NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

February 23-24, 2012

NASA Headquarters
Washington, D.C.

MEETING MINUTES

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Alan Boss, Chair

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Rita Sambruna, Executive Secretary

February 23, 2012

Welcome and Conflict of Interest Review

Dr. Alan Boss, chair of the Astrophysics Subcommittee (APS), convened the meeting by welcoming those present. He then asked the APS members to introduce themselves and state any conflicts of interest with the agenda.

APD Programmatic Update

Dr. Paul Hertz, Acting Director of NASA's Astrophysics Division (APD), presented an update of activities in the Astrophysics Division, including science highlights, a programmatic review, and discussion of the President's Fiscal Year 2013 (FY13) budget.

Science highlights

Dr. Hertz highlighted a few of the many recent scientific accomplishments that have been described in NASA press releases. The Chandra X-ray Observatory found small flares in a supermassive black hole, which were also detected in the optical by the Very Large Telescope in Chile. Astronomers used Chandra and Hubble spectroscopy observations to further understanding a supernova explosion in a nearby galaxy, which involved accretion of mass from a companion star onto a white dwarf. Before its decommission in January, the Rossi X-ray Timing Explorer (RXTE) satellite provided time-resolved observations of the variable X-ray emission from a black hole system. The Kepler mission found small, hot, rocky planets about the size of Venus orbiting around a Sun-like star outside of our solar system. Early Kepler results tend to be primarily hot planets because of Kepler's initial sampling. There will be more variation as the mission proceeds. Spitzer has found solid buckyballs in space for the first time, confirming model predictions.

Programmatic update

Personnel changes: Dr. John Grunsfeld is the new Associate Administrator (AA) for the Science Mission Directorate (SMD). Mr. Geoff Yoder, the previous Acting Director of APD, has taken on a new role in the Administrator's office. Dr. Hertz showed a chart outlining SMD and APD's organizations at Headquarters, and the structure of the Program Offices at the centers. The latter include the Exoplanet program office at the Jet Propulsion Lab (JPL), the Cosmic Origins (COR) and Physics of the Cosmos (PCOS) program offices and the Astrophysics Explorer at Goddard Space Flight Center (GSFC). The Stratospheric Observatory for Infrared Astronomy (SOFIA) program has its own program office at Dryden Flight Research Center (DFRC). The APD research program is based entirely at headquarters. Finally, the Wide-Field Infrared Survey Telescope (WFIRST) study office is located at GSFC while the study is part of the Exoplanet program at JPL.

Active missions

Dr. Hertz discussed the status of active missions. The decision on whether to decommission the Galaxy Evolution Explorer (GALEX) is pending. Although the NASA function is complete, another entity could continue it without NASA involvement. If no organization takes it over, NASA will proceed with decommissioning.

The Nuclear Spectroscopic Telescope Array (NuSTAR) is scheduled to launch in March 2012, although a delay is possible. While no mission launches are planned for 2013, the Explorer down-selection will occur that year. Two mission launches are on the schedule for 2014, GEMS and Astro-H. The upcoming senior review will evaluate the science return of the operating missions, and this information will be used to decide which one(s) to extend, and for how long, in FY13 and FY14. At the same time, many suborbital flights will launch, along with a number of balloon campaigns.

The Japan Aerospace Exploration Agency (JAXA) continues to develop the Astro-H X-ray astronomy mission, while Japan is still recovering from the devastating earthquake and tsunami of 2011. A possible outcome is a shift of the schedule for the mission. NASA is building the engineering models with the mirrors and shipping them to Japan. Astro-H passed the mission Critical Design Review (CDR) in February 2012 in Japan.

At the time of the meeting, NuSTAR was scheduled to launch on March 21. NASA has shipped it successfully. However, there were some anomalies that needed to be worked out in the areas of flight simulation, avionics, and the Pegasus launch vehicle fairing ejection system. The fairing ejection system was the biggest issue. There were two successive failures with ejection systems developed by Orbital Sciences Corporation. NASA was incorporating lessons learned from those Taurus XL failures. There were some discrepancies sith the avionics software through the testing procedures, and further testing was being watched closely. Dr. Hertz explained that if NuSTAR could not launch before March 24, NASA would have to wait 2 months for another launch opportunity at the Kwajelein launch site, and pay the costs of extending the development and launch team. Therefore, a March launch date was desirable to stay in budget, as well as for the initiation of science.

SOFIA completed its Segment 2 development phase in December 2011. This phase included 45 early science and telescope characterization flights; these observations have resulted in over 30 science papers that are to be published in peer-reviewed journals (Astrophysics Journals and Astronomy & Astrophysics). SOFIA's Segment 3 downtime is currently underway; major upgrades to the observatory avionics and mission control system are being conducted. These software and technology upgrades will lead to compliance with the current air traffic control system so that it can fly to commercial airports around the world. Upgrades aimed at stabilizing and improving the telescope in order to attain the desired performance are also being pursued. Every time NASA conducts maintenance on SOFIA, it also upgrades the observatory's capabilities for science. It is important to demonstrate that NASA can attain the telescope image quality that was stated as a goal in the Announcement of Opportunity (AO).

The selection of second-generation instruments will take place no later than April 2012 and will be the first selection with Dr. Grunsfeld leading SMD. The funds available are capped, so a balance between one expensive instrument (or upgrade to an existing instrument) or multiple inexpensive instruments must be reached. In answer to a question about SOFIA's science compared to that of the Herschel Space Observatory, Dr. Hertz deferred to Dr. Chris Davis, who explained that SOFIA complements Herschel and Spitzer. It is more flexible, is well suited to targets of opportunity and repeat observations, and is expected to find niche areas at mid-infrared and submm wavelengths. Herschel typically observers at longer wavelengths and has poorer spatial resolution than SOFIA, which has a long projected lifetime and can carry large, complex instruments offering multiple modes.

Dr. Hertz next discussed the Gravity and Extreme Magnetism Small Explorer (GEMS), which is an Explorer mission in Phase B. GEMS recently demonstrated Technology Readiness Level (TRL) 6 for the instrument. The project recently realized that GEMS would not meet its cost cap and asked for permission to proceed with the higher cost. That permission was received and, if GEMS is confirmed, the cost will be higher than planned. The mission had already descoped from three telescopes down to two. There were additional items found to be more expensive in the design integration. The prime mission lifetime is still 9 months. The team is now working on the detector lifetime, demonstrating its limits as a requirement for confirmation. It looks promising.

The Kepler mission, in its twelfth quarter, has had many accomplishments and recently released data from the fourth, fifth, and sixth quarters. There was an exciting science conference at NASA Ames in December 2011. Among the more prominent scientific accomplishments was the discovery of the first planet in the habitable zone of a Sun-like star. Kepler also discovered some Earth-sized planets, though they orbit their stars too closely to be habitable. Kepler has also confirmed that planetary systems of binary stars are common. To date, Kepler has confirmed 11 multi-planet systems hosting 26 confirmed planets.

The balloon program was reactivated after an incident in Australia that caused the program to revise its safety standards. The Stratospheric Terahertz Observatory (STO) was launched from Antarctica in January 2012 and met the minimum science requirements.

Potential missions

Regarding the ongoing X-ray and Gravitational Wave (GW) mission and instrument concept studies, APD is looking at how to accomplish the science of the large missions laid out by the Decadal Survey (DS), i.e. IXO and LISA, with a much smaller budget than anticipated in the DS. The Division put out a Request for Information (RFI) to the community and solicited a Community Science Team (CST) to advise on this issue. The team is identifying notional mission concepts for which APD will do some design work in order to see how they might fall in the budget. The goal is to come up with possible scenarios that realize as much of the IXO and LISA science goals as possible at significantly lower cost. After NASA presents the findings to the National Research Council (NRC) Committee on Astronomy and Astrophysics (CAA), the CST will be disbanded. There have been 29 responses in the X-ray area and 17 responses for GW. The X-ray CST has selected three notional mission concepts for further study: a calorimeter mission, a gratings mission, and a wide-field imaging mission. Similarly, the GW CST is looking at three possible mission concepts to realize some of the LISA science.

The European Space Agency (ESA) is moving ahead with the L-1 competition in its Cosmic Vision program, looking at three possible missions: the Advanced Telescope for High Energy Astrophysics (ATHENA), the New Gravitational Wave Observatory (NGO), and the Jupiter Icy Moons Explorer (JUICE). The down-selection is scheduled for April. NASA must determine how and whether to partner with ESA, both a science and a financial issue. In the medium-class mission category (M1 and M2), ESA down-selected Euclid and the Solar Orbiter. To receive community feedback on whether to partner with ESA on Euclid, NASA asked the NRC to set up a panel of experts. The panel convened in Washington, DC, in early January 2012 and reviewed presentations on Euclid, WFIRST, and the Decadal Survey report. The panel concluded that NASA participation in the Euclid mission would support DS priorities on Dark Energy science. The panel recommended NASA provides the NIR detectors in exchange for a US PI to become a member of the Euclid Science Team, and his/her team to be part of the Euclid Consortium with full access to the data. A draft report with the panel findings and recommendations was issued on February 3. On February 13, NASA sent a letter to ESA stating that the Agency would partner with ESA, providing Near Infrared (NIR) detectors. ESA responded positively, and therefore the approval process is moving forward with both NASA and ESA.

An internal cost estimate to determine NASA's likely contribution comes to $40-60 million. That includes both the total partnership cost of the science team and the hardware, estimated at $20-30 million each. ESA is spending $1 billion, and NASA's contribution will come to about 10 percent of the payload. Dr. Sara Heap observed that NASA's contribution to the Herschel mission is 6 percent, but U.S. scientists have about half of the usage. In response to a question about NASA aligning technology with ESA future selections in order to contribute, Dr. Hertz explained that NASA is conducting studies to see how to advance International X-ray Observatory (IXO) or Laser Interferometer Space Antenna (LISA) science on a smaller budget. If ESA selects NGO or ATHENA in its L1 downselection process, NASA will then face questions about whether and how to partner. However, at this point there is no budget for the L1 partnership.

Budget

Dr. Hertz showed a schematic of the FY12 budget, which totals $643.5 million. This total does not include SMD budgets assigned to the APD budget line. The FY13 SMD budget strategy is to continue to provide the most productive Earth and space science programs for the available resources. This will be guided by national priorities and informed by DS recommendations. SMD will continue to manage national investments in robotic space

missions, plan and conduct a Mars program in conjunction with other NASA organizations, and adequately budget for launch services.

The President's FY13 budget does not include funds for new large missions. NASA currently lacks credibility with its stakeholders on managing large missions on budget, and must prove the Agency can keep on budget with the James Webb Space Telescope (JWST) in order to receive new starts for future missions. NASA must successfully execute JWST within cost and have success in order to re-establish the Agency's credibility for conducting large missions.

Dr. Hertz presented the President's proposed SMD budget through FY17, cautioning that the FY14-17 projected budgets are notional. The overall APD budget stays flat, with slight growth after FY13. The major change is that many program lines remain flat, whereas there had been growth. Much of the budget reflects ongoing project dollars more than anything else. Hubble is still in its prime, and Fermi is going from prime to extended mission, so its funds are held for the senior review. This is one of the main factors accounting for the reduction over time of the PCOS program funds, while the COR and Exoplanet programs budget lines stay flat or increase. The DS priorities drive much of the budget, though SMD has some flexibility. After WFIRST, supporting Explorer is APD's highest priority according to DS recommendations. Since there is no budget for a launch of WFIRST before JWST in the President's budget, the Division will be investing in the Explorer program.

A graph of SMD actual and planned launches from 2011 through 2020 indicates a fairly even distribution for APD through 2019. Astro-H and GEMS have been rephased to accommodate programmatic changes. As noted, NASA is pursuing a partnership with ESA on Euclid. Growth in out-year budgets has been removed, and the budget does not support large technology development programs. Balloons and Research and Analysis (R&A) have been held flat. The Explorer budget has been delayed by 1 year. This implies that the downselection of the Explorer mission and Explorer Mission of Opportunity will be finalized in spring 2013, for a launch in 2017-2018.

A number of programs remain unchanged. These include SOFIA, which continues development and early science flights; Hubble, Chandra, and other operating missions, subject to the senior review; and the Keck Interferometer operations, which will cease in 2012 according to plan.

Dr. Hertz showed a slide demonstrating the APD budget trends, with and without JWST, from 2004 projected through 2018. The apparent surge in funds in 2004 was related to the switch to Full Cost Accounting that brought in civil service labor costs. The budget curve with JWST shows an increase for APD of $200 millions for FY13, which is substantial. The curve without JWST is flat. To place the development of JWST into perspective, Dr. Hertz presented a historical chart going back to all the large missions developed since 1978 to the present; the graph shows that APD develops only one large mission at a time, aside from the anomaly of Compton in the early 1980s. He noted that it is within the historical pattern to hold off the start of the next large mission until the current one is launched or near launch, and that the present situation with JWST is consistent with the historical pattern. The difference is that JWST is taking longer because it is more expensive than any previous large missions. Another chart showed that there has been no change overall in the fraction of the APD budget spent on large missions, and that this fraction historically amounts to 60-70%

Also plotted on the budget diagram chart were the requested funds for the outyears with and without JWST. The diagram shows that, while the requested funds for the portion of the budget without JWST have been reduced by $100M in FY13 and beyond relative to the notional planning budget included in the runout of the President's FY12 budget request, the budget including the JWST funding has increased significantly. To the stakeholders and outside community, which see the total (APD+JWST) portion of the budget as representing NASA astrophysics, it appears that Astrophysics as a whole has received a significant boost in funding for FY13, above what was actually projected a year ago.

Regarding Explorer options, the FY13 budget request does not support an AO for both missions and missions of opportunity (MO) in late 2012. The first priority for the Explorer Program is to complete the Explorer missions currently in development. These include NuSTAR, Astro-H, and GEMS. The second priority is to downselect and fund the development of one mission and one MO from the projects currently in Phase A studies. The next priority is to solicit and select new projects through an AO and fund them for development. This process involves determining a budget cap, looking for a point where Phase B and a reasonable profile can be accommodated within the future mission budget wedge, and backing up 2 years from the Phase B start for a two-step AO release date, which is reasonable based on how long it really takes. The DS stated as second highest priority in the large mission category for APD to augment the Explorer program to achieve eight missions over a decade. The President's budget request supports that with increases for Explorer, from $40 million to $100 million by 2015.

Because MOs cost less, APD can do an AO for one in fall of 2012 in the range of $50-60 million. Dr. Hertz discussed the benefits of maintaining the option of selecting a larger-cost MO versus two smaller-cost ones, which should be dictated by the relative science returns. This strategy will allow APD to issue an AO for a Small Explorer (SMEX) and a MO in late 2013 or early 2014, with the cost caps and actual dates to be determined by the summer of 2012.

Dr. Hertz was uncertain on the future of the medium-class Explorers (MIDEX), besides an anticipated 6 to 12-month delay due to limited funding. It is important not to waste the time of Principal Investigators (PIs) in writing proposals when there is no funding. The hope is that there will be more choices for launch vehicles by 2016. There are companies aiming to deliver Delta-2 capabilities at affordable prices. Development of commercial capabilities is an Agency-wide priority for delivery of cargo to the International Space Station. The last MIDEX AO, without the launch vehicle, was within 10 percent of the cost cap for the Explorer 2011 AO. NASA could do fewer, bigger Explorer missions or more SMEXes. The DS recommended alternating them, but APS can recommend otherwise based on programmatic issues.

The intent is to issue an announcement sooner rather than later for the fall AO parameters, so that PIs can plan their proposals in advance. The announcement will list the key decisional gates and will likely be issued in the summer. APD will be able to plan funding for the mission and announce that range, so that PIs can size their concepts accordingly.

WFIRST

In 2011, with the delivery of the Interim Design Reference Mission, the WFIRST Science Definition Team (SDT) has shown that a mission fully compliant with the DS recommendations can be achieved at a cost of $1.6 billion. The SDT was given updated guidance in December 2011 for its 2012 activities.. The SDT was given two tasks, one to complete the DRM for a mission fully compliant with the DS recommendations, and the second to produce a DRM for WFIRST that does not duplicate capabilities with Euclid, LSST, and JWST. The final report will be issued in June. The rationale for the SDT tasks is that should a wedge in the budget open for large missions before the end of the decade, NASA will be ready to move forward with WFIRST.

The President's budget does not currently include funds for WFIRST, and it is unlikely that APD will receive permission to begin a new large mission until JWST is launched. It might be possible to start planning close to the JWST launch, but the Division does not know if it will get that budget wedge back. WFIRST will not launch in this decade, and will take 5 to 7 years to build once funding becomes available. Dr. Hertz cited the December 2011 NRC report (the Burrows-Kennel report) that stated that a launch of WFIRST beyond 2022 invalidates one of the rationales for making WFIRST the top priority in the Decadal Survey. In the meantime, APD is partnering with ESA on Euclid. NASA's contribution of detectors to Euclid is good experience for some of the WFIRST work. The Agency is keeping the WFIRST technology requirements in mind as part of the overall technology plan.

Question and Answer Session with Acting Division Director

It was pointed out that even without the WFIRST technology funding, the APD budget includes some funds for wide-field imaging and spectroscopy development. Dr. Hertz agreed, noting that it is included in the narrative on Strategic Astrophysics Technology. Regarding the Burrows-Kennel report, Dr. Steve Ritz added that the issue was about staying consistent with the DS, which stated that if WFIRST were to launch later, it would roll into the time period covered by the next DS.

Dr. Heap observed that two events occurred since the DS was issued: the budget situation has changed, and the Kepler mission has been producing results. She wondered if the exoplanet component is still as imperative for WFIRST. Dr. Hertz said that the NRC will be standing up the CAA soon, which will weigh in on these very issues. The co-chairs will be David Spergel and Paul Schechter. NASA will be able to go to CAA to describe how the Agency has been responding to the Committee's recommendations, and CAA can advise on whether NASA is making good decisions within the constraints. NASA will also request a mid-decade review of the DS, as required by law. This review will probably be issued in 2015. Dr. Hertz expects the reviewers to contemplate questions like Dr. Heap's. NASA will not rewrite the DS and will take advantage of the opportunities the Agency has. However, the mid-decade review could comment on the Agency's emphasis, based on progress in developing technology and science priorities. NASA will receive that feedback on whether the Agency is making the right decision or whether there should be changes.

Dr. James Kasting asked about the status of the exoplanet exploration RFI, given that several programs have asked to study Probe-class missions. Dr. Hertz replied that APD had two pending RFIs that are now on hold until the replanning is complete, following the reduction in proposed out year resources. As for probes, NASA will look for science payoffs and good opportunities for science. It will be easier to do probes after JWST is launched. He would like the mid-decade review of the DS to address NASA's investment in probes.

Dr. Paul Ray asked if the mid-decade review will reorder or add priorities, given the new financial landscape. Dr. Hertz answered that NASA can ask the CAA to advise on specific questions, and NRC will modify CAA membership to meet NASA's needs. Historically, these mid-decade reviews have not reordered priorities. However, everyone is aware of the constraints on implementing the DS and the need to accommodate the new budget environment. There is no interest in rewriting the DS at the 5-year point, however.

Dr. Ray then asked if there is any rationale for starting a project other than WFIRST once the budget wedge reopens. Dr. Hertz responded that the DS is the touchstone for making decisions. NASA must nonetheless ask the CAA if there is a better way of moving forward given the new financial constraints. NASA can tell the CAA that it is not possible to implement the DS recommendations as proposed and get feedback on proposed alternatives. Implementing DS priorities with a much lower level of funding than anticipated by the DS requires further guidance by the community. The DS stated that in a constrained budget environment, NASA was to develop, launch, and operate WFRST, then implement the Explorer program and core research program augmentations. The emphasis was on implementation during a 10-year period.

Dr. Chris Martin asked whether any other programs were in danger of being cut. Dr. Hertz replied that there were no other deep cuts to be made. Of the remaining $800 million funding wedge through 2021, most will go into growing the Explorer program to reach a launch rate close to recommended, with additional investments in R&A and technology. Funds will also include operating missions as recommended by the Senior Review. Because the next Senior Review was so close to the time of the APS meeting, Dr. Hertz did not want to speculate about its outcome. He wanted the Senior Review to assess every mission's science output relative to its budget, and noted that the reviewers will not be given budget information. He did anticipate that APD would be able to respond quickly regarding implementation of the ensuing recommendations.

Going forward, he hopes to see funding of NASA participation in Euclid and GEMS, a response to the senior review, and one-year hiatus of the TDEM Strategic Astrophysics Technology (SAT) call from the Research Opportunities in Space and Earth Sciences (ROSES) 2011. He plans to work with program offices to develop a rebalanced plan, including technology development, postdoc fellowships, and mission concept planning. Priorities include technology development that may have both near-term value and lead to advancing DS priorities. He will work with the advisory structure to prioritize the opportunities and will receive the NRC mid-decade review comments. He also plans to enable some science through smaller opportunities before a large mission would be possible.

Dr. Hertz said that the key message for the community should be that, overall, the President's budget request for Astrophysics has increased. The Nation has given space-based Astrophysics significant resources, and he looks forward to receiving APS help for optimal investments of the allocated funds within APD.

JWST Update

Dr. Eric Smith, JWST Deputy Program Director, presented an update on the project. The Program set a new baseline and completed its replan in September 2011, so that it is now consistent with the recommendations of the independent comprehensive review panel. The President's budget request for FY13 fully funds JWST. The primary mirror backplane is on critical path and has been accelerated; it is near completion. The five-layer sunshield template is now in testing, which is difficult technically. Instrument deliveries are to begin in the spring. Additional funds carried over from the two prior fiscal years helped to accelerate some items on the critical path. The primary mirror wings moved up 18 months, the Backplane Support Frame (BSF) moved up by 4 months, and the end of Flight Optics Integration accelerated by 4 months. Instrument deliveries have slipped, however, so the overall 31 months of slack in their schedule is now 26 months. The NIR detectors failed, which means new ones are necessary, but there are still 11 months of slack in the ISIM need date for I&T with the telescope even after including these new detectors..

NASA had development costs change in the replan. Dr. Smith showed the master schedule, which included all of the above information with additional detail. The Program is now completing testing of a new detector manufacturing process. The short-wave detectors (2.4 micron cutoff) have been tested, and the mid-wave detectors (5 micron cutoff) are being tested for noise, efficiency, and other features. Once those tests are done, the Program will rapidly go into procurement mode. The Canadian Space Agency's fine guidance sensor is progressing, and the aft optics system is ready to test. With the instruments coming in, the project team will integrate and test the Integrated Science Instrument Module (ISIM).

Dr. Smith discussed the major milestones for JWST in FY12. So far, performance is doing well, and everything has been completed on or ahead of schedule. But there are things that will slip against the original milestones. The Cryo-Cooler cold head assembly will not meet its delivery milestone. The Near InfraRed Spectrograph (NIRSpec) flight bench has cracks and must be replaced, though the spare has been examined and found to be suitable. The cause of the cracks was workmanship at the bolt holes, and resulted in part because the bolts were over-torqued. The Mid-InfraRed Instrument (MIRI) flight instrument has gone through thermal vac testing, but a vibration test must be repeated, making the instrument about 2 weeks late. Dr. Smith showed a pie chart illustrating the amount of work left to be done in each major area prior to launch. Depending on the piece, the range is 21 to 85 percent. The big pieces are the sunshield and spacecraft (60 percent left to go), and the ground system (76 percent).

Dr. Ritz asked why the spacecraft CDR is scheduled for the winter of 2014 and not sooner. He thought it was an enormous risk to wait so long. Dr. Smith said that the spacecraft is not yet ready. The program had so much technology development up front that the project does not have the standard funding profile. Dr. Boss asked if the project is moving ahead at full speed despite all the ups and downs. Dr. Smith explained that there have been

challenges in getting funds to people on time. For example, there were funding issues at the Johnson Space Center since the money came from a different funding line. However, this has not resulted in JWST slowing down. There is also a phased reserve, some allocated for each year, coming to about 22-27 percent of the budget in a given year. In FY12, the project has through about half of its reserve. In addition, Northrup Grumman has a 10 percent reserve. In FY14 and beyond, there are additional unallocated future expenses (UFE or sometimes called reserves) set aside at NASA Headquarters, which would require a request from the project and directorate program management council approval to access. The UFE situation is why presentations on JWST do not include total dollars on the pie chart showing the relative sizes of the budgets for various mission components.

Extended Discussion

With some time available before moving onto the next item on the agenda, Dr. Boss proposed reviewing Slide 50 from Dr. Hertz's presentation, in which the DS recommendations are listed alongside recommended funding and NASA's plans for responding. The idea was to go through the chart line by line, giving each project a grade.

Dr. Boss led the discussion, item by item. The first priority program was WFIRST, which the DS recommended at a funding level of $1.6 billion. Since there is no budget line for WFIRST, it received an "X" indicating that the project is not meeting DS expectations. Next on the list of large programs was Explorer Augmentation, recommended by the DS at $463 million for 10 years. The APD plans an augmentation of $20M/yr in FY14 increasing to $70 million in FY16. It received a "check" for meeting DS expectations. Dr. Ritz observed that APD is being very responsive to the DS.

Next was LISA Technology with a recommended funding of $852 million for the 10 years. The program currently has $3.4 million in FY12. In FY13 and beyond, NASA plans to support LISA technology through PCOS SAT funding. Dr. Hertz noted that the funding is for supporting technology for Gravitational Waves, not for building the LISA mission, which has been canceled by ESA. The APS task is to evaluate that the correct priorities are being set under the constrained budget environment. Dr. Gabriela Gonzalez suggested that they consider how the technology will be done independently of ESA's level of participation. Dr. Boss gave LISA an X, with the caveat that it has received a small amount of funding.

IXO was next, with a similar situation to LISA. The DS recommended funding at a level of $200 million. The funding level in FY12 is $6 million for RFI studies, and starting in FY13 IXO technology will be supported through the PCOS SAT program. It received an X. In response to questions about why IXO is funded at a higher rate than LISA, when LISA preceded it on the DS priority list, Dr. Hertz explained that the investments were driven by strategic directed efforts that needed to be continued, and would be readjusted based on a SAT competition that has not yet occurred. The funding that went to IXO was through a competitive call. He would like to see what progress can be made for a smaller amount of money. That will be laid out to CAA for comment.

In the medium size category, New Worlds Technology had a funding recommendation of $100-200 million; it will be receiving $12M in FY15 increasing to $15M in FY17. It is currently receiving $9 million in FY12. . If the goal is to grow annual spending by $10-20 million per year, NASA will meet it by the end of the decade. Dr. Boss pointed out that the funding line includes fellows, along with directed and competed technologies and tools for exoplanets. The fellows run $3-4 million annually, and there is growth occurring in archival costs. Nevertheless, the planned funding in within the bottom end of the range by the end of the decade, so New World Technology received a check mark. Inflation Probe Technology had a target of $60-200 million. In FY12 it has an investment of $0.3M through the SAT program. The plan is to fund IP technology through the SAT and Apra in FY13 and beyond. The line in the chart received an X with a question mark, depending on the proposals success rate in later years.

The programs in the Small category were listed alphabetically, as they were not assigned a rank. The Astrophysics Theory Program had a DS funding recommendation of $35 million for 10 years, and the planned contribution is 10 percent. There was concern about the percentages distribution among the various programs. Dr. Hertz said that the current plan is to fund those programs that can move forward first, rather than spread funds evenly across the programs without further consideration. The ATP program received an X.

The definition of a future UV optical space capability is on track and received a check. The Intermediate Technology Development is included in other areas. Dr. Hertz asked that it not be called out separately, as there is no way to assess it. There is no distinct funding for it, but the project is included in three programs. It received a question mark. Lab Astrophysics is receiving somewhat more funding than the theory program. The APS members decided to revisit this program later in the year. The Space Infrared telescope for Cosmology and Astrophysics (SPICA) received a check, since it is a candidate for an Explorer mission and will be allowed to compete. However, there is currently no money for it.

The Suborbital Program was given an X mark, since the budget will be held flat. Theory and Computation , shared with the National Science Foundation (NSF) and Department of Energy (DOE), will be given $1.3M per year, subject to review after 3 years. It is believed that DOE is not participating. It received an X. The final project was Additional Core Program Augmentation. There was discussion about how the decisions were made to fund some programs and not others that the DS recommended. Dr. Hertz said that the funding reflects community recommendations, as well as areas of proposal-driven R&A. This is part of a long-term plan to grow other areas that APD can no longer plan on.

WFIRST SDT Update

Dr. James Green, of the University of Colorado and co-chair of the SDT, presented a snapshot of the Team's work. The SDT concluded its activities in 2011 by delivering to NASA the Interim Design Reference Mission (IDRM) report in July 2011. The team assumed that the Joint Dark Energy Mission (JDEM) omega was the baseline, and restricted the discussion to ready-to-fly technology only, with the idea that WFIRST would launch by 2021. For 2012 the SDT has been tasked by NASA with two main acitivites: completing the IDRM identifying a stand-alone WFIRST mission at the lowest cost point, and developing a new DRM for a mission that does not duplicate the capabilities of Euclid, the Large Synoptic Survey Telescope (LSST), and JWST.

Dr. Green described the off-axis design assumed for the IDRM. The telescope would have the same collecting area, more stability, and higher science yield than an on-axis design as originally assumed for JDEM, but its optics would be more complicated. The Focal Plane Array instruments will include two spectroscopy channels and an imaging. He provided the basic outline of this design. The science driver is the amount of sky that can be sampled, and there is substantial debate about shallow survey versus depth of survey. The figures of merit depend on the strategy and the number of galaxies expected to be seen. The SDT identified as an option a DRM with a single channel operating at a time, either spectroscopy or imaging, reducing cost while still allowing for flexibility, and high scientific yield. This option proves to be a winning strategy for microlensing, because of the larger covered fraction of the sky, while the loss of simultaneity between the spectroscopic and imaging channels somewhat penalizes the Baryon Acoustic Oscillation (BAO) technique. With the advent of Euclid and LSST before a WFIRST mission, the single channel design will provide flexibility to adapt to the new science constraints they will have provided. This is still a matter of debate, however. WFIRST might also employ H4RG detectors allowing larger sky coverage, though it is not yet clear whether that would save money.

In summary, the single channel advantages are increased field, flexibility, decreased complexity and, possibly, lower cost. The disadvantages are loss of simultaneity, prisms that harder to design, and an additional mechanism. The result would be 8 percent more science in 8 percent less time. However, the H4RG technology is not mature enough yet for launch.

As part of future studies, the SDT plans to examine SNIa spectroscopy through an integrated field unit rather than a prism. The advantages are higher quality spectra in less time and reduced system level requirements. There are, however, the added expenses of building and integrating the unit. Despite some disagreement, most on SDT believe it presents a net scientific benefit. Another trade study is the extension of bandpass cutoff from 2.0 mu to 2.5 mu. This makes infrared devices easier to procure and differentiates WFIRST from Euclid by allowing it to reach higher-redshift sources, but the thermal design will have to be re-evalkuated to provide colder mirrors.

The SDT is now forming a subcommittee to act on the second task – developing a DRM that does not duplicate existing capabilities. Possible capabilities to drop include BAO, weak lensing, or both. The SN study and the IR and GO programs would stay as unique WFIRST features. Dropping BAO eliminates the need for prisms and filter wheels. However, the single channel design brings in one or two prisms, which is a minimal difference in hardware costs. The BAO performance requirements do not drive the system, and dropping BAO does not save much. If weak lensing were to be left out of WFIRST, the mission would still need a large array, although the costs could be lower. Dropping both BAO and weak lensing capabilities while keeping the supernovae technique only for dark energy science would still involve the NIR array. This does not radically transform the nature of the mission or eliminate the fundamental requirement of a large array of IR instruments. The least capable mission would still exceed $1 billion. If all capabilities are kept, Euclid and WFIRST will not produce the same level of data product. Euclid will have greater potential for error and less breadth. The bottom line is that they are not duplicative.

The baseline is to keep all techniques for dark energy. The larger cost will be to launch the mission into an L2 orbit. There is no funding for WFIRST in the President's budget for the next 5 years, and the project will slip further with any JWST slips. However, modest investments now for detector development and science simulations will pay enormous dividends later, enabling a more rapid schedule development. It is crucial to understand the best way to do the weak lensing, and improving on the studies conducted so far. There is much more study to be done before making commitments to certain technologies.

Dr. Boss asked if Euclid could be quantitatively compelling. Dr. Green replied that the dark energy figures of merit improve as survey depth increases, until they reach a systematic limit. There is no community-wide agreement on what is the appropriate level of systematic errors to include in the figure of merit calculations. If the systematics are well controlled, the Euclid surveys will yield compelling science on their own. If the systematics are larger than assumed, the scientific quality of the surveys will be diminished, possibly to a level that is not compelling. The lack of agreement on the level of systematic errors that will remain after corrections are applied means there is not a uniform opinion on whether the data produced by Euclid will be sufficiently compelling to address the fundamental questions on dark energy.

Impact of Balloons Return to Flight

David Pierce, Senior Program Executive for the Suborbital Program discussed the corrective action plan and further progress in NASA balloon operations. The Suborbital Program implements safety and Mission Assurance functions separately for Suborbital (Balloon) missions. The Program accepts 85 percent mission success, but safety is implemented to the fullest extent of agency policies.

In April 2010, while conducting a balloon launch in Australia the Launch crew failed to activate the payload release system (launch head). In trying to catch up with the balloon, the crew drove out of the hazard area to the fence at the perimeter of the airport, in very close proximity to the public gathered to watch the launch. While trying to abort the launch, the restraint cables broke, releasing the payload, which subsequently hit 2 cars and came close to injuring the spectators.

A Mishap Investigation Board (MIB) was established by the GSFC Center Director. The Program stood down for 7 months, while working with CSBF to develop a comprehensive Corrective Action Plan to address each recommendation by the MIB and conducting a return-to-flight review for each campaign site. The Program completed this work in time to conduct the Antarctica Campaign in late 2010. The intent was to solve the identified problems without adding unnecessarily onerous restrictions.

The Corrective Action Plan included five principle elements: 1. Revise the flight safety program and institute hazard zones; 2. Assign to each launch an independent Range Safety Officer with unquestioned authority to stop a mission; 3: Complete Interim Response Team (IRT), hazardous systems certifications, procedural training for each balloon mission, and conduct tabletop simulations; 4. Use an improved launch release mechanism designed by the Columbia Scientific Balloon Facility (CSBF) and verified by NASA; and, 5. Conduct flight readiness reviews and authority-to-proceed reviews prior to approving launches.

Mr. Pierce discussed in considerable detail the corrective actions and lessons learned. Prior to launch, science teams must now complete lifting certification training. NASA also now requires procedures for hazardous operations and safety supervision. Science teams must submit hazardous procedures for review. NASA or CSBF ground safety support pre-launch and flight line operations. In the launch phase, science teams use personal protective equipment, and they are involved in payload preparations and go/no-go decisions until launch. Teams working with ground safety have access inside the launch hazard areas during launch, but hey are not allowed on the launch pad itself during launch. Teams submit payload recovery plans, but access to the payload is restricted in case of a mishap.

Mr. Pierce listed the steps in the safety process toward launch, and the hazardous procedures. He also showed a photograph of a launch area with the operations perimeter and pre-launch danger area superimposed. A launch limit area restricts launch vehicle operations; any vehicle that goes beyond that boundary triggers an abort. Wind speed and direction are factored in, to ensure safety of the public.

In the year since returning to flight, the Balloon Program has completed 17 launches, 3 above the decadal average. Two were launched on the same morning. Science teams have been supportive of the new procedures despite concerns about losing launch opportunities. PI's responding to a survey liked the safety training, and they thought the pre-briefings about launch operations and table-top simulations were useful. Their biggest issue was time away from payload preparation while completing required training and much less independence in processing their payload, even with the new certification training. There is some concern about multiple teams having to share a single safety officer, which has led to training of CSBF crew as safety officers. Access by science teams in and around the launch pad during a launch was also a concern. They understand the rationale for the changes, and they hope to help CSBF refine the process.

R&A Update

Dr. Linda Sparke, APD Research Program Manager, presented an update on that program. She began by listing funding for research awards from FY04 through FY12, which increased by about 10 percent from FY11 to FY12. Dr. Sparke next reviewed the success rates for ROSES 2009-2011. So far, the FY12 success rate is lower than that of FY11, despite more funding. In several areas, there were more proposals and therefore proposal pressure on the budget. In FY12, no area has yet funded over 25 percent of the proposals submitted.

Compared to actual expenditures in FY11, the expectation is that the research award totals in FY12 and FY13 will remain higher, but will not increase significantly from FY14 onward. For FY 12, the Research Program anticipates spending $1 million more on suborbital payloads than in FY11, and almost as much more on lab astrophysics. The increased funding for suborbital payloads follows a Decadal Survey recommendation.

For a joint NASA-NSF initiative in Theory and Computation Networks (TCNs), NSF-AST and APD considered having a workshop organized by the Astronomy and Astrophysics Advisory Committee (AAAC), with a written report to follow. The purpose was to consider what constitutes a network, identify any requirement for multi-disciplinary activities, determine whether proposals should be restricted to addressing certain key questions, and identify the needs for a TCN program in terms of the balance between theory and computation and for workforce initiatives. In December 2011, AAAC agreed instead to talk to community members and report on what could be done for $2 million per year. The Committee has not yet drafted a report, and it may request community comment via email.

Dr. Vicki Kalogera said that she understood the point about the increasing the number of proposals, but pointed out that the Origins and Theory areas had the lowest success rates in FY12, just as in prior years. A reasonable argument could be made that the funding should reflect the Decadal Survey recommendations. Dr. Sparke agreed. However, she did not think that APD should select at the same rate across programs; a higher selection rate may reflect a programmatic need for more investigations in that area. While the Origins of the Solar System is a small area, she would like to see more funding go to that.

Update on X-Ray RFI Study

Dr. Andrew Ptak of GSFC presented on behalf of Dr. Rob Petre, discussing the PCOS x-ray concepts study status. In the 1990s, a large astronomy mission called Constellation-X (Con-X) was proposed as the strategic x-ray observatory for the next decade. In 2008 Con-X merged with ESA's XEUS to become the International X-ray Observatory (IXO). Since IXO was not given top priority by the 2010 US Decadal survey for astronomy, ESA terminated IXO and formulated Athena as an ESA-only option. NASA also terminated the IXO program, but asked for a study to determine what IXO science could be achieved at lower cost, along with new ideas that would fully engage the community, and ensure that all voices were heard. NASA is not revisiting IXO, but the Agency is looking at science priorities and notional missions. It is also not certain whether ESA will actually implement Athena. The original IXO science was exciting – it was to look at the cosmic dawn, young stars, and the physics of the universe. There were many sub-elements, such as direct detection of gas flow. The RFI brought in 29 responses. Of these, 16 were mission concepts and 13 were enabling technologies. The latter addressed a wide range of technologies, all posted on the PCOS website at http://pcos.gsfc.nasa.gov. Science and technology teams analyzed the 29 responses and conducted a workshop where all of those who wrote RFIs could present their concepts for feedback.

NASA formed a Community Science Team (CST) who developed three mission concepts. The design labs of Goddard are building virtual versions of the concepts. There was also a Mission 0, which was formulated immediately after IXO was terminated, the Advanced X-ray Spectroscopic Imaging Observatory (AXSIO), to cost under $2 billion. Mission 1 is a gratings-only misison, aiming to be less than $600 million; Mission 2 is a calorimeter-only mission, aiming to be less than $1 billion; and Mission 3 was for wide field imaging only, also aiming for less than $1 billion. All three would be configured for an L2 orbit, which maximizes observing efficiency. Mission 2 is the most desirable if ESA does not select ATHENA.

Mission 1, gratings only, was inspired by two other designs and represents an effort to merge the two gratings design concepts. The key science includes large-scale structure, matter under extreme conditions, and the lifecycles of stars and protostars. For Mission 2, the calorimeter, the key novel feature over previous calorimeter designs is a point source array, which allows for observation of very bright sources. Each calorimeter pixel is a spectrometer. This covers most of the IXO science except with lower effective area. The wide-field imager, Mission 3, is an alternative for the calorimeter mission if the latter cannot be done for less than $1 billion. Mission 3 must itself cost less than $1 billion, however. The study team is considering two mirror designs for Mission 3, one with three identical mirrors and the single AXSIO mirror. The key science includes black hole evolution, high-redshift obscured Active Galactic Nuclei (AGN), and large-scale structure clusters of galaxies.

Design labs have begun, and there has been an instrument design lab for the calorimeter. The study team is planning three traditional mission design lab runs, with alternatives to reduce costs. The project may need mission design lab time to assess the costs of adding instruments to single-instrument designs. A week of deltas has been reserved, which will have the same people study cost-saving changes to the original designs. They will look at adding more instruments so that a medium or large-class mission does not involve only one detector. AXSIO will be the baseline for cost assessment. In assessing science per dollar, the costing personnel are very meticulous, and costs are usually estimated on the high side.

Dr. Heap observed that the project looked like a bigger and better CHANDRA plus the X-Ray Multi-Mirror Mission (XMM), in that it seems like they have the same targets and questions. She asked Dr. Ptak to describe the compelling science that cannot be done elsewhere. It struck her that the team was to judge among many different versions to determine the most important questions. Dr. Ptak said that the compelling science had to do with imaging spectroscopy to measure the velocities of hot gas in clusters of galaxies and supernovae, which requires high spectral resolution. Likewise the detailed study of accretion onto black holes tests general relativity and also requires high spatial resolution. Ann Hornschemeier the chief scientist of PCOS at NASA added that the study team is not supposed to re-evaluate DS priorities. IXO science was an important priority. Black holes and their variability on short time scales are priorities that go beyond the capabilities of Chandra and XMM. The team started with a description of IXO, which calls out high-resolution x-ray spectroscopy and imaging spectroscopy.

Dr. Terry Oswalt asked for clarification on who determines the costs of the concepts submitted in the RFIs. Dr. Ptak explained that the study team cost estimates are based on experience with current designs and are essentially educated guesses, with the exception of AXSIO, which was costed by an MDL run last year. The first round of costing found that the gratings option was the least costly of those under consideration. The likelihood is that costs will ultimately come out higher. The three notional missions are have not had MDL runs yet which will provide costs. While adding a second instrument to a $1 billion mission would likely send that mission over $1 billion, it might be possible to keep the increments low. The cost numbers are being generated with input from community science and engineering teams seeking science cases with financial plausibility.

Update on GW RFI Study

Dr. Robin Stebbins began his presentation by explaining that the goals of the study were similar to the goals of the X-ray study presented by Dr. Ptak. The GW study looked at the science from LISA rather than IXO. A public workshop was held in late December 2011 with RFI respondents and the 10 members of the CST. The Core Team and CST are now working with Team-X at JPL to cost the mission concepts.

Both ESA and NASA have put substantial funding into the LISA Pathfinder, which will launch in 2014 and demonstrate GW technology in space. New Gravitational wave Observatory (NGO) is one of the three missions proposed to ESA in the L-class,; the donwnselection process will be finalized in late April, before the end of the CST study. The GW study is based on the premise of a stand-alone, US-led mission. NASA received 17 responses to the RFI, which fell into four groups: Non-drag-free concepts (2); Geocentric orbits (4); LISA-like (5); and Other (2). Dr. Stebbins explained that “LISA-like” incorporates drag-free control, continuous laser ranging, heliocentric orbits, million-kilometer arms, and laser frequency noise subtraction. As submitted, the RFIs offer a range of options. Some of the presented concepts are inaccurate and have other issues.

Dr. Stebbins presented details of the two non-drag-free concepts. The issues with these concepts include misunderstanding of the signal-to-noise ratio and inconsistent representation of noise sources. In addition, there is concern about the reliance on very long arms or geometry to reduce the effect of disturbances on the strain measurement, how solar disturbances affect the measurement, modeling of spurious forces, and displacement noise. The non-drag-free concepts require models and corrections that cannot be validated. Any of these could be fatal

flaws, coming to light late in the development process of the mission.

Of the four geocentric concepts, two were virtually identical to each other, one was cheaper than LISA, and the fourth incorporated several concepts previously presented by the Stanford team. The issues are largely technological, including radiation from the Sun on the telescope and an unfavorable thermal environment. The low cost concept trades on nanosat technology, lower reliability and a different business model.

Among the five LISA-like concepts, the primary issues were descoping to a point with marginal science return for the investment. Among the "other" concepts, one does not provide sufficient information for assessment, another does not save costs, a third doesn't work, and the fourth seems interesting but the cost savings is unknown.

The DS endorsed LISA because of its science promise. Looking at that science from other perspectives, the CST did calculations, came up with preliminary results and known problems, and looked at the horizon capability. Increasing or reducing sensitivity does not make much difference. The various detection rates eliminate some of the concepts altogether. Dr. Stebbins gave some examples of problems, such as those of the black hole horizons.

Four concepts are on the schedule for runs through the JPL lab. These include the LISA-like Space Gravitational-wave Observatory (SGO) Mid in early March; the no-drag-free LAGRANGE concept in late March; the OMEGA instrument in late March; and the OMEGA mission concept in early April. Cost credibility is the main issue with the OMEGA concept. This mission concept was proposed a long time ago and has only evolved slightly from its original design. The no-drag-free concepts are the most innovative ideas.

In answer to a question about development of the atom interferometry concept, Dr. Stebbins explained that the Core Team and the CST had concluded that laser frequency noise, the dominant noise source, wasn't included in the sensitivity curve. Further, insufficient information was given to replicate the claimed performance. Atom interferometry incorporates many innovative, precision measurement techniques, but to achieve the claimed sensitivity curve, the proposers would have to advance several critical parameters by orders of magnitude. Without a specific instrument design, the CST concluded that the atom interferometry concept could not be considered.

Summary of Day 1

Dr. Boss reviewed the highlights of the first day of the meeting. He identified the following items to include in the letter report:

1. The proposal regarding the balance of different sizes of missions for the Explorer program.
2. The priority WFIRST should have in the current environment, rephrased to have APS discuss whether to do some of the "small science" related to WFIRST or reinvest those dollars. Dr. Hertz observed that there is currently no technology development money for WFIRST, and it would be helpful to know whether near-term technology investments are useless unless NASA commits to WFIRST, or whether such technology can be applied more broadly. APD would find that to be useful feedback.
3. The decisions associated with the chart of DS priorities. Dr. Boss asked the Subcommittee members to think further on these priorities. The outstanding issue was whether some of the items not called for in the DS should still be supported and, if so, to what extent.

Dr. Ritz added that with the President's new budget supporting JWST, it would be appropriate to remark on that and express gratitude early in the report.

Dr. Boss adjourned the meeting for the day at 4:59 p.m.

February 24, 2012

Dr. Boss opened the meeting with a roll call of the people in the meeting room and on the telephone.

ExoPAG Activities Report

Dr. James Kasting presented an update on the Exoplanet Exploration Program Analysis Group (ExoPAG). The most recent meeting was in January at the American Astronomical Society (AAS) meeting, at which there were talks from two ongoing and one potential future Explorer class mission studies:

- TESS: transit survey of nearby stars, identifying potentially habitable planets for JWST to investigate;
- FINESSE: NIR spectra of transiting exoplanets;
- EXCEDE: Phase-Induced Amplitude Apodization (PIAA) coronagraph for direct imaging of circumstellar disks—technology development only.

The ExoPAG also had a 2-hour joint session with the Cosmic Origins Program Analysis Group (COPAG), ExoPAG has a number of Study Analysis Groups (SAG), the most active of which is Exozodi Dust. This group is about to release a report on the seriousness of exozodiacal dust in exoplanet direct imaging missions and how to quantify this interference from the ground. It has proven to be a contentious issue, however, because defining the "zodi" - the unit of dust absorption – has been controversial, with many factors involved. The other active group is addressing flagship mission requirements, specifically a direct imaging mission they would like to do eventually. The charge was to assemble the science requirements and objectives for a telescope. A report is forthcoming but will likely need to be adjusted for Kepler data on η_{Earth} – a parameter used to describe the frequency of rocky planets in the habitable zones of Sun-like stars.

Dr. Kasting and four others are cycling off of the steering committee, and Dr. Kasting sought APS approval of the proposed new steering committee members: Scott Gaudi, Dave Latham, Remi Soumer, Peter Plavchan, and Jonathan Fortney. All have agreed to serve and were selected to represent the expertise that is rotating off. The steering committee chair must be a member of APS. The proposed chair is Dr. Gaudi, who has been nominated for APS but not yet formally approved.

As this was his last meeting as a member of APS, Dr. Kasting provided his personal observations about where exoplanet scientists and astronomers are headed. First, it appears that the plan laid out in the DS is completely gone. WFIRST is zeroed out, and Dr. Kasting does not believe it is needed except for the microlensers. Second, the TPF technology development money is back to normal, meaning it is relatively low, though more funding could come in toward the end of the decade. With TPF unlikely to happen in next decade, it might not fly until 2040. The silver lining on that cloud is that there is ample time to do things properly. The short-term exoplanet strategy involves Probe-class missions. The Exoplanet Exploration program office is hoping to explore the possibility of these missions, although Dr. Kasting thought that might be ambitious. The long-term exoplanet strategy is to find and characterize rocky planets around nearby stars. For this, NASA must send up big, space-based telescopes, which is expensive and risky.

No one wants to think about what happens if JWST fails to deploy successfully. It took an initial reservicing mission by astronauts to pull Hubble out from being a failure, which speaks to a possible need to partnering with the human space program. Four subsequent reservicings extended the lifetime of Hubble to more than 20 years and allowed for all of the instruments to be replaced with newer ones, over time. Therefore, future flagship missions should design for possible maintenance by astronauts. JWST was designed without this maintenance possibility—an unavoidable decision, given the retirement of the Shuttle and a current lack in manned space flight capability to replace it. JWST will be in orbit at L2, which is more difficult for humans to reach than low Earth orbit, but not out of the realm of

possibility. There are creative ideas for doing this, including transferring the telescope to Earth-Moon L1 and doing the servicing there. NASA should have the capability of servicing future large space telescopes, one way or another. The planetary program is focused on human missions to planets, but it is less expensive to service a telescope. People in space can help NASA succeed.

Dr. Kasting presented one action item: approval of the steering committee chair and members. He thanked NASA for setting up ExoPAG and for giving the community a forum to discuss these issues.

Dr. Boss thanked Dr. Kasting for his service on APS and ExoPAG. There was unanimous approval of the proposed steering committee chair and members

COPAG Activities Report

Dr. Martin provided an update on COPAG. The executive committee is adding up to three new members, two of whom are mulling it over. Dr. Martin asked APS to approve Paul Scowen, who has already agreed to serve.

COPAG has four SAGs. SAG2 and SAG3 are driven by the choice of a monolithic coronograph versus an external occulter. Technology focus areas would enable these kinds of missions (SAG4) for far IR. COPAG would like to add SAG5, to examine the scientific capabilities of a set of probes, possibly linked, devoted to Cosmic Origins science..

COPAG held a workshop in January, with the first issue being development of a single, coherent science story. Dr. Martin discussed cosmogony, which tries to determine the flow of Baryons from the cosmic web to the planets. He described following the flow from low density. The ultimate goal is understanding planet formation and evolution. A large ultra-violet optical (UVO) telescope will follow the flow of matter from the cosmic web to planets. A set of three smaller probes may also be able to make significant progress. The next issue becomes that of translating this into quantitative science objectives and technical requirements.

Dr. Martin listed some of the science measurement capabilities and presented a comparison of the measurements to the DS science questions, noting which measurements address which questions. As an example, Dr. Martin discussed tracing the flow of Baryons from the Inter-Galactic Medium (IGM) to the Circum-Galactic Medium (CGM) to and from galaxies, describing the capability, sample investigations, and technology requirements. He presented a range of detector requirement definitions for specific technology areas, defined for relevance.

In developing technology priorities and a technology roadmap for UV technologies, NIR, and Far IR, Dr. Martin reviewed the Technical Figures of Merit: current and projected performance; implementation and operational issues and risks; cost/time to TRL-6 and leverage; and relevance to and impact on possible future missions. There are three levels of cosmic origins technology priorities. The highest priority are mission enabling. COPAG provides preliminary roadmaps for these technologies. The second priority are mission enhancing and should be considered contingent upon science and mission priorities. The third level might hold promise but are not yet qualified for the first two levels. Dr. Martin also discussed UVO infrared (UVOIR) technologies, identifying those that were determined to be at the first and second priority levels.

For 2012, COPAG will expand its investment in communications, seeking regular bulletins with the AAS "Exploder" and having a COPAG newsletter planned. There will be an email list and detailed technology roadmaps with the Cosmic Origins program office. Another goal is to make the science requirements more quantitative, and to investigate a joint mission. Finally, there will be a workshop in the fall.

Three compelling issues face COPAG. The first is monolithic versus segmented mirrors. This is very controversial, essentially a fork in the road, and comparisons are difficult. It may be easier to do a large monolithic mirror now, but

there are fundamental disagreements about the impact on mission cost. Recently, segmented mirrors have been progressing, obviating the benefits of monolithic mirrors. Still, comparisons remain difficult.

The second issue concerns smaller probes versus flagship missions. Flagship missions take so long to plan and implement that they can become obsolete before launch and cannot sustain a vibrant science community. Dr. Martin gave three examples of probes that might be done in the intermediate term. There is a need to understand the costs and science per dollar, as well as to learn how the community can decide between a series of probes or a more capable flagship mission further in the future.

Finally, COPAG seeks to understand how to take ownership of costs and, if possible, change the cost paradigm. There is a need to understand the real costs while discussing potential missions, and this requires cost-estimating tools. Dr. Martin's presentation compared not understanding the real costs while discussing missions and science to not understanding gravity while discussing cosmology and astrophysics. Since flagship missions can only occur once every 20 to 30 years, the definition of a flagship has scaled down to include more modest missions that use existing technology. There must be incentives for cost efficiency.

Dr. Martin asked APS to take the following actions:

1. Approve the new member (Dr. Scowen);
2. Approve the Probe SAG;
3. Approve the direction for 2012 activities.

APS approved Dr. Scowen as a member of the executive committee. For the new SAG, there was discussion. Dr. Martin said that a probe has to be focused, and NASA could develop a portfolio of probes. The great observatories are successful because the scientific goals are synergistic; this would be the case with the probes. Dr. Heap agreed that the community should take ownership of costs and that the needed information is often lacking. She noted that some of the technology belongs to the military. Dr. Hertz added that SMD has a study underway at Langley on costing models and which ones could be made available for AO proposals. He welcomed APS input on that. Each model has its own biases, but identifying the model used will help in the analysis. APS approved the Probe SAG and the COPAG direction.

PhysPAG Activities Report

Dr. Ritz updated the Subcommittee on the activities of the Physics of the Cosmos Program Analysis Group (PhysPAG). He observed that many of the named mission priorities from the DS were related to PCOS, but they are not funded.

There have been some changes on the executive committee. Dr. Roger Brissenden has ended his term on the PhysPAG Executive Committee (EC), and Dr. Jay Bookbinder has been nominated as his replacement. Dr. Ritz sought APS approval of Dr. Jay Bookbinder as an EC member.

The PhysPAG met at the January AAS meeting in Austin TX, and had two special sessions where the X-ray and GW study scientists presented the ongoing CST activities, along with additional invited presentations summarizing international perspectives in both areas.Dr. Ritz explained that the PCOS program includes many different science communities and this is a main factor in the PhysPAG activities and communications. To reflect this variety of stakeholders, the PhysPAG proposes to create three new SAGs, one each for Gamma-ray, X-ray, and GW. The Technology SAG, previously chaired by Dr. Brissenden, would evolve into these three new SAGs. The Communication SAG will be terminated as it has fulfilled its mission.

At the meeting, the PhysPAG heard presentations from Drs. Rob Petre and Nick White, who discussed the trade-offs in reducing costs for the RFI concept missions and the situation in Europe. There was also discussion of inflation probes to study the polarization of the Cosmic Microwave Background (CMB), for which the Inflation Probe (IP) SAG is reviewing the near-term technology needs. The IPSAG is very active, with 60 members, and the Group developed a prioritized technology roadmap which was given to the PCOS program office as input for their Program Annual Technical Report.

Dr. Ritz submitted the following statement to APS on behalf of the PhysPAG:
"Scientifically and technically, PCOS opportunities continue to be extremely exciting. In all areas of PCOS science discussed, the very limited and uncertain budget situation severely reduces the program developed in connection with the NWNH Decadal Survey. New focal points are needed for community organization, beyond the current studies."

The proposed new SAGs will take on the work of the technology and communications SAGs, which will terminate. The executive committee will handle the few areas not connected to these SAGs.

The proposed SAGs are:
1. X-ray SAG, which will enable community discussion and input for future X-ray mission planning. Among the tasks for this SAG are fostering mission concept studies and discussions, and considering missions and capabilities at a variety of cost points. The TechSAG did not compare or prioritize different PCOS technologies for X-rays, which the X-ray SAG can do.
2. The GW SAG will have a similar mission, though the community needs are different. This will likely lead the two SAGs along different paths.
3. New Gamma SAG, which will assess the current status and the current and future needs of the gamma-ray astrophysics community, while providing a forum for that community. The deliverable is a white paper.

Dr. Ritz reiterated that the PCOS stakeholders are both from the physics and astrophysics side, from a variety of disparate communities. It is thus difficult to find a venue attended by all to hold the PhysPAG meetings. The PhysPAG will not meet at the American Physical Society this year. Instead, PhysPAG would like to have a jamboree meeting in Washington during the week of Augist 13, after the RFI study reports are published. Splinter sessions of the SAGs are also contemplated. In 2013, PhysPAG will meet again at the January AAS meeting, as well as the American Physical Society and High Energy Astrophysics Division (HEAD) meetings. There will be a full PhysPAG meeting at one and a town hall on a specific area at the other.

Dr. Ritz asked for APS approval of the following:
1. The new executive committee member, Dr. Bookbinder;
2. The three new SAGs;
3. The shift of TechSAG activities.

APS approved Dr. Bookbinder's membership. Regarding the new SAGs, there was discussion about overlap in the constituent communities. Dr. Ritz explained that only the SAG chair is chosen, while other membership is open. The SAGs reflect the thrust areas. Particle rays and cosmic rays will likely fall to the Gamma SAG because of some scientific overlap. The SAGs reflect more the DS, what is needed by the cosmic ray community, and what NASA funds. This is where that community should interact. Dr. Hertz asked about members who might advocate for their own missions. Dr. Ritz said that, given the seismic shifts in funding and programs, the communities need opportunities to regroup within themselves. The SAGs are not separate, they are part of PhysPAG, which prevents single-advocacy. SAGs are where communities can work out ideas and report them up to PhysPAG, which determines the balance. The SAGs help incubate new ideas in the context of realism. He sees PhysPAG as a funnel of ideas to APS. There is much concern in the PCOS community about the funding situation, and PhysPAG can

communicate that. Dr. Boss reminded APS of the statement cited earlier. He wanted to see it in the letter report.

E/PO Updates for APD and SMD

Dr. Hashima Hasan and Ms. Stephanie Stockman spoke about Education and Public Outreach (E/PO). Dr. Hasan gave an overview of the Astrophysics Division E/PO portfolio, which consists of the Astrophysics and Science E/PO Forum (SEPOF), development of thematic initiatives reflecting the science and technology of the individual missions and the overall thematic elements of the program by the thematic Program Offices, E/PO plans executed by individual missions, and programs competitively selected through the Education and Public Outreach for Earth and Space Science (EPOESS) solicitation. Dr. Hasan gave some examples of E/PO activities conducted by the SEPOF and Astrophysics missions.

The Science Education and Public Outreach Forum (SEPOF) helps E/PO work together with programs effectively and efficiently. Highlights include a brochure, community retreat, an online course for teachers, a cosmology resource guide, and Astro4girls, to reach girls through public libraries. Other activities, like the Kepler Planet Candidate Data Explorer, allow public participation, such as looking for planet candidates in the Kepler database. E/PO has a number of programs to involve amateur astronomers and the general public in real science. Dr. Hasan described internship programs and additional efforts to get girls involved in science and astronomy. The From Earth to Solar System bilingual traveling exhibit went to Puerto Rico recently, and is a follow on to the very successful From Earth To The Universe (FETTU) program that won an International Year of Astronomy 2009 award. The SOFIA Joining Forces program reached out to military families, when E/PO activities were organized for them in conjunction with the landing of the SOFIA plane at Andrews Air Force base in September 2011. A session organized by the SEPOF at the American Astronomical Society meeting, Austin TX, in January 2012, to engage scientists in SMD-funded E/PO activities was well attended,

In response to a question, Ms. Stockman explained that the E/PO grant program is open to any college or university. E/PO has forums that reach out to education organizations like universities to let them know about funding opportunities. Many pre-service teachers, undergraduate students, and others get their science content from community colleges, which NASA needs to reach. Data show that many science majors receive their basic science education through community colleges. A survey of community colleges helped identify their needs. There are community colleges near some of the NASA centers. The colleges often work to move students on to a 4-year college, with the colleges accepting the community college courses by prior agreement.

Ms. Stockman is in charge of SMD's E/PO portfolio. The last time she spoke to APS, it was about portfolio development and middle schools, where students often take their initial steps into Science, Technology, Engineering, and Math (STEM) fields. But now a budget cut has caused the Agency to refocus and pull back on some of these activities, and has brought in educators and budgeters to decide what the NASA education portfolio should look like. The first task was to look at internships. They found a lot of duplication at the centers, and have looked at developing efficiencies. SMD does not have many internship programs. The fellowships are considered a research program. Since SMD's E/PO budget was reduced by 30 percent for FY13, the first priority is honoring existing commitments. The mitigation strategy is to have no Education and Public Outreach for Earth and Space Science (EPOESS) call in ROSES 12; cancel the E/PO supplements program for ROSES science awardees; and scale back other E/PO services. The number of proposals was low to begin with, however, in the ROSES supplements.

Dr. Mary Elizabeth Kaiser said that the outside evaluation component of the grants with E/PO elements can be expensive. Ms. Stockman explained that there are guidelines for the evaluator. Dr. Oswalt asked if the E/PO office had considered adding a broader impact component to PI grants. They have not, but Ms. Stockman thought it was a great idea. Dr. Hertz cautioned about diverting research funding for other purposes. The breadth of the funding

reduction indicates a desire to spend less at NASA in those areas, so moving funds from research to education would not be supported. Dr. Edna DeVore pointed out that NSF has that broader impacts requirement for all of its proposals. It is important to consider the social impact of research, which sets a frame of mind in the proposals. She works on both NASA and NSF proposals. Her scientists are often surprised that they have to deal with that.

Ms. Stockman said that the Office of Science and Technology Policy (OSTP) is looking at STEM education across the various agencies to do an inventory. Some of the E/PO missions are part of that. E/PO believes that its collaborations have led to more students. Dr. Ritz cited an NSF survey indicating that of students getting Bachelor's degrees in physics or astronomy, 36 percent had gone to a community college.

ATT Overview

Ms. Tina Swindell provided an overview of the Astrophysics Technology Team (ATT). The ATT held its kick-off meeting in October, with 16 attendees. In bi-weekly meetings the Team has since developed goals and its charter. The Team will advise APD on technology development activities. Ms. Swindell reviewed the highlights from the Terms of Reference document. These include:

- Provide the knowledge and capabilities to allow for an efficient development of a technology process to manage APD technology planning and execution;
- Conduct regular independent reviews to assess technical capabilities and resources;
- Advise the APD Director on planning and budgeting activities;
- Use program office technology plans as the basis for regular independent reviews;
- Develop and maintain an integrated technology portfolio and data to interface with external organizations;
- Support technology procurement activities.

In discussions that followed, the APS asked whether the ATT manages, or will manage, the Nancy Grace Roman Fellowships. It was pointed out that these fellowships are managed by the Astrophysics Research Program, not the ATT. There was further discussion contrasting the Office of the Chief Technologist (OCT) Fellowships and the Roman Fellowships, and of ATT activities to align the Small Business Innovation Research (SBIR) solicitation with Astrophysics Division technology development needs.

Question and Answer with John Grunsfeld, SMD Associate Administrator

Dr. Grunsfeld, the new Associate Administrator for SMD, started off by offering a few introductory remarks. He welcomed the APS members and introduced himself, recounting his astronomy and space science background. His primary goal for SMD is to enable the best possible science within the current resources. This entails taking some risks, but some of the riskiest science yields the greatest return. He is relying on the team at NASA Headquarters as well as the teams at OMB and OSTP to work together to achieve the best possible science return.

APS has a responsibility as representatives of the community to NASA and of NASA to the community, as special governmenet employees. NASA needs and wants the APS advice, and in turn the APS members need to represent fairly NASA and APD.. When functioning as members of APS, he would like them to be careful in what they say and how the say it, since it will trickle through the public and reach the White House and Congress, which make decisions with significant impact on NASA. Dr. Grunsfeld asked that when they make comments as APS members, they represent the community interest. That will help the Agency make the best possible decisions.

Science-wise, this is an incredible time for astrophysics, cosmology, and exoplanets. The existing great observatories are very active, and soon we will have new missions in space, such as NuSTAR. SOFIA is being upgraded, and we have healthy suborbital and balloon programs. The President's proposed budget is flat for SMD,

but given the various economic pressures, “flat” is the new “up.” As the economy recovers, there may be new wedges opening in the budget enabling new activities. APS members should foster an athmosphere of support by talking to the public about the exciting work they and their colleagues do.

The floor was open for questions from the APS members.
Dr. Heap asked if it possible to be informed about the rationale for NASA decisions, when they are taken, before providing input. For example, her colleagues have been asking about the reason other areas of space science have to shoulder the funds for JWST. Mr. Rick Howard had previously said that three of the four SMD divisions would have to contribute to JWST, and it is not clear how the obligation is being split among them. Dr. Grunsfeld said that he will be as transparent as possible on rationales, and will rely on the recommendations of the APD Director as much as possible. As for JWST, for FY13, there were priorities identified Agency-wide. First priority was to safely and effectively run the International Space Station (ISS), the second one on developing new launch vehicles (SLS) and spacecraft (MPCV). The third Agency-wide priority was JWST. Mr. Howard reports to the Administrator. The project has a cap of $8 billion for a 2018 launch. The new program plan specifies that the budget requirements, allocating funds each year, and that part of the outyear budget is not notional. The previous funding scenario had JWST funded across the SMD divisions according to a formula. There has been a change. Funds have not been taken from the divisions in an active trade. The Planetary Sciences Division (PSD) funding was already declining, as was that of APD. Those divisions, along with Heliophysics, are now essentially flat, while JWST received what it needed. PSD was facing declines due to completing development of existing projects; those funds were taken out rather than reallocated. A flagship mission is about to land on Mars, and the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft will launch in 2013. These form the core Mars science. The PSD DS was not a tenable plan under the current budget situation. Dr. Grunsfeld supports JWST because of its strong community support.

Dr. Boss asked about possible synergy between astrophysics and human space flight, like having astronauts service telescopes. Dr. Grunsfeld said that he is a huge advocate of space servicing, but NASA learned from the Hubble that it is difficult. He would like future telescopes to be designed to be serviced by a robot. Hubble was reinvented every time it was serviced – astronauts removed and replaced instruments, and it was powerful, but it would have been much simpler if it could have been done robotically. Service will not be possible with JWST, because of its L2 orbit. If NASA ever launches a large telescope that characterizes exoplanet atmospheres, the detectors defined prior to launch will be obsolete by time the mission launches. He would like to see plug-and-play instruments as a servicing architecture. There are blunt synergies to examine. Human space flight is building a rocket to launch in 2017. He sees a rocket with a big faring, and NASA should take advantage of that. In a human space flight program, there is a cadence of launches, which could work with science at a marginal cost and be hugely enabling. For a flagship mission, most of the engineering is done to survive the launch, but for human flight, it is done more gently and larger, with suspension systems. NASA should look at using the infrastructure for human space flight.

Dr. Boss asked whether Dr. Grunsfeld would consider robotic de-orbiting for Hubble. Dr. Grunsfeld said that that is the plan. While it has been said to be expensive, people have been working on concepts for a 2025-26 disposal mission. By then, the space infrastructure should allow it to be less costly. SpaceX and Orbital are producing commercial flight capabilities that could do it, and NASA should be able to engage them in a competition for that service.

In answer to a question about how JWST results will be communicated in a timely way and effectively, Dr. Grunsfeld said that a plan is already in the works. Previous experience with the Great Observatories will be invaluable. The Hubble produces two peer-reviewed scientific papers per day, half of which come from archival research and many of which are not even funded by NASA. All of the Great Observatories have expansive archives, and he would like to see high schools accessing them for science projects. Many more discoveries will come from the archives, and he would like to see more engagement from the greater community. Amateur observers are

becoming more and more sophisticated in their data handling techniques, and he wants to enable them to use the archives. He wants more citizen scientists, and NASA should open its doors to them.

Dr. Gonzalez asked about his philosophy on the priority given to flagship missions, compared to the past decade. Dr. Grunsfeld wants to first have the opportunity to build the next flagship. He would like to see robotic service capability explored in the early requirements phase so that NASA can build the robotics to extend the instruments, s. Ground-based observatories have huge opportunities if Hubble continues, and other Great Observatories will produce similar results that will be powerful and exciting.

Public Comments

Dr. John Nousek, Pennsylvania State University, made two remarks. First, applauded the plan to have a MOO in late 2012, but suggested that MOOs should not be replacing Explorers, as NASA needs to fly missions. Second, he cautioned against being too strict in addressing the DS priorities for the Explorer missions. He advised not labeling the Explorer calls into SMEX and MIDEX and letting the proposals quality only drive the mix at any one time.

Dr. Gary Melnick from the Harvard Smithsonian Center for Astrophysics commented on the WFIRST presentation. As the group works to define the mission relative to Euclid, it would be useful to know more about how WFIRST will improve on Euclid in the area of determining W and W-Prime. The NRC report from January was put together quickly and had general statements, with nothing quantitative about how the improvements over Euclid translate, which people will want to know. The community will want to know what they will learn by reducing the uncertainty and whether it is worth the funding. The WFIRST study team should keep in mind the questions that motivate the mission and not get stuck on how it is better in the details relative to Euclid.

Discussion

In order to develop the letter report, Dr. Boss went through his notes chronologically.

The first issue concerned what mixture of SMEXes and other-size Explorers APD should have. Drs. Kasting and Kaiser agreed with Dr. Nousek's suggestion that the process should be proposal-driven. Dr. Hertz said that APD decides the cost caps for each AO. A recent Explorer competition had a cap of $200 million (exclusive of launch vehicle). He has thought about having multiple classes of missions in the same AO for 15 years, but the best proposers always come in close to the cost cap because that maximizes the science. That is why NASA alternates between small and medium, to force some small missions. This conversation on cost cap takes place with every AO. It is easiear to think about price points. He would welcome an assessment from outside NASA. When the commercial resupply program is successful, there will be more launch vehicles available and APD can leverage off of that. Dr. Kalogera said that it might be useful for the community to have a call in 2012, even if just for a MOO, rather than wait until 2013.

Dr Ray wrote some text encouraging NASA to conduct the Explorer missions in a timely manner, and Dr. Boss suggested using that text in the report. Dr. Ray wondered if it was even possible for APS to come up with the right solution at this point to balance out the mix of SMEXes and MOOs. Dr. Boss recommended that this be on the agenda for the next meeting, with a presentation from APD. The APS membership agreed that it was important to have a fall 2012 AO. They also agreed that they would solicit comments from their colleagues to bring to the next meeting.

On the second issue, regarding WFIRST, Dr. Boss again suggested using some language that Dr. Ray had written, along with Dr. Ritz, about the need for the mid-decade review to rethink mission priorities and the proper mission environment. In addition, Dr. Hertz had asked APS for more specificity and an appropriate level of funding in regard

to WFIRST technology development. Dr. Hertz pointed out that the mid-decade review will take place in 2014, with a report in 2015. There was concern that the report and accompanying recommendations are needed sooner.

Dr. Kasting noted that the detectors might be useful for other projects, and therefore NASA might want to develop the technology regardless of where WFIRST goes in any revised list of priorities. Discussion centered on whether and how to determine if, with no definitive decision on WFIRST in the foreseeable future, the technology development would warrant the funding compared to other technology development. Dr. Gonzalez said that with budget cuts being made in so many areas, spending on WFIRST should be examined carefully, although it is not up to APS to set the priorities. Dr. Boss said that there will be a better sense of where WFIRST fits into the big picture when the CAA issues its report. Technology development for WFIRST can be proposed, but there are no funds set aside. APS does not have sufficient information at this point.

Dr. Heap asked about a SAG that ought to have addressed a follow-up for Kepler but did not. She was concerned about funding allocation. Dr. Kasting agreed that no actions were taken and explained that recruitment of members for the SAG was the main issue. ExoPAG is specifically prohibited from giving funding advice and does not make policy. Dr. Boss pointed out that many of the Kepler targets are distant, but there will be an opportunity to follow up from the ground. Dr. Heap said that she has been hearing concerns about the needed exposures times. It was agreed that ExoPAG will assess the issue and report to APS on the observing time, quality of spectrometer, and NSF's willingness to collaborate.

Dr. Ritz suggested that the letter report start off with a clear, strong statement of gratitude for President funding JWST in his proposed FY13 budget, adding how important this is. He agreed to write this, also thanking NASA Administrator Charles Bolden for elevating JWST to a NASA priority.

Dr. Kasting asked an explanation of why the TDEM SAT funds in FY13 were being drastically reduced, with cancellation of the ROSES 2012 call. Dr. Hertz clarified that those funds are being used for LBTI to measure exozodiacal dust. Because there had been some confusion, Dr. Kasting took on the action item of quickly conveying to the community what the ROSES SAT TDEM cancellation really involves.

The next issue concerned the development of cost models: there are often large discrepancies among the costs performed by various sources and this affects the outcome of proposals. APS requested that APD develop a standard cost model, and Dr. Hertz replied that the Division was already considering it. Dr. Ritz said that in his experience with cost models, the outcome is driven by the assumptions on the various model parameters. Therefore, having a model available does not address the issue in and of itself. He suggested making available a facility where investigators could get their models costed. Dr. Hertz said that APD was thinking more along the lines of having proposers identify the models used and the way they set the parameters. APD could then recreate and validate those models, similar to the way scientists recreate each other's work. Dr. Nousek from the audience said that in his long-time experience developing missions, there is a huge range in the models which generates many uncertainties, making agreement among different models unlikely. Dr. Ritz agreed, but thought that it could be helpful to bring in some people who have done this in order to provide feedback. Dr. Hertz said that that might be a second step. NASA is conducting some internal studies at Langley. While they might be ready by the next meeting, he was not sure how much can be shared. Dr. Boss put this topic on the agenda for the next meeting, which will be in summer.

Next, Dr. Boss called attention to two statements made by Dr. Ritz, one about the Inflation Probe and the other about the PCOS program not having much activity in the future in terms of upcoming missions. He suggested APS accept the statements as a communication from PhysPAG to the Subcommittee.

Mrs. DeVore found the cuts to E/PO regrettable, as the programs are often organized to bring NASA's excitement to the public and support STEM education. Dr. Kalogera recommended that the letter report state that APS wants to

recover that loss. Dr. Boss agreed that a 30 percent cut is significant and should not go without comment. Dr. Hertz explained that this was as a result of a White House decision to reduce redundant education programs across multiple agencies, part of a broad agenda of making government more efficient and concentrating funding in expert agencies. The White House concluded that having education programs in many agencies was not effective. Dr. Ritz advised identifying specifically what would be lost, especially from APD and SMD. Dr. Hertz added that the view should be long-term, past the sharp change in the budget level. It was noted that these cuts were across the Agency, and that the Education Committee of the NASA Advisory Council (NAC) will be dealing with this issue. It was suggested that APS send a message to that committee. Dr. Gonzalez noted that it is still unclear how the EPO efforts for astrophysics will be addressed elsewhere. Dr. Boss asked Mrs. DeVore to write the language on re-evaluation of this policy. Dr. Kaiser was concerned that there was no guarantee that the broader education program will still emphasize STEM, and there was some discussion that the Department of Education will not retain the same emphasis as currently in APD, but will instead address STEM education for STEM teachers.

Finally, Dr. Boss led APS through a review of the DS priority chart that the Subcommittee had evaluated the previous day, in order to confirm their decisions and discuss any potential changes. It was noted that what they had discussed as the LISA project, the chart addressed actually LISA technology development. Even in the unconstrained environment envisioned in the DS, WFIRST was to be developed and readied as a mission, while LISA and IXO were to follow in the next decade. Dr. Boss said that the chart was not correct, that it should have said "LISA" instead of "LISA technology development."

It was agreed to add a footnote on New Worlds Technology due to a timing question. On the Inflation Probe, there are some competed technologies, but it received an X mark as it is not associated with a line item. For the smaller projects, all of the projects remained consistent with the DS recommendation up to the Additional Program Augmentations, which were proposal-driven. Dr. Hertz explained that there were considerations of the previous year's run-out budget. He asked that if APS made different recommendations, it would help to have the rationale in order to respond intelligently and justify in a possible future budget. Dr. Boss suggested that the letter report state that APD has responded to proposals and will continue to do so. Dr. Kalogera agreed to draft that portion of the report.

Dr. Boss asked about the projected program balance for the next decade, given the likely run-out. It was agreed that the balance was about as good as possible given the budget issues. Drs. Kaiser, Martin, and Bernstein including advocated a statement about the need to support the suborbital programs and keep them vibrant.

Dr. Hertz thanked APS and thanked Dr. Boss for his service as chair. It was his last face-to-face APS meeting as chair, due to his term expiring in April. Also leaving were Drs. Heap, Kasting, Dey, and Hughes. The proposed new members were still in the formal approval process and were not named. The next face-to-face meeting will be in mid to late summer, with dates to be determined later. At that point, there were no plans for a teleconference in the interim.

Dr. Boss adjourned the meeting at 3:44 p.m.

Appendix A
Attendees

Subcommittee members
Alan Boss, Carnegie Institution, *Chair Astrophysics Subcommittee*
Rita Sambruna, NASA, *Executive Secretary*
Gabriela Gonzalez, Louisiana State University
Sara Heap, GSFC
Mary Elizabeth Kaiser, The Johns Hopkins University
Vicky Kalogera, Northwestern University
James Kasting, Pennsylvania State University
Chris Martin, California Institute of Technology
Terry Oswalt, Florida Institute of Technology
Paul Ray, Naval Research Laboratory
Steven Ritz, University of California Santa Cruz

NASA attendees
Mansour Ahmed, NASA/GSFC
Marc Allen, NASA SMD
Jaya Bajpayee, NASA HQ
Max Bernstein, NASA HQ
M. D. Bicay, NASA/ARC
Bill Danchi, NASA HQ
Chris Davis, NASA HQ
Holly Deyn, NASA HQ
T. Jens Feeley, NASA HQ
Jonathan Gardner, NASA/GSFC
Hashima Hasan, NASA
Jeffrey Hayes, NASA HQ
Ann Hornschemier, NASA/GSFC
Illana Harrus, NASA
Doug Hudgins, NASA HQ
W. Vernon Jones, NASA HQ
Beth Keer, NASA/GSFC
Raymond Kinzer, Jr., NASA/GSFC
Chryssa Konveliom, Marshall SFC
Billy Lightsey, NASA
Marian Norris, NASA HQ
Bill Oegerle, NASA GSFC
Mario Perez, NASA HQ
Trent Perrotto, NASA HQ
David Pierce, NASA HQ
Andrew Ptak, NASA GSFC
Wilton Sanders, NASA
Linda Sparke, NASA HQ
Karl Stapelfeldt, NASA GSFC
Robin Stebbins, GSFC
Stephanie Stockman, NASA HQ

Tina Swindell, NASA HQ
Jackie Townsend, NASA HQ
Glenn Wahlgren, NASA HQ
Dan Woods, NASA HQ

Other attendees
Gerald Blazey, OSTP
Jay Bookbinder, SAO
Dom Conte, Orbital Sciences
Randall R. Correll, Ball Aerospace
James Green, University of Colorado
Bethany Johns, AAS
Jason Kalirai, Space Telescope Science Institute
Joydip Kunda, OMB
Michael Moloney, NRC
Matt Monzer, STScI
John Nousek, Penn State
Ronald Polidan, NGAS
Marc Postman, STScI
Miriam Quintal, Caltech

Webex
Ben Bass, FDCH
Dominic Benford, NASA
Gary Bernstein, University of PA
Jay Bookbinder, SAO
Joy Bretthauer, NASA HQ
Richard Capps, JPL
Ruth Carter, Program Office Goddard
Kaitlin Chell, Cal Tech
Ed Cheng, Conceptual Analytics
Dominick Conte, Orbital Sciences
David Content, Goddard
Gerard Daelemans, Goddard Program Office
Christopher Davis, NASA HQ
Michael Devirian, JPL
Martha Froetschner, Hutchinson KS
John Gardner, GSFC
Neil Gehrels, Goddard
Thomas Griffin, GSFC
Richard Griffiths, NASA
Lewis Groswalk, National Academy of Sciences
Shaul Hanany, University of Minnesota
Ilana Harrus, NASA HQ
Ingolf Heinrichsen, JPL
Louis Kaluzienski, NASA HQ
Richard Kapps, JPL
Beth Keer, NASA

Jeff Kruk, NASA Goddard
Stephen Leete, NASA/GSFC
Dan Lester, University of Texas
Marie Levine, JPL
Amy Lo, Northrup Grumman
Chris Martin, CalTech
Matthew Mazur, NASA GSFC
Stephan McCandliss, Johns Hopkins
Gary Melnick, Harvard Smithsonian Center for Astrophysics
Stephen Murray, Johns Hopkins
William Oegerle, GSFC
Cathy Peddie, NASA Goddard
Thai Pham, NASA GSFC
Ronald Polidan, Northrup Grumman
Andy Ptak, NASA
Norman Rioux, NASA/GSFC
Paul Schechter, MIT
Marcia Smith, spacepolicyonline.com
Karl Stapelfeldt, NASA GSFC
Lucinda Taylor, NASA
Kathy Turner, NASA
Michael Werner, NASA JPL
Nicholas White, NASA

Appendix B
NAC Astrophysics Subcommittee Members

Alan P. Boss, Chair
Carnegie Institution for Science
Department of Terrestrial Magnetism

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

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

Arjun Dey
Associate Astronomer
National Optical Astronomy Observatory

Gabriela Gonzalez
Professor, Physics and Astronomy
Louisiana State University

Shaul Hanany
School of Physics and Astronomy
University of Minnesota/Twin Cities

Sara R. Heap
ExoPlanets and Stellar Astrophysics Laboratory
Goddard Space Flight Center
National Aeronautics and Space Administration

John (Jack) P. Hughes
Department of Physics and Astronomy
Rutgers 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

James F. Kasting
Distinguished Professor
The Pennsylvania State University

Chris Martin
California Institute of Technology

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

Appendix C
Presentations

1. *Astrophysics Division Update*, Paul Hertz
2. *JWST Update,* Eric Smith
3. *WFIRST SDT Update,* James Green
4. *Impact of Balloons Return to Flight,* David Pierce
5. *R&A Update,* Linda Sparke
6. *PCOS X-Ray Concepts Study Status,* Andrew Ptak
7. *Status of Gravitational-Wave Mission Concept Study,* Tuck Stebbins
8. *ExoPAG Report*, James Kasting
9. *COPAG Report*, Chris Martin
10. *PhysPAG Status*, Steven Ritz
11. *EPO Updates for APD and SMD,* Hashima Hasan, Stephanie Stockman
12. *Astrophysics Technology Team Update,* Tina Swindell

Appendix D
Agenda

Astrophysics Subcommittee Meeting
February 23-24, 2012
NASA Headquarters
AGENDA

Thursday, February 23
Location: 8R40

9:00 – 9:05	Welcome and Conflict of Interest Review	A. Boss
9:05 – 10:30	APD Programmatic Update	P. Hertz
10:30 – 10:45	Break	
10:45 – 12:00	Q&A	Committee Members
12:00 – 1:00	Lunch	
1:00 – 2:00	JWST Update	R. Howard/E. Smith
2:00 – 2:30	WFIRST SDT Update	J. Green
2:30 – 3:00	Impact of Balloons Return to Flight	D. Pierce
3:00 – 3:15	R&A Update	L. Sparke
3:15 – 3:45	Break	
3:45 – 4:15	Update on X-ray RFI Study	A. Ptak
4:15 – 4:45	Update on GW RFI Study	T. Stebbins
4:45 – 5:00	Summary Day 1	A. Boss
5:00	Adjourn Day 1	

Friday, February 24
Location: 7H45 (Mic7)

9:00 – 9:30	EXoPAG Activities Report	J. Kasting
9:30 – 10:00	COPAG Activities Report	C. Martin
10:00 – 10:30	PhysPAG Activities Report	S. Ritz
10:30 – 11:00	Break	
11:00 – 11:30	EPO Updates for APD and SMD	H. Hasan/S. Stockman
11:30 – 11:50	ATT Update	M. Moore/T. Swindell
11:50 – 1:00	Lunch	
1:00 – 1:30	Q&A with J. Grunsfeld	Committee members
1:30 – 1:45	Public Comment Period	
1:45 – 2:00	Break	
2:00 – 4:00	Discussion	APS members
4:00 – 4:30	Summary of Meeting	A. Boss
4:30	Adjourn	