can enter formulation before FY17. Suborbital programs and Explorer opportunities are being funded. Regarding the next large mission, APD must be prepared for anything in terms of the need to make a decision in 2015. If the Division does not recover the JWST funding wedge, it will be unable to do another mission.

Dr. Hertz's near-term plan is to study WFIRST options, solicit community ideas that address DS priorities, conduct mission concept studies, and set up community analysis groups. In 2013-14, APD will invest in concept studies and technology development to queue up potential choices for 2015. As noted, the Division will make a decision about the next mission in 2015 and start the preliminary work in order to enable formulation starting in FY17. This plan will be presented to the mid-decade review in 2015. That review will be complete in 2016, at which point APD will analyze and revise its plans as needed. Dr. Hertz stated that the earliest APD can make a decision will be by 2015. The Division is putting together a white paper explaining budget choices and near-term opportunities. Dr. Hertz will give a draft to APS and to the National Research Council (NRC) Committee on Astronomy and Astrophysics (CAA), then present it to the community before the Long Beach American Astronomical Society (AAS) meeting.

In an optimistic scenario where APD had the resources to stay near its historical funding level, those funds would be sufficient to begin one mission in 2017 and another in 2019, before the next DS. However, the Division can have probes, which are midway between the costs for Explorers and large missions. NASA's stakeholders on Capitol Hill and in the Administration perceive anything that costs over $1 billion as "large." Dr. Hertz would like to see if there are compelling missions that can be done under $1 billion.

Telescope assets transferred to NASA by the National Reconnaissance Office (NRO) may provide an opportunity to implement the science of the top-ranked Decadal missions. Based on quantitative assessments, NASA may choose not to use them. However, they offer the Agency additional choices; they have had a remarkable impact with the community, which is bursting with enthusiasm about possible future uses in astrophysics. Anything NASA does with them will be observed and scrutinized. The decision to study them further will be made at the Administrator's level, including what is their best use across the Agendy's other Divisions and Directorates.

It was suggested that the plan to bring the probe concept to the mid-Decadal Survey review might be a problem since it is not in the Decadal Survey if the NRC Committee takes a narrow interpretation of their charge. Dr. Hertz explained that APD will ask the NRC to assess how well the Division is doing in following the DS. The review will look at how NASA is responding to the budget situation. The review panel will not make decisions or choices, nor will APD present them with choices.

The funds to extend the operating missions came from reallocated mission concept and technology development money. The budget for the Research and Analysis (R&A) program remains flat. The previous APD Director, Jon Morse, had grown R&A by 10 percent, and Dr. Hertz is honoring this committment. Hertz also spent some reserve lines to extend the missions.

JWST Update

Geoff Yoder, JWST Program Director, described the current status of the program. The budget remains in line with the 2011 replan as JWST achieves its milestones within cost and schedule. Key accomplishments include the following:

- Successful cryo-testing of all flight optics;
- Completed Aft Optic System integration, alignment, and cryo-testing is underway;
- Completed primary mirror backplane support structure center section, with wing fabrication ongoing;
- Completed sunshield full scale Engineering Development Unit for layers 3 and 5, with layer 4 in test and analysis;
- Start of flight instruments delivery, with two of the four flight instruments now in-house.

The program brought some work back in with additional FY11-12 funds. Since the replan, the project went from 13 months to 14 months of planned critical schedule slack. That could change in either direction during the integration activities over the next year. The budget profile has not changed. Mr. Yoder pointed out the Unidentified Future Expenses (UFE) area of the budget, which is being used to handle problems in FY12 and not push work out to further years.

Mr. Yoder said that now that the cost and schedule are stable, his emphasis is on executing, communicating, and educating. Executing means doing what the team said they would do, and better, through the entire lifecycle. Communicating means being open. Educating means highlighting the science that is the reason for the mission. The 2013-14 watch points are the Integrated Science Instrument Module (ISIM) cryo-vac tests, with instrument deliveries and test plans that have flexibility for integration; mass margins, which need to be appropriate for the phase of the mission; the overall schedule margin and competing critical paths; workforce balance to avoid burn-out, stress, or fatigue; and a consistent message for the team that can keep them inspired from now through the time of the launch.

Mr. Yoder told of his previous assignment in NASA's assessment office. In that capacity, he had participated in an ongoing look at JWST to see where it was with respect to its baseline measures and direction. He showed a summary from the review, which indicated that the technology and cost/budget areas were "green." The schedule was also determined to be green despite some concern that the ISIM cryo-vac testing sequence and strategy are not yet fully understood and carry some risks.

A review of the schedule showed that there are three cryo cycles planned for ISIM, one of which may need to be modified somewhat. Gear motors need to be replaced on the primary mirror segment assemblies and secondary mirror, and the same team (at Ball Aerospace) is doing all of them. The Optical Telescope Element/Integrated Science Instrument Module (OTIS) integration has had more tests added. Near InfraRed Camera (NIRCam) A and B modules are at Lockheed being tested for performance and workmanship; that integration and test (I&T) schedule is sliding a bit. The same is true with the Near InfraRed Spectrograph (NIRSpec), where the I&T schedule is tight. All mirrors are complete, and the team has completed the mirror backplane support center section structure. There were some stress issues with the primary mirror wings, which have been addressed, and the wings are being assembled now. The sunshields are in testing, template layers 3 and 5 are complete, layer 4 is in data analysis, and layer 2 is being manufactured.

A recent storm and electric power crisis affected much of the area around Goddard near the end of testing for the Optical Telescope Element Simulator (OSIM). Fortunately, the team was able to complete the test, but the program is now looking at purchasing an emergency generator as a mitigation activity, as this could happen again and the risk is too great if actual flight hardware were in the chamber when power was lost. Modifications for Johnson Space Center Chamber A were completed in July, and ground systems are being worked on.

The Space Telescope Science Institute (STScI) is nearing completion of the Science Operations Design Reference Mission (SODRM) to get a realistic idea of what 1.6 years of operations would look like, and is working on certification of the onboard scripts. If the team finds something wrong in the chambers during integration and test, they (scientists) need to have a lot of scenarios ready in advance, which is where the Science Working Group (SWG) comes in. The JWST program is asking the Group to leverage their expertise through the upcoming (I&T) phases. The SWG is also providing a 5-page top-level science paper for educators and laypersons, along with charts that teachers can use to inspire children.

Mr. Yoder reviewed the milestones that his team tracks. There are challenges in I&T, but the right team is in place to execute the launch readiness date commitments. Finally, he gave an overview of the milestones for FY12; the program is developing an FY13 version. JWST has challenges and it will have problems – that is part of spacecraft development. However, he is confident that NASA has the right team in place, which will lead to success.

Discussion

When asked about the risk of delayed testing on NIRSpec and NIRCam, Mr. Yoder explained that NIRSpec was always planned for after ISIM Cycle 1 in order to have the full final assembly (with new detectors) for Cryo 3. He also explained that the spacecraft Critical Design Review (CDR) was moved forward into late 2013 and could be moved up even sooner.

<u>WFIRST Design Reference Mission (DRM)</u>

Dr. Paul Schechter of MIT introduced himself as the co-Chair of the WFIRST SDT, which will be giving its report to NASA soon. The SDT was appointed in 2010 in order to come up with a Design Reference Mission (DRM). That task has been completed [and the report delivered in August].

WFIRST is not a dark energy mission, an exoplanet mission, an infrared survey mission, Euclid, or **<u>the</u>** creation of the APD DS. The Astro2010 EOS panel had multiple proposals to do completely different things with similar telescopes and almost the same focal plane. Large segments of the astrophysics community had the same idea, to develop a wide-field infrared space telescope as a cooled, gold, three-mirror device. This wide-field infrared space telescope has had several incarnations, including the one in the DS, which the SDT was asked to improve. The Team was first charged to prepare an interim DRM. They were then told to finalize this and to prepare a second one, DRM2, taking into account possible duplication with Euclid, the Large Synoptic Survey Telescope (LSST), and JWST. An NRC committee reported this year that Euclid and WFIRST are nonduplicative, but the SDT did not accept that as a given and spent several days discussing the issue of duplication. They reviewed the implications of including and excluding every capability. The cost savings are achieved by decreasing the number of photons collected, either by going to a smaller telescope or by shortening the duration of the mission. Changes in the instruments save little by comparison.

The result is that DRM2 has all the capabilities of DRM1, but has a somewhat smaller telescope and smaller lifetime. DRM2 allows for a smaller launch vehicle and less redundancy. If DRM2 were to last 6-7 years, beyond the planned 3, it can do everything in the DS. DRM1 addresses the DS directly. Although it is smaller than DRM1, DRM2 must include the next generation of detectors. Both missions are pixel-limited. DRM2 would cover more of

the solid angle by virtue of having more pixels. The trade-off is a loss of resolution.

One of the science goals for WFIRST was to complete the census of exoplanets. Kepler is doing an outstanding job inside the "snow line." The community would study exoplanets
beyond the snow line using exoplanet microlensing. WFIRST will study the history of cosmic acceleration using supernovae and Baryonic Acoustic Oscillations (BAO). WFIRST and Euclid do not duplicate each other's BAO capabilities. WFIRST's weak gravitational lensing capability offers a substantial redundancy because this is a difficult measureMEN. WFIRST can cross-correlate with itself, but Euclid cannot due to its lack of redundancy, leaving open the possibility that its measurements could be questioned. The Near InfraRed (NIR) capabilities of WFIRST provide a factor of 100 improvement in infrared surveys.

Examples of possible general observer programs would be:
- Search for Kuiper Belt objects;
- Open cluster mass functions to 25MJup;
- Stellar populations in nearby galaxy halos; and
- Lower main sequence in globular clusters.

Dr. Schechter presented a graphic showing the DRM1 and DRM2 fields of view and focal plane layout, as well as that of JWST. When discussing the representations of the instrument layouts for DRM1 and DRM2, he pointed out that the dry weight of the latter would be 500kg less than that of DRM1.

The DS independent cost estimate of WFIRST was $1.6 billion, which the project office determined was the likely highest cost for DRM1. DRM2 was estimated as having a lifetime cost of $0.95 billion. The SDT determined that NASA could move up a bit from DRM2 if the funds were to come through. Both DRM1 and DRM2 are compelling opportunities, and the time has come for WFIRST.

Discussion
Dr. Gary Melnick observed that many specifications are being driven by the need to do dark energy correctly. While this mission differs from Euclid, the question will arise as to how much WFIRST will reduce error bars on what Euclid will deliver by 2025. Dr. Schechter said that WFIRST would measure cosmic acceleration further back in time with deeper infrared. As to how this distills to the ultimate constraints that exist, he said that there are always questions first, about how instruments perform and second, about whether the universe "cooperates". There are two sets of assumptions on the universe, but the team has to assume the telescope acts as planned.
By working in the infrared, WFIRST can obtain weak lensing estimates in multiple filters,
allowing for cross-checking and cross-correlation that Euclid's single optical filter does not allow.

<u>R&A</u>

Dr. Linda Sparke began her presentation by showing the research program spending for FY12. The biggest areas of expenditure were for the balloon program and data archives. The rest of the R&A projects are competed research awards. The funding history for awards from FY04 to FY13 shows that the budget has increased slightly, about 9 percent. The funding awarded in each discipline fluctuates from one year to the next, depending on what is selected, but has not changed greatly over that period. The average FY12 success rate for proposals was 24 percent.

Among the DS recommendations was one for a cross-agency program on theory and computational networks. Therefore, the Astrophysics Division is considering a joint program in this area with the Astronomical Sciences Division of the National Science Foundation. The two agencies asked the Astronomy and Astrophysics Advisory Committee (AAAC) for advice on how best to spend roughly $2 million annually on such a program. The AAAC recommended $500,000, 3-year awards to collaborations with PIs at three or more institutions; the effectiveness of these collaborations should be a criterion for evaluating the proposals. The two agencies are working on a joint solicitation for competition in 2013.

The Nancy Grace Roman Technology Fellowship program aims to foster early-career researchers while developing innovative technologies that can enable major scientific breakthroughs. In its first competition in November 2011, the Fellowship program received 16 proposals from early-career PIs in non-tenured positions for a 1-year concept study to generate detailed plans and commitments for a 4-year development effort. APD selected three concept studies. The Fellows' reports will be submitted as proposals that will be externally reviewed to select the studies that will continue to development. The next round of concept-study proposals is due in November 2012.

Discussion

The FY13 budget request allows selection of one Roman Technology Fellow to continue to the Development Effort. In future years funding could be increased, e.g. to fund two new Development Efforts in every second year. APD could hypothetically reduce funding in another program, such as the Hubble Fellows, to increase the number of Roman Fellows. It is not yet clear if the Roman Fellowships will work as envisioned, and succeeds in helping young researchers into stable positions. So APD would like to wait before shifting funds from another program. It was noted that the total funding for each 5-year Roman Fellowship is roughly $1 million, compared to $330,000 for the 3-year Hubble fellowships.

NuSTAR Launch Update

Dr. Fiona Harrison of CalTech explained that NuSTAR just launched in June. The project is going very well, but it is still in the early stages and results are preliminary. NuSTAR is a high-energy X-ray telescope operating in a higher-energy band than the Chandra X-ray Observatory and XMM-Newton. NuSTAR's unique contribution will be sensitive images in this band for the first time. The telescope also has good spectral resolution.

The launch on Pegasus, the smallest rocket NASA uses for science, went smoothly. In order to launch near the equator, NASA did a night launch from the Kwajalein Atoll. Once NuSTAR was deployed, the mission team began setting up the instruments. It was important to avoid the South Atlantic anomaly, which affects detector background. The telescope is in a 6-degree inclination, 637X623 km, with a projected orbit lifetime of 10 years.

Dr. Harrison showed the commissioning and calibration plan, which goes at least through September. The mission team turned on NuSTAR's instruments 6 days after launch and has been adjusting and calibrating since then. As part of the cross-calibration process simultaenous observations of CasA were taken with NuSTAR, Chandra, XMM, the Suzaku observatory, and the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL).

The spectral resolution allows good low-energy spectral measurements. On-orbit performance shows that the system is working as designed. In addition, a test of background variation demonstrated that the background rate is very stable. Measured background is hard to model because the various contributions are still poorly known. The project has been mostly consistent with the best-case model.

The effective area normalization is preliminary, but a comparison with Swift shows the ratio of NuSTAR to Swift fluctuations using the Swift best-fit model. NuSTAR data will be calibrated and usable to 3-4keV. The effective area agrees with Swift over 5-20 keV. There is no indication that the high-energy response differs from pre-launch projections by more than 30 percent. The team is not ready to report the angular resolution, as it is too early to tell.

X-Ray Mission Concepts Study Team (CST) Report

Dr. Robert Petre, from NASA Goddard, was the study scientist for the x-ray mission concepts study. The study report has been sent to NASA Headquarters; once it is approved, it will go online.

In 1996, NASA began to study next generation X-ray observatories, and developed the Constellation-X concept. Overlapping studies by ESA and the United States were merged in 2008 into the International X-ray Observatory (IXO), which the DS ranked fourth among the large missions. However, ESA regrouped and developed the Athena concept, which it did not select as its L-1 mission. NASA is now re-evaluating its options. Before IXO was terminated, the team produced a mirror development plan and developed the Advanced X-ray Spectroscopic Imaging Observatory (AXSIO) concept. In September of 2011, NASA initiated concept studies through the Physics of the Cosmos (PCOS) program office to identify more cost-effective ways to conduct IXO and Laser Interferometer Space Antenna (LISA) science. The purpose of this concept study was to determine ways to achieve the IXO science objectives at various cost points. The study team sought community input, which is reflected in the report.

IXO addresses five key science questions:

- What happens close to a black hole?
- How and when did Supermassive Black Holes (SMBHs) grow?
- How does large-scale structure evolve?
- What is the connection between SMBH formation and the evolution of large-scale structure?
- How does matter behave at high density?

Dr. Petre showed a notional graphic of the concept study process, which involved a Request for Information (RFI), a workshop, design lab work, and further definition. It was important to ensure that the community understood that there were boundaries, and that the study was not open-ended. The process used the DS science objectives, studied representative missions for various cost classes, and made no recommendations. Most of the 30 RFI responses were strong enough to warrant further consideration. They included 14 missions and 12 enabling technologies. The mission concepts were sorted into three cost bins: under $600 million, $600 million to $1 billion, and $1billion or more. The small missions typically fulfill a single IXO science objective, while the medium and large missions generally fulfill more than one.

The report found that by developing technology first in order to minimize risk and by reducing mission complexity relative to IXO, a mission that captures most of the fundamental IXO science at a fraction of the IXO cost can be developed. This conclusion is based on the four notional missions that were studied:

- AXSIO, which had already gone through the design lab at Goddard;
- N-XGS, a grating mission;
- N-CAL, a calorimeter mission; and
- N-WFI, a wide-field imaging survey.

It became clear that a mission incorporating a calorimeter fulfills the broadest range of IXO science goals, although had ESA selected Athena, the study team would have placed the highest priority on a complementary gratings mission.

Dr. Petre described how the study team ensured that the science goals were fulfilled. As an ensemble the three single instrument notional missions (N-CAL, N-XGS, and N-WFI) fulfill all of the IXO science objectives.

A common set of assumptions and processes was used to estimate the cost of the four notional missions. The team assumed a 3-year lifetime, an L2 orbit, Technology Readiness Level (TRL) 6, a class B mission, a mid-decade start, and funding responsibility completely with NASA. The Goddard Mission Design Laboratory was used to develop

point designs for the four concepts, and cost estimation was performed using PRICE-H whenever possible, and heritage-based grassroots and "wraps" otherwise. The cost includes mission Phases A-F as well as the launch vehicle.

The notional calorimeter mission addresses all of the IXO science objectives, though some not as comprehensively as others. Much of the IXO science can be attained simply by longer exposures. N-CAL also recovers some of the high-timing capabilities of IXO by the introduction of a central "Point Source Array" in the center of the calorimeter. The cost estimate for N-CAL is $1.2B. The grating mission has high spectral resolution in the 0.2-1,2 keV band, matching that of IXO. A generic mission design was developed so that either of the two candidate grating instruments could be accommodated. The cost of this generic mission is about $780 million. The notional wide-field mission has a large field of view, consisting of three identical telescopes. It would have use an Atlas 5 launch vehicle and was estimated to cost just under $1 billion. AXSIO is the representative large mission, costing about $1.5 billion.

Dr. Petre emphasized that these are notional missions, but they show that the IXO science objectives can all be fulfilled under for $2 billion, with a significant fraction under $1 billion. Although the study team assumed that all costs are to be borne by NASA, it is more realistic to assume that a foreign partner could help reduce costs while NASA remains the prime partner.

When it came to enabling technology, the study team used the RFI responses to understand technology needs for the notional missions. They identified key instrumentation and estimated the minimum costs to attain TRL6. The x-ray community has concerns about both the science and the capabilities changing, which led to discussions about the long-term technology. The cost estimates presented in the study report for attaining TRL-6 are considered by the study team to be low, but they still are considerable. NASA has the option of deciding whether to pursue all the identified technologies or only those that are needed for a specific mission.

Next steps include putting the report online for the public after NASA Headquarters approves it. The team will also present the report results the Physics of the Cosmos Program Analysis Group (PhysPAG) meeting in August. The study team will create a technology development plan based on the technology discussed previously and will do a follow-up study to maximize the science return for a $1 billion class mission concept. They would like to be able to provide a better-defined mission and cost estimate to Dr. Hertz for the mid-decade review decision.

Discussion

Dr. Petre explained that the study team did try to obtain independent cost estimates, but were unable to obtain them in time to include in the report. It was pointed out that the cost estimate for IXO submitted to the DS was $3 billion, and an independent estimate came in at $5 billion. Dr. Petre replied that the study team used considerably simplified mission concepts and assumed that the technology had reached TRL-6. The nature of the NASA/ESA arrangement on IXO complicated the mission; ,having the United States should maintain control instead of assuming a 50/50 split reduces overall programmatic risk and thus cost growth.

<u>Gravitational Wave (GW) CST Report</u>

Dr. Robin Stebbins, Study Scientist for the Gravitational Wave (GW) mission concepts study, noted that his team's process was similar to that of the x-ray team. GW has a long investigation history with a corresponding level of investment, so it is hard to start with a clean slate. The National Science Foundation's (NSF's) ground-based Laser Interferometer Gravitational-Wave Observatory (LIGO) will likely make the first detection of GWs. There is a lot of interesting information in this area due to decades of study and technology development. For example, many NRC reviews focused on robust science, technology readiness, and low risk. The Europeans intend to do a GW mission in the future, as well.

The CST goal was to develop mission concepts that will accomplish some or all of the LISA science objectives at lower costs. The team explored how architectural choices affect science, risk, and costs. They were especially sensitive to risk. They also looked at enabling technologies, solicited community involvement through RFIs, and held a workshop and open house. After analyses and deliberations, the team tried to abstract the choices and consequences thereof for the final report, which also discusses LISA science.

Dr. Stebbins showed a chart of the RFI responses, including metrics such as estimated cost, arm length, spacecraft, orbit, trajectory, and more. The non-drag-free concepts use the center of the spacecraft mass as the inertial center, which is challenging. Some proposals changed many aspects of the fundamental LISA concept; CST did not select those. When examining the architecture choices, the team looked at orbits and trajectories, inertial reference, time of flight, and flight systems.

There were several mission concepts found capable of delivering a significant fraction of the LISA science. The science of compact object captures may be at risk due to significantly reduced detection numbers. Concepts with three arms significantly improve estimation over two-arm designs, while additional years produce more science return for a very modest additional expense. Progress in this area allows much more science than initially modeled. Similarly, three-arm concepts present less risk than do two-arm concepts.

All cost estimates were over $1 billion, making LISA a flagship mission by definition. There were no significant cost savings in having two arms instead of three, nor was there much difference between heliocentric and geocentric designs. Eliminating drag-free inertial references adds risk while presenting only modest savings, and optimizing the build plan could lead to modest savings at best. In reviewing the technology findings, Dr. Stebbins said that CST did not see the need for any totally new technology that has not yet had some investment. There is no huge benefit from refinement of the core LISA technologies.

Dr. Stebbins concluded by showing a comparison of how each of the study concepts performed against the science metrics. The risks pile up below a certain cost level, which is dangerous territory. The team found that scientific performance decreases far more rapidly than cost. At the same time, there is no technology that can make a dramatic reduction in cost.

Discussion

When the issue of the full LISA cost arose, Dr. Stebbins said that it was $2.1 billion. The costs he gave were not full lifecycle costs; technologies were presumed to be at TRL 6. Originally, when LISA was planned as a collaboration with ESA, the assumption was that the latter would contribute about 850 million Euros. In further discussion about ESA's involvement, it was noted that a partnership was still possible, but that it was not likely to be a 50/50 partnership.

<u>2.4m Telescopes</u>

Michael Moore of APD provided an in-depth look at the status of the NRO telescopes. In January, 2011 NASA was informed that there was residual equipment from the NRO that could be made available. The equipment turned out to be 2 2.4 meter space telescopes. NASA sent a team in for a quick look to see if the Agency might be even remotely interested. The team determined that NASA might be able to use the assets for a lot of science, quite possibly WFIRST, and possibly at a cost savings. Therefore, NASA decided to take possession of the hardware. Senior leadership is now discussing next steps, along with some community input.

The hardware is a collection of valuable parts for two space telescopes, plus some left over. The parts include, for example, optics, a spare mirror, two outer barrel assemblies with doors, a payload radiator subsystem, and some additional hardware to support instrumentation. There were about 1,600 line items of parts, including screws and other little things. This state-of-the-art hardware is designed to operate at room temperature when on orbit.

The optical specifications offer an idea of what can be done with the assets. The optic is as big as that of Hubble, it is wide field, and it is extremely lightweight at 1,700 kg (Hubble is 8,000 kg). Mr. Moore showed a graphic comparing a wide-field observation that the NRO equipment might produce to Hubble's narrower view, similar to what a wide-field camera lens might produce compared to a telephoto lens. To do wide-field science, an instrument like Hubble is impractical. The Office of the Chief Technologist (OCT) has been asked about using the assets for coronagraphy. There are funding issues, however, and it is not sure which, if any, ideas would go forward.

NASA is reviewing this opportunity through the Agency's Strategic Implementation Planning Process (SIPP) to help decide whether to move it forward. One initial impediment was that the assets were classified, which kept NASA from working on it at first. However, that has been addressed. Now NASA leadership is looking at the long-term portfolio and how the assets might or might not fit.

Discussion

Dr. Melnick pointed out that the assets were initially designed for room temperature, and WFIRST needs to be cool. He wondered how much of an obstacle this presented. Mr. Moore said that the assets' increased aperture gives them the ability to do certain WFIRST infrared activities, offsetting the thermal limitation. Dr. Melnick noted that much of what drives the WFIRST specifications is image quality, and it was not clear whether imagery might be an issue with the assets. Mr. Moore agreed that this could be an issue, but the assets have not been studied in enough detail to make that determination. Their design incorporates good stability, which can be an advantage in extracting information from images. Regarding galactic distortions, they would offer a better picture of the galaxy. Whether that feature compensates for the rest remains a question. NASA needs to look hard to see if the assets might be useful, and where. This is not WFIRST, and any use of the assets will not be cold or off-axis. The hardware is what it is, and the question for the community is if it does enough of what they want.

When asked about the state of the coatings on the optics, Mr. Moore said that he does not know the state of the coating. He has variously heard that the coating was lousy, okay, and fine. The coatings are a version of protective silver. Some people at NASA want to strip the coating and change it, which would be an expense. They have been around for about 9 years, and one looks better than other. There is very little budget flexibility, so this has to be taken into account.

On the topic of expense, Mr. Moore noted that the cost of storage is about $75,000-100,000 per year. The assets were kept in flight-qualified condition with documentation. Dr. Peterson added that the week before, the Science Committee sent a recommendation to the NASA Advisory Council (NAC) asking that NASA study the possible science uses of the telescope assets. NASA needs to understand the science options across SMD, not just APD, and now has been told to take this seriously. Dr. Hertz added that NASA has an agreement with NRO that the Agency will not use this equipment to look at Earth.

<u>Recap of Day 1</u>

Dr. Peterson said that he did not see many problems emerge during the first day. The only significant question he saw come up was about how the selection of a future major mission might be done in 2015, and it was premature to think of that. He asked if there were any additional thoughts.

Dr. Melnick was still unclear on the role new mission concepts would play in 2015, but he was asked to hold that for the following day's discussion session with Dr. Hertz. Dr. Louis Allamandola reported that a number of people have talked to him about being disappointed that SOFIA instrument competition went the way it did with the delay and the process of choosing the upgrades. Dr. Terry Oswalt endorsed the serious evaluation and consideration of NRO hardware. Dr. Nousek said that it was not clear where the WFIRST discussion was leading, and he would like more

clarity on the status of possible near-term hardware development. He also wanted more on the WFIRST relationship to the 2015 date.

Dr. Sambruna told the Subcommittee members that the following day would begin with the evaluations required by the Government Performance and Results Act of 1993 (GPRA). The goal of the discussion was to grade NASA on a stoplight scale of green, yellow, or red. She had emailed a first draft and encouraged the members to make adjustments. The report will be made public, so their contributions were to be in language that the average taxpayer could understand. While the writing could be done away from the meeting, the color grades were to be assigned during the public meeting so that they could go on record. Dr. Hertz added that SMD wanted to gauge the science outcomes, not the missions, in the grading. He noted that SMD gets all three colors in GPRA. The point is whether the Division is accomplishing the science.

Adjourn

Dr. Peterson adjourned the meeting at 5:00pm.

July 31, 2012

Explorers

Dr. Wilton Sanders provided an update on the APD Explorer program, which offers frequent flight opportunities for focused science topics using small satellites. A highly competitive selection ensures that the most current and best science will be accomplished. Full missions can either be Medium Explorer (MIDEX), Explorers (EX), or SMEX. In terms of cost, the SMEXes have a PI cost cap of about $100 million, with the MIDEXes coming in at around $200 million. NASA has an additional cost of about $100 million per mission, and a MIDEX may ultimately cost up to $350 million when all expenses are totaled. The program also offers MOs for instruments flown as part of another mission, whether run by NASA or by a NASA partner.

Active Explorer missions include the Wide-Field Infrared Survey Explorer (WISE), NuSTAR, the Interface Region Imaging Spectrograph (IRIS), and Astro-H. GEMS was to have been an Explorer mission, but it is in the process of being terminated. When a question arose as to the number of Explorers and the DS recommendations, Dr. Hertz pointed out that the DS advises selecting a certain number within a decade.

Recent solicitations have resulted in two Explorers in Phase A:

- FINESSE – Fast Infrared Exoplanet Spectroscopy Survey Explorer
- TESS – Transiting Exoplanet Survey Satellite

Because the cycle from AO to launch is about 7 years, the selected Explorer will go up between late 2016 and 2017. In answer to a question, Dr. Sanders explained that the Pegasus launch vehicle can lift 300-400 kgs into Low-Earth Orbit (LEO). NuSTAR was launched on a Pegasus weighing about 400 kg.

On NASA's plans for late summer or early fall of 2012 was issuance of a Stand Alone Missions of Opportunity NASA Research Announcement (SALMON). Policies in the solicitation will be similar to the policies in the most recent Explorer MO, and access to space will be provided by NASA for the International Space Station (ISS) and the balloon program. This is a departure from previous practice, in that PIs proposing for the balloon program used to have to include the cost of the balloon. Now NASA will provide the launch. In terms of the review process, this will be a one-step selection; there will still be a Phase A, but no concept studies. The PDR and CDR will come into the process at the usual junctures.

Regarding solicitation policies, there was concern expressed about suborbital opportunities, as some in the community view the space-level program management requirements on balloon proposals being excessive. Dr. Sanders was asked if inclusion of these requirements was deliberate or if it was happening accidentally by virtue of the projects being bundled into the same AO. Dr. Sanders replied that some tailoring of the AO is possible. Dr. Hertz added that the PIs can propose adjustments. If the adjustments made sense, APD would support the request with SMD. While SMD lacks the authority to waive the requirements, the Directorate but can make the case to the Office of the Chief Engineer. This has been done in the past, but not with suborbitals. Dr. Sanders added that the burden is on the PI to propose a tailored arrangement, and Dr. Hertz noted that if a suborbital is done through R&A, APD views it as level of effort. However, for Explorers, there is a higher level of expectation of mission success. A marriage of the two is not something the Division has dealt with. The Explorer program is not the first place a person should be a PI. APD always selects under the current NASA rules, which change. The Division has had to rule on whether the scope of work changes and address PI issues accordingly.

Dr. Sanders continued his presentation by noting that the Explorer program is targeting a down-select in the summer of 2013. The MO flight might be in 2017 or 2018. The currently approved Explorer Program planning budget is sufficient to select and execute one MO at $60 million, or two MOs if both are balloon missions or other proposed investigations well below the $60 million PI-managed cost cap. Regarding the limitations on the balloon costs, that is the result of some analysis of historical missions proving that it can be done.

The DS recommendations were for two MIDEXs, two SMEXs, and annual MOs. The DS was unclear on the selection versus the frequency of AOs. Assuming that GEMS is indeed terminated, plans are for the two AOs mentioned, plus a SMEX in 2013, plus additional AOs for a full mission and one MO. Launches are all figured to be 7 years later. Although out-years are notional, the projected budget increases for the Explorer program as a whole and for future missions. These increases follow the DS recommendation to double the program. Funding comes in part from the ramping down of current missions. It is a delicate balancing act.

Discussion and GPRAMA Report Assignments

Dr. Sambruna introduced Jennifer Kearns, SMD Performance reporting contact. Ms. Kearns explained that while GPRA has been in effect for a number of years, Congress passed the GPRA Modernization Act (GPRAMA) just over a year ago. The updated Act would not affect content at the APS level, though others might make revisions further along in the process. In order to stay in compliance with GPRAMA, SMD must report on several metrics each year. Among these metrics is whether the division has achieved specific Outcomes for its Strategic Goal, and for that the Directorate sought input from the various Subcommittees. The time period under review is mid-2011 through mid-2012. To be included in the report, the science results had to have been published during that time period, which precluded imminent results. There must have been at least a press release on the results, and a peer-reviewed journal article was preferable.

In order to help with the process, sample press releases were included in the materials sent to the members. However, they were not obligated to use those press releases. The final report has various audiences, including taxpayers, the Office of Management and Budget (OMB), and Congressional staffers. Ms. Kearns advised writing for the intelligent layperson in order to minimize the need for rewriting. Although APS could present as many items as the members wished, NASA typically publishes three to five items from each of the science objectives. If the members thought that a particular item should be included, they were to let her know through Dr. Sambruna so that her office could inform the Agency's Chief Financial Officer (CFO).

The APS is also charged with scoring the APD performance against the GPRMA metrics at the meeting. Ms. Kearns then read the ratings guidance. A rating of green meant that the expectations of the research program were fully met in context of the budget; yellow meant that there were some shortfalls but some science was

achieved; and red meant that any science achieved did not make up for shortfalls, which were significant. She emphasized that they were just looking at the 1-year period.

Dr. Peterson brought up GEMS, which might be seen as a tremendous disappointment from a science standpoint but a good management decision. Ms. Kearns said that because APS was only to evaluate science results, the Subcommittee could choose to comment on GEMS in later years when the science results could have been expected. Years ago, the APS did this after multiple SOFIA delays, and the ESS will likely consider the loss of Glory in their FY12 evaluation. Discussion among the members led to the conclusion that it was too early to include NuSTAR, since it did not yet have science results and was still in the calibration phase. Organizationally, JWST was outside of APD and being evaluated elsewhere in NASA.

Ms. Kearns advised the APS members to ask any questions they had about whether something could be considered a NASA result. The rule of thumb is to include anything that received significant NASA funding. The implementation of GPRAMA is more difficult for R&D agencies, as the types of metrics that make sense for other agencies are often not the right approach for assessing R&D performance. In addition, the Agency performance report is not meant to be comprehensive and will show only a few examples. APS is an external expert review panel, and NASA relies on the members' expertise in judging what the Agency has accomplished. However, the end product must be accessible to the general public. Dr. Sambruna added that this is one of the reasons APS anchors its results with pictures, though they should come from the year under discussion. Dr. Peterson advised members to keep ground-based results as long as NASA had a significant involvement through one of its telescopes or NASA-supported members.

First objective

Dr. Sambruna explained that she organized her materials by science theme, not by missions. She then read the first objective and its performance goal:

> **Objective 2.4.1:** *Improve understanding of the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity.*
> **Performance Goal APG 2.4.1.1: AS-11-1:** *Demonstrate planned progress in understanding the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.*

Suggestions for appropriate examples included GALEX, for which Dr. Nousek offered to provide material, and WISE, for which Dr. Mary Beth Kaiser agreed to develop text. Dr. Nousek suggested that it might warrant mentioning that there had been proposals to terminate five missions or international partnerships, but APD has extended them instead. Dr. Peterson volunteered to put together the piece on this objective.

Dr. Paul Ray moved to vote "green." Dr. Gabriela Gonzalez seconded the motion. The members present, along with Drs. Steven Ritz and Edna DeVore on conference call, were unanimous in voting for the motion to give the first objective a grade of green.

Second objective

> **Objective 2.4.2:** *Improve understanding of the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today.*
> **Performance Goal APG 2.4.2.1: AS-11-3:** *Demonstrate planned progress in understanding the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.*

Dr. Allamandola noted that there has been tremendous progress in infrared research, SOFIA is starting to show observations, and Spitzer is producing good results. All of this research is central to the origin of life. There has also

been great progress in showing the distribution of carbon. Dr. Melnick agreed, citing Herschel, which is working beautifully and is in the prime of its mission while returning encyclopedic amounts of information. He offered to write about it and locate a photograph. Herschel is an ESA mission with a NASA component. Dr. Allamandola offered to work with him on that. Dr. Ray added that he would contribute something about Fermi's results on pulsars, and Dr. Oswalt said that he would write about Hubble and Swift observing a stellar flare and planetary response.

Dr. Allamandola moved to declare this objective green; Dr. Melnick seconded the motion. The vote was unanimous, including Drs. Ritz and DeVore via conference call.

Third objective

> **Objective 2.4.3:** *Generate a census of extra-solar planets and measure their properties.*
> **Performance Goal APG 2.4.3.1: AS-11-5:** *Demonstrate planned progress in generating a census of extra-solar planets and measuring their properties. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.*

Dr. Karl Stapelfeldt said that Kepler has been amazing in regard to exoplanets, finding the three smallest planets that have been seen to date and providing good information on habitability. He suggested also highlighting NASA's contribution to Herschel, which is an ESA mission. Dr. Peterson agreed, adding that this would stress the wisdom of NASA's decision to collaborate with ESA on Herschel. After some discussion, the Subcommittee agreed to look for results from the Hubble mission that might apply as well. Dr. Staplefeldt volunteered to write the piece.

Dr. Nousek made a motion for a grade of green; Dr. Gonzalez seconded. The vote to approve was unanimous, including those on the telephone.

Ms. Kearns asked that the writing assignments be completed and turned into Dr. Sambruna by the end of August, so Dr. Peterson asked that they be sent to him within 2 weeks.

Discussion

Because there was substantial time before the designated lunch break, the Subcommittee resumed general discussion. There were several questions to bring forward, one being about the efficacy of the TMC review and whether the TMC reviewers could have foreseen the GEMS situation.

GEMS and TMC

Dr. Stapelfeldt reminded the Subcommittee that Dr. Hertz had said that TMC was only part of the GEMS situation. He suggested that APS think in more general terms about NASA's need to understand what happened as part of a lessons learned process. Dr. Peterson agreed, but he wanted to ensure that TMC was included in the review, and he wanted to make sure that APS was briefed. Dr. Nousek compared GEMS to a $50 million mission failing on launch. Two years ago, TMC gave GEMS a passing grade. Especially in a cost-constrained environment, NASA should not have this outcome again. The lessons learned document should be distributed to proposers and NASA centers.

There was concern about NASA's enforcement of cost caps. NASA must be realistic about what things actually cost, and the Agency must select according to its cost caps. Several APS members recounted their experiences working on NASA projects and needing additional funds. Dr. Martin explained that he had been on the GEMS TMC. It was extremely thorough and careful, but because of the early stage, the proposal was based on limited information. Dr. Peterson said that while there could be good reasons why TMC did not flag GEMS as being potentially problematic, NASA must ask the question.

Dr. Melnick said that each investigation is unique, greatly limiting NASA's ability to draw on history for comparisons. Only when a mission has spent about 10 percent of its total allocated funds is there enough information to project the budget with any confidence. Yet the concept funds are only 1 percent. NASA might consider either having sufficient reserves for missions that override their cost caps, or investing more in the initial development phase. A number of Subcommittee members agreed. Dr. Sambruna noted that NASA's rules for cost overruns have tightened with JWST and the cost-constrained environment. It was suggested that the termination of GEMS is a sign that the system works better than it used to. Dr. Peterson suggested that the two ideas be combined, to say that because the tolerance for overruns has decreased, missions need to receive more funding up front to ensure that they can develop to stay within budget.

Dr. Ritz asked if every mission should pass its confirmation review. Dr. Nousek thought that a system that works well should have an occasional rejection. He was not questioning the review. The issue that struck him was that 2 years before, GEMS passed a thorough and detailed cost evaluation, so it was considered in a good state of TRL and cost reserves. The change from success to failure seemed sudden. Perhaps that was an outcome related to the uncertainty involved in proposing missions. He wondered if they might be able to prevent a future occurrence if they looked at what happened. Dr. Hertz should decide what is feasible for an investigation. This might not be characterized as a failure, but $50 million was spent from the Explorer budget and there will be no science from it. Dr. Martin explained that TMC does not operate on a pass/fail basis, but instead grades across five levels. Dr. James Bock reminded APS that Dr. Hertz had said there were multiple issues, not just the TMC review.

Recommendations to mid-decade review

A number of Subcommittee members wanted more information about the process by which Dr. Hertz planned to take mission concepts to the mid-decade review for consideration in the next DS. Dr. Hertz, who was not present during this part of the discussion, had said that NASA would down-select the mission. There was a desire for more information on how he planned to get from where APD is now to that decision point in 2015. Dr. Peterson said that if there is a plan for how NASA will make the selection, APS should have a preview at the next meeting. Members also expressed concern that a decision on the next major mission or probes would be made at NASA before the mid-decade review. The timeline for funding is likely to dictate that something go before Congress prior to the conclusion of the review. Dr. Peterson said that he would ask Dr. Hertz to explain the situation better.

One of the issues is that the DS evaluated science per dollar, which has changed since the report was written, raising the question of whether to interpret the DS as recommending science priorities or mission selection. If it is the science priorities, that makes the situation somewhat more straightforward. Dr. Peterson added that this is where the NRO telescopes are a complication, because they present opportunities to address APD's science priorities, but they can also pull the Division away from those priorities. Another concern was that the science community should have an opportunity to weigh in through various outside organizations.

Euclid

The issue with Euclid was the level of involvement. The NRC had advised additional review for a Euclid commitment over $30 million. However, Dr. Hertz had reported that NASA was contributing about $50 million in hardware and a comparable amount in supporting the science team, which totaled $100 million. In negotiations, ESA told NASA that it wanted the "triplets" that had been described during the first day of the APS meeting. While the explanation of NASA's participation was clear, funds expended were greater than expected. The Subcommittee determined that they wanted Dr. Hertz to provide more explanation of how this evolved. Dr. Kaiser pointed out that at a previous APS meeting, each Subcommittee member voted by name on the funding commitment, and they are now looking at something that is higher by a factor of three. Dr. Ritz suggested that the letter should at least say that this differs from what the NRC report recommended.

Discussion continued

After breaking for lunch, the Subcommittee resumed discussion.

WFIRST and Euclid

The question was raised as to whether, given ESA's selection of Euclid, WFIRST would have remained the DS's first choice for a major mission. Conditions have changed markedly since the DS was written: Euclid has been selected, total funding for new initiatives in APD has dropped from $4 billion to about $1 billion, and the WFIRST configuration has changed. It was suggested that APS would do well to receive a report by a team similar to the one that did the Euclid review. In addition, some members wanted to know more about the activities leading up to the 2015 mid-decade review. Dr. Ray thought the baseline issue was how to decide what to do next without redoing the DS. He wanted to hear how Dr. Hertz will make that decision, what inputs he will get, when he will make the decision, and how the technology will be developed. It was as if they were already late. He wanted to know the procedure. Without funding for a major mission, the option appears to be a probe-class competed mission in 2015.

Another concern was that incorporating the NRO mirrors into WFIRST would require a significant reconfiguration, driving up the total system cost. There would also need to be a third mirror, according to Dr. Kaiser. Dr. Oswalt suggested that putting out an AO with the mirror specifications would allow the community to present the most cost-effective and productive uses.

Dr. Melnick was troubled by Dr. Schecter's defense of the WFIRST capabilities in regard to Euclid, especially his statement that the WFIRST will be necessary due to Euclid's lack of cross-correlations. He wanted to know why NASA is investing in Euclid if it does not answer key questions reliably. He thought that Dr. Schechter essentially said that Euclid was not competent to meet one of its science goals. There was additional concern expressed about the level of investment. Dr. Kaiser, for example, reported getting calls from the dark energy community because they worried that the $30 million investment in Euclid would preclude NASA doing WFIRST. Now they are hearing that the investment is $100 million. Dr. Nousek agreed, saying he was uncomfortable with both badmouthing and investing in Euclid. Dr. Peterson thought the question was about the robustness of Euclid's gravitational lensing and who will believe results based on a single waveband. Given that shortcoming, the question then becomes why NASA both increased its investment in Euclid and still thinks WFIRST is necessary to fill Euclid's gaps.

Administrative issues

Dr. Sambruna told the Subcommittee that this was her last meeting as Executive Secretary, as she was going on detail in the Office of the Administrator for a year. She thanked the members. Dr. Hertz praised her for the excellent job she has done. It was suggested that APS write a letter of commendation for all her service.

There will be an APS teleconference before the week of November 12.

<u>ExoPAG</u>

Dr. Douglas Hudgins, Kepler program scientist at NASA, gave an update on the Exoplanet Exploration Program Analysis Group (ExoPAG). The Group has not met since the last APS meeting, and its next scheduled meeting is on October 13-14 in Reno, NV, before the AAS meeting for planetary sciences. Presenting before this AAS meeting will help the Group reach an under-represented segment of the exoplanetary community, those in planetary science. The agenda will emphasize near-term opportunities and challenges in exoplanetary science.

Ongoing activities center on the Science Analysis Groups (SAGs). All of the SAGs have either completed their work and are about to be closed down, or are inactive. The SAGs are:

1. Debris Disks and Exozodiacal Dust – Work completed; report accepted for publication.
2. Potential for Exoplanet Science Measurements from Solar System Probes – Work completed.
3. Exoplanetary System Architecture and Dynamical Stability – Inactive; activities suspended.

4. Measurements Needed for Exoplanetary Characterization – Work completed; report in process.
5. Exoplanet Flagship Requirements and Characteristics – Work completed; report in process.
8. State of Precision RV Measurements for and Exoplanetary Census – Inactive; plan to renew activities with new ExoPAG executive committee leadership after ExoPAG-6.

After ExoPAG-5 in January, five members of the executive committee left; five new members have joined, including Dr. Scott Gaudi, who is ExoPAG chair and a new member of APS. Dr. Hudgins is the Exoplanet Exploration Program Scientist. ExoPAG also decided that the outgoing chair would remain on the executive committee in an ex officio capacity for another year to facilitate a smooth transition.

Dr. Stapelfeldt interjected that, related to ExoPAG, the exoplanet mission technology funding was cancelled in the Research Opportunities in Space and Earth Science (ROSES) in March. This is a setback for the ExoPAG community, for it jeopardizes their ability to pursue the technology. He thought APS should be aware of this, as it goes against DS recommendations. Dr. Hudgins said that it is difficult to maintain a technology development program when there are funding gaps like that. This year, APD had no funds for new starts, so it cancelled the Technology Development for Exoplanet Missions (TDEM) component of the ROSES solicitation. However, there are some ongoing tasks in the area. Dr. Melnick cautioned that this lack of current funding could place a steep technology development curve in front of NASA should a high level decision be made to include for the next decade a mission for direct detection of exoplanets.

Dr. Hertz said that in the President's FY13 budget request, the APD budget was lowered by $100 million against the plan. Most of that came from technology and future mission lines. This reduction forced APD to cancel the TDEM call. So although he personally agreed that the funding is necessary, his job is to make decisions on how to allocate insufficient funds. If APS tells APD to shift priorities, NASA can consider that. OMB has given all agencies a 5 percent reduction challenge, and sequestration would be an 8.5 percent reduction. Dr. Hudgins added that APS has been offering TDEMS every other year, so the ongoing projects will finish next year. Even with no growth, APD would have funds because of that. The annual budget for TDEM is $2.5 million.

CoPAG

Dr. Martin said that, like ExoPAG, the Cosmic Origins Program Analysis Group (CoPAG) has not met for a while. He briefly reviewed a list of activities and mentioned the community workshop at the AAS meeting. He will be making a presentation to PhysPAG, where he will discuss CoPAG activities and discuss possible coordination between the two groups. The Cosmic Origins program office has released an RFI. CoPAG will likely be involved in distilling that information into something usable by the community and NASA. There will be a workshop in December on trying to articulate compelling science objectives for next generation medium and large missions, plus the uses of the NRO telescopes for cosmic origin missions.

The following SAGs have been active:

- SAG1: Science Goals, Objectives, Requirements for Cosmic Origins missions. Most activity has been focused in this area.
- SAG2: Determine technology focus areas for a monolithic 4m aperture UV/ optical/NIR mission with internal Coronagraph for exoplanet imaging. This SAG and SAG3 have had some collaboration with ExoPAG.
- SAG3: Determine technology focus areas for a segmented 8m aperture UV/optical/NIR mission with external occulter for exoplanet imaging.
- SAG4: Determine technology focus areas for future Far IR Instruments
- SAG5 [to be modified]: What is the scientific case for a set of linked probes and corresponding technology requirements? Can this be accomplished with one NRO telescope?

- SAG6 [to be approved]: Develop a plan for community costing transparency, training, ownership, and effecting systemic change.

CoPAG is trying to focus on increasing communication with the community, which is large and diffuse. Some of the discussions are difficult to establish, so he is interested in suggestions. One effort is to distill the large science reach of cosmic origins into a single compelling story. Cosmonogy can be broken into multiple stages. At this point, more is known about what occurred than how it occurred.

CoPAG has settled on six broad science goals:

- Goal 1: Characterize the growth of large-scale baryonic structures in the intergalactic medium.
- Goal 2: Observe and explain the assembly of galaxies over cosmic time.
- Goal 3: Trace and understand the flows of baryons between galaxies and the intergalactic medium.
- Goal 4: Trace and understand the cycles of matter and energy within galaxies.
- Goal 5: Measure and explain the history of star formation in galaxies over time.
- Goal 6: Determine how the conditions for habitability arise during planetary system formation.

Dr. Martin reviewed a number of corresponding science measurement objectives. He also mapped the DS science questions to these measurements, gave examples of science measurement requirements, and showed how the measurement requirements correlate with mission objectives.

With a couple of graphics, Dr. Martin showed the spectroscopic and imaging focus possibilities using a 2.4m probe. He also reviewed the mission requirements for a hypothetical mission using next generation UV technology. A key to making such a mission successful is understanding and controlling costs, for which there are three elements: serious early investment; cost ownership and consistency, in which costs are treated like other technical requirements and understood in as much detail; and break cost paradigm, meaning that the mission must be kept to below its cap instead of assuming it should reach the cap.

A concern is that funds are being moved to operate ongoing missions. Dr. Martin urged APS to discuss this, as the DS did not address it. He does not feel that the community has come to grips with the need for cost ownership and consistency. APD must break the cost paradigm to ensure that missions do not come in at the cap for the project area. NASA needs to force cost discipline, and cancelling missions sends that message. The cost paradigm was one of the three “burning issues” Dr. Martin identified. The other two were the ongoing discussion of probes versus flagship missions, and the NRO telescopes.

Dr. Martin asked APS to approve:

1. The general direction of ExoPAG activities;
2. The modification of SAG5 to include consideration of the NRO telescopes; and,
3. The creation of SAG6 to address cost issues.

Dr. Hertz asked that APS delay action on the third item until there can be more in-depth discussion. Dr. Peterson added that there would be value in a full presentation on the issue. Dr. Martin agreed, noting that he thinks that with the enormous amount of effort that goes into costing, the DS did not consider it. Dr. Peterson asked that the members discuss the first two actions during their next discussion period.

<u>PhysPAG</u>

Dr. Ritz began his PhysPAG update by explaining that PCOS spans the fields of high-energy astrophysics, cosmology, and fundamental physics, and includes a wide range of science goals. PCOS science is well-represented in the unfunded DS missions.

Recent PhysPAG activities include interactions with the Project Office on Technology, and planning for the upcoming August jamboree in Washington. One of the jamboree goals is to start approved SAGs for the x-ray, GW, and gamma ray communities, while continuing the work of the Inflation Probe SAG (IPSAG). The jamboree will include both plenary and parallel sessions. PhysPAG is also proposing a Cosmic Ray SAG (CRSAG).

Dr. Ritz listed a number of upcoming meetings, then provided additional details about the jamboree, including the proposed agenda. The primary purpose is to bring the broader community together. There will be reports on the GW and x-ray studies, and it is hoped that the event will both facilitate a discussion with NASA headquarters and enable the community to plan their next steps. Among the highlights will be reports from CoPAG and ExoPAG, and long discussions about cosmic ray science. The GW and x-ray communities will have an opportunity to discuss where to go next. Other topics will include dark energy and IPSAG. Finally, Dr. Hertz will address the meeting.

The goals of the proposed CRSAG are to provide NASA with an assessment of the status, and current and future needs, of the cosmic ray astrophysics community. The SAG would act as a focal point and forum for the cosmic ray community. CRSAG would have a deliverable of a white paper on science opportunities and technology input. The SAG would also report on what the community feels it needs. If the SAG is approved, PhysPAG would like the group to start writing the white paper at end of this year, with the goal of presenting it in April.

Dr. Ritz thanked all the SAG members and Dr. Sambruna. He asked APS to discuss the CRSAG proposal and provide feedback on PhysPAG activities. Dr. Kaiser moved to approve the direction of PhysPAG, including the new SAG. The motion was seconded and received unanimous approval.

Discussion of CoPAG

Dr. Peterson noted that CoPAG sought approval of its general direction, as well as modification of the probe SAG to incorporate the NRO telescopes. Because the Science Committee, to which APS is a subcommittee, has already recommended that NASA do a study of the NRO assets, it was agreed to table this CoPAG request until NASA reports back. Dr. Hertz said that in addition to briefing the community on this topic, he would like to see NASA cast a broad net when seeking input on how the assets can advance the DS. Dr. Martin said that CoPAG had hoped to have the NRO telescopes as a principle agenda topic at a September meeting at Princeton. Dr. Hertz explained that the Princeton workshop is not a NASA activity. On the other hand, while he hoped that by then there would be no issues with discussing the NRO telescopes, he cannot give permission for a NASA-sponsored workshop to discuss possible use of the assets because NASA has not yet even decided to study using them. The Agency's highest levels are making that decision.

It was determined that it was premature to consider the NRO telescope assets and the cost SAG. Dr. Nousek motioned that APS endorse CoPAG activities with the stipulations that this endorsement does not include NRO discussion or the cost SAG. In the vote, Drs. Martin and DeVore abstained. All others voted in favor of the motion.

<u>Public Comment Period</u>

As required by the FACA regulations, the meeting provided time for public comment. Following a substantial silence, Dr. Peterson determined that there were no members of the public wishing to comment.

<u>Discussion continued: SOFIA</u>

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Discussion continued: SOFIA

Dr. Allamandola noted that SOFIA was supposed to fly in 2001 but did not have its first official flight until 2010. Despite the recently approved instrument upgrades, there is no new technology going forward for this program. He wanted to report out some language about the situation, noting that it is important for the technology to advance. He found it particularly frustrating in that he keeps hearing that the technology development program should be a training ground for new people, yet there are unmet opportunities in that realm. SOFIA can go all over the country and people can touch it, so the program offers possibilities for education and public outreach. His concern is that some of these missions are being cut. He was on the review panel for the proposals. It was clever and creative, and it touches all the science they are hearing about now. If there is no new instrumentation, therefore, this is a loss. Dr. Hertz said that there is a continuing wedge in the SOFIA budget for new instruments. The first part was spent on the HAWC upgrades. There will be new instruments every 3 years. Cost and complexity are issues – APD guarantees a rate of spending, not of bringing in new instruments.

Dr. Martin raised the issue of the need for a programmatic decision on fueling the airplane, investing in new instruments, and flight frequency. A year ago, he asked what percentage of the budget goes to new instrumentation. It would be useful for APS to have that number. There is also a requirement to fly a certain number of hours per year, and he was not sure where that requirement originated. Dr. Hertz replied that the annual budget for new instruments is $3 million year, the total budget is $80 million per year, and about $30 million of that goes to fuel. There was discussion about the possibility of reducing flight hours slightly in order to fund additional instrumentation. Dr. Hertz said that he is always working on optimizing the budget. Dr. Melnick suggested that APS endorse Dr. Hertz's plan to issue an AO for new instruments in 2 years and to do so on a regular interval thereafter.

After further discussion about the possibilities of supporting new instrument development, Dr. Peterson said that this is an operational decision that APD should revisit periodically. Dr. Hertz offered to have the chair of the SOFIA advisory council come brief APS. He agreed that APD should keep looking at the program. Dr. Melnick noted that he is on the advisory committee for SOFIA, and that he heard that NASA was re-evaluating its advisory structure. He believes that SOFIA has suffered from being isolated and insulated.

In answer to a question, Dr. Hertz explained that instruments have to pass stringent airworthiness tests before they can be flown on SOFIA. The last call asked for technology demonstration instruments. He was a SOFIA program scientist, so he knows that the expense of meeting airworthiness requirements adds to the costs of even simple instruments. SOFIA will eventually go to a senior review, and he wants the reviewers to see that the science has been valuable. Regarding the suggestion of low-cost autonomous specials, he said that there are things that could be done, just not funded through the SOFIA program. SOFIA has a very exciting education and public outreach program, with an Airborne Ambassadors program that pairs educators with PI teams, then has the teachers fly along.

They take the experiments back to their educational institutions, which can range from grade schools to museums. The educators are selected partly on their plan to carry the experience forward. Most flights have teachers on board now. Dr. DeVore agreed, adding that a goal of the program is to have people to return to their communities and extend the outreach. The call for proposals for teachers to fly will come out this fall. She ran the teacher program on another project, and it received very positive press.

Division Director Debrief

Dr. Peterson began the debriefing by observing that APS discussed many intertwined issues. The Subcommittee is especially concerned that conditions have changed since the DS came out. Regarding WFIRST, Euclid was selected, the total funding for new missions is a lot less than the DS assumed, and NASA now has the NRO telescopes that may or may not be suitable for the program. In selecting a new major mission, there is no need to do anything until 2015, but given all of the related factors, APS is concerned about program issues. They are still trying to understand that NASA chose to participate in Euclid but made a contribution much higher than the $30 million that was to have elicited a review. Finally, the weak lensing capabilities in Euclid are not what APS would want.

Dr. Hertz said that, with regard to Dr. Schechter's concerns about Euclid, the NRC report was enthusiastic about NASA participation and cast no doubt on it. As for cost, the original estimate for cost assumed that NASA would only contribute detectors and not triplets. NASA agreed to do more for a practical reason: ESA has a plan for Euclid and a schedule. It is not possible for ESA to meet the schedule if NASA provides the detectors and they get the rest of the triplets separately. So ESA said it would rather not partner with NASA if the Agency only contributed the detectors. NASA discussed this with the CAA and came away with the impression that this was okay with them. NASA did take seriously the report comment saying to check back on any increased cost. That is the thought process; it is always a judgment call. Partnering on the $30 million level was not an actual option, which is why NASA went with $50 million.

Dr. Gonzalez pointed out that the issue was whether there was consultation with the community. Since CAA was consulted, it sounds like there was such consultation. Dr. Melnick said that everyone imagined a different bottom line. Dr. Hertz explained that the hardware cost includes reserves, and the science team will cost $30-50 million. The total is $80-100 million spread over 13-14 years, with the hardware expenses allocated primarily during the next 3 years, the science team over the development and life of mission, plus funding for archival data analysis.

Dr. Peterson said that a related issue is that a decision will be have to be made in 2015 about what to start in 2017. APS understands that APD will put together a white paper for AAS. Dr. Hertz explained that the white paper will discuss the lead-up to the decision. Lining up the right stakeholders, getting the right technical data, and soliciting input will take time. He will share the white paper with APS before their November teleconference. If the decision is to move forward with something addressing WFIRST priorities, it will be an easy decision. If it is something else, that will not be easy. WFIRST is the top priority from the DS for the next strategic mission, so it is NASA's job to make that determination. APD will only start one mission in 2017, even if it is the first in a line of probes. Because he values the DS, he believes the mission must flow from the DS.

The next issue Dr. Peterson raised was the nonconfirmation of GEMS. APS does not question the management decision, but the members do want to know the outcome of the lessons learned effort, especially with regard to the TMC process. Dr. Hertz said that NASA will present a public version of the lessons learned. The TMC process evaluates the plan that is put forward and whether it can be executed within cost and schedule. The GEMS plan could have had been good or inadequate. At this point, NASA is still looking at what went wrong. The Agency did look back at the TMC process and tried to determine whether TMC was seeing GEMS correctly or if the review panel could have caught something. Some things cannot be caught before they show up. Once there is a public version of the review online, he will send the link to Dr. Peterson to disseminate.

Dr. Peterson observed that this experience made it clear that the tolerance for overruns is greatly reduced from what it was in past. APS is concerned that it is hard to really know what a mission costs until about 10 percent of its budget has been spent. To address this, perhaps Phase A of the PI-led missions should be more heavily loaded. Dr. Hertz replied that PI-led missions are cost-capped no matter how much NASA gives them in Phase A. If the point is that Phase A is underfunded, and there is a need for deeper design maturity, that would help APD avoid selecting those missions that will not be under the cost cap. When Dr. Peterson confirmed that that was the Subcommittee's conclusion, Dr. Hertz explained that APD has gotten that same message from other sources. This is doable. APS might want to talk to the PIs who have completed Phase A, though he advised that they wait until after September 21. This is a hard line to draw, however. It could lead to spending more on projects that APD will not take forward. The ideal is to find the point at which NASA and the investigators learn about the likelihood of success. NASA has thought about that, and the thinking evolves. On strategic missions, NASA does not make a cost commitment until after the confirmation review, and the Agency invests more than 10 percent of the total cost on that. The cost commitment is made at the 70 percent confidence level. NASA now sets aside more funds than its management believes will be needed. Since the Agency started doing that, its performance has been demonstrably better. APS should look beyond the GEMS situation to whether APD is improving.

Dr. Gonzalez said that the community would like to know what will happen after NASA receive the reports on the GW and X-ray concept studies. The next steps are not clear. Dr. Hertz replied that there is no clear path forward, as funding is insufficient to do what APD would like in those areas. However, in the pursuit of balance, such reports are useful input for the decision process.

Adjourn

The meeting adjourned at 4:04 p.m.

Appendix A
Attendees

Subcommittee members
Bradley Peterson, Ohio State University, *Chair Astrophysics Subcommittee*
Rita Sambruna, NASA, *Executive Secretary*
Louis Allamandola, Ames Research Center
Gary Bernstein, University of Pennsylvania (via WebEx)
James Bock, Jet Propulsion Laboratory
Edna DeVore, SETI Institute (via WebEx)
B. Scott Gaudi, Ohio State University
Gabriela Gonzalez, Louisiana State University
Mary Elizabeth Kaiser, The Johns Hopkins University
Chris Martin, California Institute of Technology
Gary Melnick, Harvard University
John Nousek, Pennsylvania State University
Terry Oswalt, Florida Institute of Technology
Paul Ray, Naval Research Laboratory
Steven Ritz, University of California Santa Cruz (via WebEx)
Karl Stapelfeldt, Goddard Space Flight Center

NASA attendees
Mansour Ahmed, NASA/GSFC
Jaya Bajpayee, NASA HQ
Ann Hornschemeier Cardiff, NASA/GFSC
Joan Centrella, NASA/GSFC
Ellen Cohen, NASA HQ
Chris Davis, NASA HQ
T. Jens Feeley, NASA HQ
Dave Gallagher, NASA/JPL
Richard Griffiths , NASA HQ
Hashima Hasan, NASA HQ
Paul Hertz, NASA HQ, *Director, Astrophysics Division*
Doug Hudgins, NASA HQ
Jennifer Kearns, NASA HQ
Lia LaPiana, NASA HQ
Mike Moore, NASA HQ
Susan Neff, NASA/GSFC
Marian Norris, NASA HQ
Bill Odgerle, NASA/GSFC
Mario Perez, NASA HQ
Rob Petre, NASA/GSFC
Larry Petro, NASA HQ
Wilton Sanders, NASA
Eric Smith, NASA HQ
Linda Sparke, NASA HQ
Robin Stebbins, NASA/GSFC

Steve Unwin, NASA/JPL
Glenn Wahlgren, NASA HQ
Michael Werner, NASA/JPL
Geoff Yoder, NASA HQ

Other attendees
Gerald Blazer, OSTP
Jay Bookbinder, SAO
Kaitlin Chell, CalTech
Anne Connor, House Science, Space, and Technology Committee
Dom Conte, Orbital
Mike Garcia, SAO
Niel Hold, SDL
Scott Jensen, SDL
Bethany Johns, AAS
Jason Kalirai, Space Telescope Science Institute
Carol Lane, Ball Aerospace
Marc Postman, Space Telescope Science Institute
Paul Schechter, MIT
Deron Scott, SDL

Webex
Loli Chatterjee, DOE
Gerard Daelesman, NASA/GSFC
Sean Dreyer, Orbital
James Green, University of Colorado
Fiona Harrison, CalTech
Illana Harrus, NASA
Ingolf Heinrichsen, JPL
Louis Kaluzienski, NASA
Jeff Kruk, NASA Goddard
Joydip Kundu, OMB
Julien Lamamy, Orbital
David Lang, NRC
David Leisawitz, NASA
Dan Leone, Space News
Stephan McCandliss, Johns Hopkins
Jon Morse, Rensselaer
Virginia Neale, Northwestern University
Anthony Nicolleti, NASA
Anne-Marie Novo-Gradac, NASA HQ
Andy Patak, NASA
Thai Pham, NASA GSFC
Michael Salamon, DOE
Alan Smale, NASA/GSFC
Marcia Smith, spacepolicyonline.com
Randall Smith, SAO
Kim Terrell, KIMS

Appendix B
NAC Astrophysics Subcommittee Members

Bradley Peterson, Chair
Department of Astronomy
Ohio State University

Rita Sambruna, Executive Secretary
Astrophysics Division
Science Mission Directorate
NASA Headquarters

Louis J. Allamandola
NASA Ames Research Center

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

James J. Bock
Jet Propulsion Laboratory

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

B. Scott Gaudi
Department of Astronomy
Ohio State University

Gabriela Gonzalez
Professor, Physics and Astronomy
Louisiana State University

Mary Elizabeth Kaiser
Principal Research Scientist
Department of Physics and Astronomy
The Johns Hopkins University

Vicky Kalogera
E.O. Haven Professor of Physics & Astronomy
Northwestern University

Chris Martin
California Institute of Technology

Gary Melnick
Senior Astronomer
Harvard University

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

Terry Oswalt
Professor and Head,
Department of Physics and Space Sciences
Florida Institute of Technology

Paul S. Ray
Naval Research Laboratory

Steven Ritz
Santa Cruz Institute for Particle Physics
University of California

Karl Stapelfeldt
Goddard Space Flight Center

Appendix C
Presentations

1. *Astrophysics Division Update*, Paul Hertz
2. *JWST Update,* Geoff Yoder
3. *WFIRST DRM,* Paul Schechter
4. *Astrophysics Research Programs,* Linda Sparke
5. *NuSTAR: The Nuclear Spectroscopic Telescope Array,* Fiona Harrison
6. *The NASA X-ray Mission Concepts Study,* Rob Petre
7. *Final Report of the Gravitational-Wave Mission Concept Study,* Robin Stebbins
8. *New Telescope Assets,* Michael Moore
9. *The Explorer Program*, Wilton Sanders
10. *ExoPAG Report*, Douglas M. Hudgins
11. *COPAG Report*, Chris Martin
12. *PhysPAG Status*, Steven Ritz

Appendix D
Agenda

Astrophysics Subcommittee meeting
July 30-31, 2012
NASA Headquarters
AGENDA

Monday, July 30
Location: 7H45 (Mic7)

9:00-10:00	Mandatory Ethics Training	K. Spear
10:00-12:00	APD Update and Q&A	P. Hertz
12:00-1:00	Lunch	
1:00-1:30	JWST Update	G. Yoder/E. Smith
1:30-2:00	WFIRST DRM	P. Schechter
2:00-2:30	R&A	L. Sparke
2:30-3:00	NuSTAR Launch Update	F. Harrison
3:00-3:15	Break	
3:15-3:45	X-ray CST Report	R. Petre
3:45- 4:15	GW CST Report	R. Stebbins
4:15- 4:45	The 2.4m Telescopes	M. Moore
4:45- 5:00	Recap of Day 1	B. Peterson
5:00	Adjourn Day 1	B. Peterson

Tuesday, July 31
Location: 7H45 (Mic7)

9:00-9:30	Explorers	W. Sanders
9:30-12:30	Discussion and GPRA Report Assignments	S. Ritz
12:30-1:00	Lunch	
1:00-1:30	ExoPAG	S. Gaudi
1:30-2:00	CoPAG	C. Martin
2:00-2:30	PhysPAG	S. Ritz
2:30-2:45	Public Comment Period	
2:45-3:00	Break	
3:00-3:30	Discussion	Committee members
3:30-4:00	Division Director Debrief	B. Peterson
4:00	Adjourn Meeting	B. Peterson