NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

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NASA Headquarters
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MEETING MINUTES

Alan Boss, Chair

Rita Sambruna, Executive Secretary

Welcome and Conflict of Interest Review

Dr. Alan Boss, chair of the Astrophysics Subcommittee (APS), convened the meeting by welcoming those present. Dr. Rita Sambruna, APS Executive Secretary, explained that WebEx difficulties were being experienced but that they would be resolved within the hour. Dr. Boss then asked the APS members to introduce themselves and state any conflict of interest with the agenda. Dr. Boss reminded the Subcommittee members that they are subject to Federal Advisory Committee Act (FACA) rules. This meeting included a public comment period. Otherwise, only APS members were to participate in the discussion. Dr. Boss then asked for a roll of those attendees, both in the meeting room and on the conference call, who were not members of the Subcommittee.

APS will have a phone meeting on November 21, jointly with the APD monthly teleconference with the National Research Council (NRC), the AAAC, and SSB Chairs. During the telecon Mr. Geoff Yoder, Acting Director of the NASA Astrophysics Division (APD), will update APS on several issues, including NASA's possible participation in the European Space Agency's (ESA) Euclid program.

Regarding where APS stands in relation to other advisory groups, such as the Astronomy and Astrophysics Advisory Council (AAAC), it was explained that APS is an organism that advises NASA exclusively, while the role of the AAAC is to coordinate the implementation of the Decadal Survey (DS) report among three Agencies, namely NASA, NSF, and DoE. APS also provides APD with input regarding the implementation of the DS.

FACA Briefing

Dr. T. Jens Feeley, Senior Policy Analyst for the NASA Science Mission Directorate (SMD) and current Executive Secretary for the NASA Advisory Council's Science Committee, gave a presentation on Federal Advisory Committee rules and how they apply to APS. The Federal Advisory Committee Act (FACA) of 1972 establishes the legal requirements for federal advisory committees, while the General Services Administration (GSA) Federal Advisory Committee Management Final Rule lays out how to implement these requirements. NASA has issued its own policy directive on the subject, which requires that NASA-sponsored advisory committees operate in full compliance with FACA; that any subgroups operate in the same manner of openness and accountability as FACA committees; and that NASA advisory committees are strictly advisory. The NASA committee management officer is Diane Rausch, and the APS designated federal officer is the executive secretary, Dr. Sambruna. Public meetings are central to FACA, but the statute requires public access, which is not the same as participation. This means that meeting minutes must be made available for public inspection within 90 days after the meeting, meetings are to be announced in the Federal Register, and the public must have access to the meeting room or the conference call. Only a very few exceptions to FACA allow closed meetings and NASA's advisory committees rarely qualify under any of these exceptions. Members may conduct administrative and preparatory work, but not consensus deliberations, in non-FACA meetings; these meetings require a memorandum certified by the executive secretary and approved by the NASA General Counsel's office and the Agency Committee Management Officer.

APD Programmatic Update

Mr. Yoder, Acting Director of the Astrophysics Division (APD), explained that the current challenge in the budget constrained environment is to optimize the Division's budget to achieve the maximum amount of science for the limited APD resources. This means spending taxpayer funds as wisely as possible. There is a great deal of science that can be done within the APD budget. Ongoing missions, such as the Hubble Space Telescope (HST), continue to produce highest quality science results.

There have been some significant personnel changes within SMD. Dr. Ed Weiler retired as SMD Associate Administrator, and Mr. Charles Gay, the Deputy Associate Administrator, is now the Acting Associate

Administrator. The latter position is likely to be filled soon. The Heliophysics Division (HPD) selected new Director, Dr. Barbara Giles, to replace Dr. Fisher who retired effective October 31, 2011. A search is still ongoing for the position of APD Director; applications were received and are being evaluated. In the meantime, Mr. Yoder is reorganizing the labor distribution within the APD personnel in order to ensure a smooth transition, vis-à-vis the upcoming departure of some scientists moving on to other positions.

Missions

Mr. Yoder gave a review of the currently operating APD missions, noting that most of them involve partnerships with other domestic and international institutions. There have been some rocket issues on the suborbital missions, but they have been resolved and launches have now continued. The Ft. Sumner balloon mission was launched a short time before the APS meeting. One of the focuses of the balloon program is on expanding the highly successful long-duration flights around Antarctica, with the possibility of ultra-long-duration balloon flights of up to 100 days.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) Announcement of Opportunity (AO) was issued in late summer, and the responses are being evaluated. One of SOFIA's science highlights was the Pluto occultation observation, which was successfully completed on June 23. This observation showcased the power of SOFIA to relocate quickly to catch interesting events in real time. Nine of the 11 basic science flights were completed by mid-October, with the remainder scheduled for early November. There had been some damage on the backside of the mirror resulting from cable tie-down fasteners becoming dislodged due the natural thermal cycling that occurs when the SOFIA transitions from ambient sea level temperatures to altitude cold temperatures during observations. After a thorough evaluation of the situation, SOFIA was cleared to continue science operations. . The First International Deployment occurred with the flight to Germany in September, as well as a stopover at Andrews Air Force Base (AFB) during the SOFIA return to United States. These events were reported by the two countries' national media, which will continue to fuel the community's excitement about this mission.

Other operating missions news included the proposed termination of the Rossi X-ray Timing Explorer (RXTE) and Galaxy Evolution Explorer (GALEX) at the end of 2011 consistent with the Senior Review; the release of an updated gamma ray source catalogue by the Fermi LAT science team; and the timely release of software for the analysis of Kepler's data.

Moving on to missions in implementation phase, the Nuclear Spectroscopic Telescope Array (NuSTAR) is on schedule, with a slight delay of the launch from February to March 2012. The NuSTAR thermal vacuum testing successfully completed in July, solar arrays successfully attached in August, and vibration testing completed in September. There was a short delay in vibration testing due to the East Coast earthquake, which required evaluation of both the test equipment and NuSTAR hardware to ensure that the instruments suffered no damage. Observatory acoustics and observatory shock tests were successfully completed in September.

The operations for Astro-H, an X-ray astronomy mission led by the Japan Aerospace Exploration Agency (JAXA), are also being slightly delayed due to the tsunami and related issues in Japan. NASA is coordinating hardware deliveries with JAXA to ensure JAXA is ready to receive the hardware. A key deliverable is the engineering model (EM) calorimeter spectrometer insert (CSI), which has completed performance and cold vibration testing. The Engineering model mirror detector is complete and has been sent to JAXA.

As for future missions, APD created a future missions budget wedge to increase the Explorer rate to allow a total four Explorer missions and four missions of opportunity (MoO) in the decade, following the Decadal's recommendations. For FY2011, 15 astrophysics Explorer mission proposals and 11 astrophysics MoOs were submitted to the first call for proposals last year. The two Explorer missions selected for Phase A studies are in the exoplanet area. Specific costs, especially for those missions that involve the International Space Station (ISS), have

yet to be determined. Over time, APD will look at the balance of missions, but at this point the Division is looking for the best proposals overall.

Communication and outreach

Effective communication relies on tailoring the content of the message to the various recipients, which encompass a wide range of backgrounds from professional scientists to members of the public at large. To address this need, APD has developed a communications plan. Information will be posted on the Websites, which will provide links to specific information to meet their interests. In addition, APD is now conducting a quarterly program office review to improve communications between program offices at the various Centers, leverage expertise, and build teamwork.

ESA

On October 4, upon recommendation of the Science Programme Committee, ESA has selected Solar Orbiter and Euclid as the M1 and M2 class missions to move forward to implementation. The planned launch dates are 2017 and 2019, respectively. While Solar Orbiter will study the solar wind, venturing closer to the Sun than ever before, Euclid will study the origin of the acceleration of the Universe. A leading theory is that the Universe is being accelerated by a mysterious force, dubbed "dark energy" that permeates it. Euclid will collect observations in the optical and NIR, mapping the large-scale structure of the Universe up to 10 billion years in the past. Euclid will study the effects of dark energy on the growth of large-scale structures which affects the observed shape of galaxies, a technique known as Weak Lensing, and on the growth of the large scale structure of galaxy clusters across the expansion history of the Universe via a redshift survey of galaxies (Baryon Acoustic Oscillations). Euclid is now moving into implementation phase with cost finalization in June 2012 and launch in 2019.

ESA has decided that the L-class missions will be European-led.
Euclid is moving into implementation rapidly, the schedule is defined, the costs will be finalized by June 2012, and the launch is planned for 2019. Any contribution by NASA will have to be finalized by June 2012. ESA has stated that the mission architecture and its science goals cannot be modified, and is moving forward with Euclid's implementation and launch regardless of NASA's participation. In late October Geoff Yoder, the Astrophysics Division Acting Director, will travel to Paris to meet with ESA's representatives and discuss possible ways that NASA could be involved in Euclid. Yoder will update the APS on the meeting outcome at the November 21st telecon of the subcommittee.

Discussion

APS members asked Mr. Yoder if NASA will be able to access Euclid's data, and what the science overlap will be between Euclid's science and the goals stated for the Wide-Field Infrared Survey Telescope (WFIRST). Mr. Yoder replied that these questions are under investigation. He reiterated that no plan for funding future programs can be made until the APD funding share for JWST is known, and until the FY12 budget release in February 2012, and added that he is focusing at present in identifying NASA's contribution to Euclid. Earlier on there were discussions between NASA and ESA of an equal exchange for participation in Euclid and WFIRST, respectively, but because the Euclid's design has been frozen, this option is no longer viable. The subcommittee remarked that since future budgets are embargoed, it will not be possible for the APS to provide input on budget priorities. Similarly, some members observed that it is difficult to make recommendations on Euclid's level of funding. Mr. Yoder said that the timeframe for Euclid's decisions is very tight.

The APS recalled that at the July meeting Dr. Weiler had said that he would consult with the subcommittees if JWST caused greater funding reductions than anticipated. He did not plan to come to them about smaller reductions that could be managed through the normal budget management process. When Dr. Weiler made that statement, he

thought there would be more clarity from Congress at the present time. NASA should hear more from the Senate soon. That, combined with the House of Representatives initial budget, should give them a sense of the FY12 budget.

Mr. Yoder noted that there is a new technology fellowship in APD, the Nancy Grace Roman Technology Fellowship in Astrophysics. He asked whether he should be concerned about measuring the benefits of APD fellowships and, if so, which metrics might be most useful. It was pointed out that fellows rise to the top in academia, which is easy to track, though it takes several years. It would be a good idea to develop a metric program for all of the fellowships.

Mr. Yoder was asked about his thoughts on how to handle possible participation in an M3 project. Mr. Yoder replied that he wants to focus on M2, then see what is in the President's budget. He is relying on the program office to help understand the options. It was noted that ESA views NASA as an unreliable partner, which increased the importance of a good faith commitment for M3 missions, but Mr. Yoder said that that is not an option until the budget has been determined.

In response to a question about his upcoming meeting with ESA, Mr. Yoder said that his main goal was to understand NASA constraints from the ESA standpoint, in order to better understand the options available. There is a June 2012 deadline for any agreement, which has to go through the State Department.

The Gravity and Extreme Magnetism (GEMS) mission is coming up for review in the spring. There has been concern about the direction since early in the year, resulting in a renewed look at the primary mission and a focus on Level 1 requirements in order to avoid an overdesign. The dates and reviews have slipped, and Mr. Yoder was concerned about it.
He also explained that the charter of the Senior Review is to look first at whether the science is right, then examine the science per dollar. The Senior Review gives priorities. Dr. John Hughes noted that, previously, the budget cuts were deeper than the Senior Review committee expected. Dr. Steven Ritz added that APS looks at discrepancies. When the budget is lower, the diversity of the program is less, so more robust advice will come from a Senior Review that is pessimistic. He suggested that Mr. Yoder consider the charge to the reviewers.

Regarding WFIRST and the possibility that Euclid might ultimately be the only option to study dark energy, Mr. Yoder said that that will be clearer with the FY13 budget. However, NASA does not expect a large funding block for any major mission until JWST launches.

JWST Follow-up

Mr. Richard Howard, JWST Program Director, discussed the current status of JWST, which is now in implementation mode. Following significant changes in JWST management, communications have greatly improved between NASA headquarters, the centers, and contractors, especially at senior management levels. An assessment of alternatives has been completed, which involved asking the science questions and determining the best way to answer them. The assessment also considered some descopes. The only milestone missed thus far relates to the delivery of the Integrated Science Instrument Module (ISIM) Electronics Compartment (IEC) to ISIM integration and test (I&T). Since the precise IEC configuration could be affected by an ongoing study of thermal margins it was determined this delivery should be deferred by a few months.

Mr. Howard described the status of four key areas: the telescope, science instruments, sunshield, and spacecraft. There are some concerns about the science instruments, specifically the Near InfraRed Spectrograph (NIRSpec) optical bench cracks that will cause a delay in the delivery of that instrument to ISIM I&T. The other key areas are proceeding well.

Twelve of the 18 primary mirrors have been tested. The final 6 mirrors are being tested right now. The X-Ray Calibration Facility (XRCF) testing of the second batch showed two mirrors with higher RMS surface figure errors at cryogenic termperatures, due to a faulty algorithm that did not carry over to other mirrors. The overall primary mirror will meet its requirements for surface figure error even if these two mirrors are used..

Significant improvements have been made on the Near InfraRed Camera (NIRCam), which has also brought together the team in solving problems together. There are cracks on the Near InfraRed Spectrograph (NIRSpec), discovered while inspecting harness tie-down chip-out repairs. Work continues to identify the root cause, but a full-flight spare optical bench looks good. The Mid-InfraRed Instrument (MIRI) has completed testing and can be delivered by April 2012. The Fine Guidance Sensor (FGS) had problems with the tunable filter module, resulting in a completely different approach, the Near InfraRed Imager and Slitless Spectrograph (NIRISS). This was presented to and endorsed by the JWST science working group and will be delivered in July 2012.

Much work has been done on the spacecraft subsystems, most of which were or will be acquired "off the shelf" at a fixed price. Integration and testing is being conducted at Goddard Space Flight Center (GSFC), in the same facility where the Hubble work was done. The ambient optical assembly stand for the Optical Telescope Element is under construction. Mr. Howard showed the hardware fabrication completion percentages, which are 25 percent for the spacecraft bus, 40 for the sunshield membranes, 75 percent for the primary mirror support, and 90-100 percent for everything else. The updated master schedule has not changed very much from the previous meeting, other than new dates for the delivery of instruments. The schedule includes 26 months of slack for the instruments, much of which will be taken up by the replacement of near infrared detectors.

When asked why JWST was still 2 ¾ years out from the Critical Design Review (CDR), Mr. Howard explained that it was moved out deliberately to avoid unnecessary forward loading. It [the spacecraft] should be the more standard, straightforward part of the program. The Project was more concerned about the risk related to the mirror. The contractor was not required to fix the mirrors because that is not necessary, as they are within specifications (see above), meet the requirements, and have one spare mirror for each prescription. The top-level science needs do not place a surface figure requirement per mirror, rather it is a total primary mirror error. In response to a question about other issues, Mr. Howard said that the near infrared detector replacement has been factored into the replan and margin (for both budget and schedule). The NIRSpec is being delivered by the Europeans and will take up some reserves (in schedule only as this is an ESA funded instrument). NIRSpec went through vibration and cryo-testing, but it was only when the team looked for contamination under UV lights that the problems (cracks) were discovered.

As NASA transitions from replanning to building, the team has already accelerated the final tests of six remaining primary mirror segment arrays at XRCF, supported by an extra $44 million in FY11 funding. NASA also told Northrup Grumman to pull in the schedule on Primary Mirror Backplane Assembly by 6-8 months. Discussion is underway to accelerate the spacecraft CDR by 6 months.

Budget issues

NASA has presented to Congress proposed offsets to support JWST's 2018 launch date. The total additional funds required come to $1.208 billion in the years FY12 through FY16. The FY12 additional request is for $156 million. Half of this is to come from the divisions within SMD, though the Earth Science Division (ESD) will not have to contribute. The other half is proposed to come from the NASA Institutional Support budget. This cross-agency support item normally receives about $3 billion annually. The FY13-16 additional requirement is $1.055 billion. This is above the President's request (which was $1.5B in those same years). The Senate markup reflects this amount for FY13 ($156M), but the House did not have the replan information in time and had to estimate.

In answer to a question about the likely allocation of the $80 million offset from within SMD, Mr. Howard explained that that was still being discussed with the Administration. The three divisions have recommended

potential cuts. This ($80M) amounts to less than 2 percent of the SMD budget, which affects ongoing programs and plans for the future. Nothing is final in terms of how that will be divided. This decision was reached jointly by NASA and the Administration. The divisions do regular exercises on how to manage cuts. The actual budget from Congress may differ from the President's budget request. NASA will have an opportunity to let Congress know how the Agency would react to the budget. The funds needed for FY17 and FY18 will be less than those for FY13-15, which will require the greatest amount. Sunk costs (from inception through FY11) come to about $3.5 billion. In terms of the institutional support, that should have little to no impact on APD research and will likely come from Agency-wide or center-wide support, such as IT support, security, or infrastructure. The Breach Report includes projected costs, schedules, and an assessment of alternatives. This will go to Congress soon.

Questions from the previous meeting

At the previous APS meeting, the Subcommittee asked Mr. Howard to return with the answers to four questions. He was able to answer three. First, he was asked for documentation about studies of de-scope/re-scope options within the past 3 years. He provided a chart detailing the history of the decisions of major impact made since 2002. Mr. Howard could not answer the second question, about documentation of studies of alternative means of achieving the scientific goals of JWST, because the information was being presented to Congress and could not be shared yet.

In response to the question about the history of project status reports over the past 3 years, Mr. Howard presented a color-coded chart showing "the stoplight history" of technical, schedule, cost, programmatic, and overall issues. Finally, a pie chart of cost breakdown by element showed the estimates of what percentage by cost (not mass) of JWST's parts have already been fabricated or are in the process of being fabricated. The chart shows where the money has gone thus far, and gives an indication of where future funds are likely to be spent.

Discussion

In response to a question about the impact of reducing the Optical Telescope Element (OTE) and ISIM Integration and Test (OTIS) from 3 microns to 2 microns, JWST Deputy Program Director Dr. Eric Smith said that there is incremental testing up to that level. NASA will test in ISIM, then OTIS, and will test mirrors to the Level 1 2 micron figure, as well as testing all elements on the subsystem level before testing the integrated assembly. The goal of OTIS testing is to ensure that the program is in the capture range on each of the active systems, not to test the instruments.

Dr. Terry Oswalt observed that the costs were to an 80 percent confidence level, which he thought might have changed. Mr. Howard replied that the Independent Comprehensive Review Panel (ICRP) report advised having the replan at an 80 percent cost confidence level. The Agency requirement is 70 percent jointly between schedule and cost. The JWST replan is consistent with the cost and schedule at 80 percent and is well above 80 percent with costs. The reason JWST does not reallocate funds that the project might need them later. No one in the Agency or the Administration has a problem with that.

The approximate cost to launch is $8 billion, which is the cap from the Senate mark-up. When it was observed that the $10 million for the science working group seemed high, Dr. Smith explained that this includes funded researchers and postdocs in addition to the top-level science working group. It also funds U.S. members of other science teams related to this, such as MIRI instrument development.

Dr. Sara Heap was concerned about the science instrument module not being an actual module, so that it cannot be readily removed if necessary. She also asked about the reserve time on the thermal vacuum tests. Mr. Howard said that the two thermal cycles are occurring at Johnson Space Center, but he was talking about the ISIM integration. The detectors fall into the 26 months. There is time in which to address any problem and stay on the integration schedule.

Mr. Howard explained that the pie chart could be reversed, from what has been spent to what remains to be spent, by flipping the percentages. The only thing missing is the reserves, which have been spent, and there will be reserves going forward, though he cannot discuss that.

Regarding the alternatives question that Mr. Howard could not discuss, Dr. Smith explained that a team of scientists and engineers at Aerospace Engineering was given the Level 1 requirements for a capability-to-achieve and asked to find a cheaper or better alternative via JWST or other means. They were told to use any means they could think of to address these science and performance requirements. Their conclusions, contained in the Breach Report, will be given to APS once it is no longer embargoed.

Several Subcommittee members praised the stoplight chart, calling it a model for every mission under development and particularly strong at showing trends. It would be helpful to see that kind of information going forward. Mr. Howard called APS attention to the list of events on the right side of the chart. NASA can only move $499,000 without approval from Congress and the Administration, which prevents quick reaction to problems. Separating JWST from other programs can help resolve these issues to a certain extent, as there will be less competition for attention and funds. When asked if he felt he had programmatic and cost insight into the spacecraft, Mr. Howard replied that the project manager reviewed all of the elements and sub-elements, including the spacecraft, in order to have a high level of confidence in the replan.

R&A Update

Dr. Linda Sparke, Research Program Manager for APD, began this presentation with a review of the Research Opportunities in Space and Earth Sciences (ROSES) competition data. The Strategic Astrophysics Technology, Astrophysics R&A, and Astrophysics Data Analysis areas all received many more proposals than in the previous year, allowing the Program to be more selective. In response to a question about the low levels of acceptance in some areas, Dr. Sparke explained that proposals in some of these areas are also submitted at the National Science Foundation (NSF), which tends to increase the total number of submissions; NASA tries to make timely decisions so that the unfunded investigators have time to rebid elsewhere. It was suggested that that balance should be achieved without regard to NSF.

Dr. Sparke noted that the overall Astrophysics Research funding has been flat since about 2008. In FY11, awards through ROSES accounted for $73 million of APD's total $124M research budget. The ROSES research awards have been spread rather evenly among astrophysics data, theory, high energy, and radio-sub-millimeter/infrared, with somewhat less going to research on cosmic rays and optical/UV, and very little to Origins of Solar Systems, a program run jointly with the Planetary Sciences Division (PSD). These ratios have not changed over the last several years. This information does not cover funding for guest observers, even though some of these are competed through ROSES. The FY12 President's Request includes a budget increase of $7 million for R&A, with substantial increases projected thereafter.

A new program, the Nancy Grace Roman Technology Fellowship program, has been launched as a way to encourage young people on the path to becoming Principal Investigators (PIs), enable innovative technologies with the potential to enable scientific breakthroughs, and put the fellows on a trajectory toward long-term positions. The program allows early-career investigators in non-tenured positions to propose a 1-year concept study for a technology project that leads to a 4-year development effort. Peer review of the concept study reports will be used to select the investigators to be funded for the development effort. The fellows must obtain an institutional commitment to lab space and other necessary facilities. The first proposals are due on 18 November 2011, with expected funding for three to six concept studies. It is expected that about half of the concept studies will result in the development funding. Dr. Sparke will look into establishing a forum or symposium for the fellows to interact with each other.

Senior Review Preparations

Ms. Jaya Bajpayee, APD Program Executive, explained that the Senior Review is the highest level of peer review. Each project subject to the Review process has completed its prime mission. Held every two years, the Senior Review evaluates proposals for continued funding of Astrophysics operating missions, which have completed their prime. The APD uses the Senior Review results to maximize scientific productivity of its operating missions. The Division will use the findings of the 2012 Senior Review to:

- Prioritize the operating missions and projects.
- Define an implementation approach to achieve astrophysics strategic objectives.
- Provide programmatic direction to the missions and projects for two fiscal years following the senior review (FY 13 and FY14)
- Issue initial funding guidelines for the 3rd and 4th fiscal years following the senior review (FY 15 and FY 16)

The Review ranks the projects by their science merit taking into account the dollars required, and APD uses the ranking in implementing its strategic approach. The 2010 Senior Review ranked GALEX, RXTE, the International Gamma-Ray Astrophysics Laboratory (INTEGRAL), and Warm Wise missions last, and those missions are now either decommissioned (WISE), about to be decommissioned (RXTE, GALEX) or ended their partnership (INTEGRAL).

New projects under consideration by the 2012 Senior Review are Fermi, Kepler, and HST. The Review will also look at Planck, Chandra, Warm Spitzer, Suzaku, Swift, and X-Ray Multi-Mirror Mission (XMM-Newton) again. The final report is expected to be issued March 30, 2012. Missions that have reached their end and are not invited to present to the Senior Review will cease operations as originally scheduled.

Senior reviews now include the great observatories, affecting the financial equation with respect to when only Explorer missions were considered. Since there are substantial cost differentials among the projects, the Senior Review Committee is asked not to arbitrarily distribute funding among the projects. These reviewers are senior scientists who evaluate the science output and reach of each project; they may recommend eliminating portions of a project whose science merit is not sufficient for the required dollars. If a portion of a project is eliminated, then those funds may be redistributed among the other projects in the review. Some survey missions, such as WMAP and WISE, which have stopped collecting data (i.e., satellite operations have terminated), continue to receive funding for final data analysis and project closeout.

In Summary, there's substantial difference in the size of missions being evaluated in the 2012 Senior Review, the ranking has an impact on their continuation, the criterion is science per dollar, and APD does not know what the results of the review may be. All of the missions invited to the Review are in an extended phase and have done what they were designed to do based on their Level 1 science requirements.

Dr. Heap remarked that, as learned at a previous APS meeting, while RXTE was producing high-quality results at a minimal cost, the 2010 Senior Review Committee chose to fund missions with higher science output. She asked if APD could present APS with a pie chart that shows a break-down of the investments in R&A. Mr. Yoder promised to provide the information by the end of the meeting.

WFIRST Project Office Update

Dr. Neil Gehrels, an astrophysicist at GSFC who was participating via phone, explained that WFIRST is a near-infrared wide field telescope that will measure the expansion of the universe and increase our knowledge of dark energy, while completing the statistical census of galactic exoplanetary systems. Although the current design meets the requirements of the NWNH report, there have been some updates, such as a 1.3m unobstructed telescope.

WFIRST is currently based at the Jet Propulsion Laboratory (JPL) under the exoplanet exploration program. This is a collaboration with GSFC in which Goddard is responsible for project management, system engineering, and instrument and spacecraft management. JPL participates in system engineering and is also responsible for telescope design and implementation and the data center. Dr. Gehrels identified the members of the Science Definition Team (SDT) and provided an activity summary, noting accomplishments to date and ongoing activities.

An independent cost estimate performed by Aerospace Corp. came to within 7 percent of the $1.6 billion estimated by NWNH. There was no reconciliation of the two estimates since they are so close to each other. The Aerospace report said that "[t]he project has presented a feasible technical design consistent with stated science goals." A requirements flow-down traces the science requirements from the top level objectives to make sure that there is consistency.

For the Detector Array Engineering Development Unit (EDU), NASA is purchasing detectors from industry and has been populating a 3X6 array. These detectors can be close-pack operate to the desired performance goals. The HgCdTe detector studies address potential issues for weak lensing galaxy shape measurement. Initial tests are encouraging and indicate that the detectors can be used for galaxy shape measurements in the near IR. Dr. Gehrels also discussed current and future pixel scale study, sky tiling simulations, and exoplanet microlensing simulations.

An important goal is to engage the science community. NWNH combined a number of different mission concepts in WFIRST, and the team is reaching out to those who might have ideas how to use the mission or alter its design. The team also hopes to engage the public.

Discussion

Dr. Boss asked if there were any simulations funded to address the sky surveys. Dr. Gehrels thought that that was being covered but said he was open to requests to look at other approaches. The scientific output will be the focus of some of the outreach workshops, which the team is opening up to a range of speakers and papers. In response to a request to compare WFIRST and Euclid, Dr. Gehrels explained that the WFIRST aperture is bigger and unobstructed; Euclid concentrates on the visible band and WFIRST on the near infrared; the pixel scales are finer on WFIRST for NIR; and the lifetimes are comparable. WFIRST is distinguished by exoplanet microlensing; the supernova program; weak lensing shape measurements in near infrared; a cleaner Baryon Acoustic Oscillation (BAO) survey with a prism; and a deeper NIR sky survey with finer pixels. WFIRST will not spend as much time as Euclid on the dark energy sky survey but will achieve comparable overall progress on dark energy studies.

It was noted that both missions have the same primary period, but WFIRST has three equal goals. Dr. Gehrels was asked how the two missions compare on dark energy alone. He replied that WFIRST has up to 3 years for dark energy measurement. The standard figure of merit is comparable for WFIRST for dark energy compared to Euclid. WFIRST will conduct some control measurements. Dr. Jason Kalirai, participating by phone, added that per unit of time, the missions are comparable. The design on WFIRST is more robust, especially in regard to weak lensing. Dr. Gehrels said that if the time aspect is removed, the raw figure of merit is comparable between the missions. Dr. Arjun Dey said that it sounded like the figures of merit had changed. Dr. Paul Schecter of MIT, participating by phone, explained that WFIRST does what Euclid does in less time, then does more. Four figures of merit are combined into a single number.

Dr. Ritz asked about what could be done with the Euclid hardware. Dr. Gehrels said that the Euclid mission is limited to dark energy, BAO, and weak lensing. It will not include supernova research. Euclid is not prepared for exoplanet microlensing. Dr. Kalirai, of the Space Telescope Science Institute (STScI) responded to another question by stating that the simulation data will be accessible, though they are not yet available.

Exoplanet Roadmap

Mr. Michael Devirian, Exoplanet Exploration Program (ExEp) Manager, began by pointing out that because the budget landscape has changed so much since the DS was issued, there might not be funds for an exoplanet flagship mission. The ExEP must plan to mitigate this risk. The DS was enthusiastic in addressing exoplanets, particularly Earth-like planets, a goal which requires a flagship mission. NWNH also advised NASA to support technology development to enable a down-select of candidate mission architectures by mid-decade, and then increase funding to prepare a flagship mission concept for the next Decadal Survey to consider.

While it may even be optimistic to think of 2020 as the next chance to get a mission going, ExEP will continue its competed technology program, the Technology Development for Exoplanet Missions (TDEM), and will continue precursor science work, such as Keplerin order to develop the DS mission concepts for leading technologies, and have mature mission concepts ready for the 2020 DS, as recommended. Parallel activities include working with cosmic origins for a potential joint UltraViolet/Optical (UVO) mission. Possible precursor science projects may be done with small, competed missions and ground observing.

The greatest risk to a flagship mission is the lack of available funds. Many factors may make a flagship impossible in the next decade. Yet another delay of 10 or more years in significant NASA exoplanet science advancement will have negative impacts on the health of the community and the field. Therefore, in addition to arriving at 2020 with a compelling argument for a flagship mission, the Program is planning mitigation activities that involve developing design reference missions for smaller strategic missions, like off-ramp mission concepts, in the $350 million to $1 billion and $1-2 billion cost categories.

Steps in developing probe-class exoplanet missions include the following:

1. Have the Exoplanet Exploration Program Analysis Group (ExoPAG) create a study analysis group (SAG) for probe-class-size missions similar to what has been established for flagship missions.
2. Identify the science questions, measurements, and key performance requirements.
3. Ask NASA to issue a Request for Information (RFI) for a minimum number of concepts by Fall 2012, with responses analyzed by the ExoPAG to define a set of compelling mission concepts for further study. *(Note: this reflects refined planning subsequent to the APS presentation.)*
4. Select community science teams to review the RFI responses and develop mission concepts at the various cost points.
5. Including a re-evaluation at mid-decade, develop mature concepts to present to the DS in case a flagship proves unaffordable.

Discussion

Dr. James Kasting pointed out that this idea had been run by the ExoPAG steering committee, which concurred. It was observed that Mr. Devirian defined “risk” as financial, but it could also be defined as not making progress. Mr. Devirian replied that the trigger for the risk is not having funds. Dr. Sara Heap said that a decade could be lost by thinking only in terms of a long-term flagship mission. She did not see anything in the presentation about follow-up on the Kepler mission, for example. Mr. Devirian said that his team would be happy to have advice on a Kepler follow-up. He did not mean to imply that a probe mission would start before 2020, just that there would be anticipatory studies. Dr. Heap advised looking at what can be done on the ground and through Kepler, which offers many candidates. She also said that people are already thinking about Explorer and probe class missions for exoplanet work, but they are not keen on joining a group to define a mission concept. She said that she understood the need to invite proposals, but it was not clear what would be gained from another round of strategic astrophysics studies in this area, which she asked Mr. Devirian to address. He said that the studies would be a kickoff. In addition to learning a lot about technology, there has been scientific progress, so some concepts need updating.

Dr. Kasting said that Kepler is producing a lot of false positives, and the follow-up can address only the largest planets, which are of the least interest. Dr. Boss suggested that ExoPAG will address this. He asked for approval of Mr. Devirian's proposal. Approval was unanimous.

PCOS and COR Roadmaps

Addressing the Physics of the Cosmos (PCOS) and Cosmic Origins (COR) Programs was Mr. Mansur Ahmed, PCOS/COR Program Manager at GSFC. The PCOS objective is to understand how the universe works, and how the basic building blocks of existence behave under the extreme conditions of the evolving universe. PCOS incorporates cosmology, high-energy astrophysics, and fundamental physics projects aimed at addressing questions about complex astrophysical phenomena such as black holes, neutron stars, dark energy, and gravitational waves. There are currently four projects under the Program: Chandra, Fermi, Planck, and XMM-Newton, with the Space Technology-7 (ST-7) in development for a 2014 launch.

The COR objectives are to discover how the universe evolved and how it works, expand understanding of the Earth and the universe, and search for Earth-like planets. COR currently has three operating projects: HST, Herschel, and Spitzer. GALEX is an Explorer mission with COR science which will be terminated this year, and WISE is in the data analysis phase.

A program acceptance review was just conducted under a Standing Review Board (SRB). The SRB found that the strengths of the scientific objectives are well aligned to the recommendations of NWNH, the program offices are well organized, and the technology and risk management plans are sound. Concerns include a lack of a viable 10-year roadmap for PCOS, and the health of the scientific community due to budget cuts. Included in the COR program is de-orbiting HST, further impacting the APD budget. No plans have been made for this project yet. Options include bringing it down into the Pacific Ocean or boosting it to a higher orbit. The program office will strive to engage other organizations in partnership for this mission to minimize the cost to the Astrophysics division.

Missions under study include concepts for an x-ray observatory, gravitational wave observatory, CMB inflation probe, UV/O observatory, and the Space Infrared telescope for Cosmology and Astrophysics (SPICA) with JAXA. Science and budget requirements for these missions are still being determined. The question is whether there are lower-cost missions that can do part of the science endorsed by the Decadal survey. The APD issued two RFIs in September soliciting mission concept ideas for X-ray and GW observatories in the cost range from $300M to $1-2B, to be discussed by the community in two upcoming workshops in December. The workshops will be coordinated by Community Science Teams, for which nominations have also been solicited through Dear Colleague letters. The CST, together with the science and engineering teams, will be reviewing the responses to the RFIs and identifying common needed technologies. The CST will write a final report to be presented to NASA and to the CAA for input to NASA on the way forward.

Discussion

A question was asked about the role of the Study Analysis Groups (SAGs) of the PAGs with respect to the RFIs and the ensuing workshops. The resulting concept studies are independent of ESA's Advanced Telescope for High Energy Astrophysics (ATHENA) or the Next Gravitational-wave Observatory (NGO). Ms. Bajpayee added that $650,000 is allocated for each study, with $50,000 of that for the workshops. In response to a question, she said that she would come back to APS with the amount spent on WFIRST development and International X-ray Observatory (IXO) and Laser Interferometer Space Antenna (LISA) follow-on.

Dr. Ritz argued that NASA is asking the community to perform a lot of work to develop mission concepts for which the likelihood of occurring is very small. The answer was that NASA is not funding missions at this stage, but only

collecting feasible scenarios that address the IXO and LISA science and at which cost, to be presented to the mid-decadal review (CAA) for their input on how to proceed

Mr. Ahmed said that this will be the first of many steps. The intent is to come up with possible scenarios of missions addressing the NWNH priorities for CAA consideration. These missions could be US-led entirely, since ESA is moving forward with the downselect of M-class and L-class missions led by Europe only and that it is too late at this point for NASA to partner with ESA. Dr. Ray remarked that partnership between the two Agencies should be pursued aggressively in the very early stages of mission concept development, and cited LOFT as an opportunity for the M3-class.

Regarding the L1 selection in January, Mr. Ahmed said that this could be the selection of one project or a down-select of two. He repeated that the intent of the RFIs and workshops is to be prepared, and be ready to move forward after ESA's decision. Dr. Kasting said that the main problem is that the timing of NASA and ESA's Decadal reviews and ensuing planning is not coordinated, and that this will be difficult to orchestrate. Dr. Ritz maintained that the community should be informed promptly ahead of NASA's decisions, and that the timing of the two RFIs was rushed because no information about funding is yet available.

Dr. Sambruna said that the timing is dictated by the need to present to the CAA in spring 2012. Ms. Bajpayee explained that the intent is to both collaborate and have NASA-only missions. The DS set science priorities, so it is important to determine which of those priorities can be met for lower costs. A possible outcome is that this is not possible within the cost cap, and if so, this conclusion will be presented to the CAA. .

Concerning the COR program, Mr. Ahmed said that UV/O telescope mission concepts are under study and will be examined in early 2012. Regarding SPICA, the COR office is working with JAXA, which requires a contribution that NASA cannot afford at this time but is considering. JAXA is aiming at a system design review in April 2012 and a launch in late 2018.

LISA and IXO have been developing technologies for a long time, but those missions no longer exist. The Program has chosen four of these technologies for a 1-year continuation, in the event of a possible contribution to the ESA M1 mission. A special Technology Management Board (TMB) was created to prioritize continued investments beyond FY12. When asked for clarification on the origin of the support, Mr. Ahmed explained that the funds originate from the directed work line of APD budget, intended to maintain core capabilities. Ms. Bajpayee took an action item to provide more detail on this at a future meeting. Mr. Ahmed said that the combined total for the four continued projects will be $2-3 million. This will all be competed starting in FY13.

Dr. Ritz asked who would address the concerns identified by the SRB. He reiterated that specifying realistic potential funding wedges and timeframes would be ideal to motivate the Teams, who are being asked to develop extensive work with no guarantee of implementation. Mr. Ahmed agreed with a recommendation to focus on the smaller missions, as the funding of $1-2 billion missions could be difficult to obtain before JWST is launched and, when available, would likely to be absorbed by the WFIRST project first. Drs. Ritz and Dey remarked that the it will be unlikely that large funding will be available for other missions besides JWST and WFIRST, given the current constraints.

Dr. Heap noted that NWNH endorsed Explorer programs but not probe-class missions. She subsequently learned that the probe-class missions were all expensive flagship missions. It was not clear why the cost estimates were so skewed. In conversation with people at Aerospace, she has learned that they do not share costing information or practices. She suggested that PCOS and COR help scientists by developing costing mechanisms. Dr. Boss recommended trying to reverse-engineer the Aerospace costs. It was observed that paying for cost models might not be good use of time since NASA cannot fund much of this work to begin with.

Q&A Session/Discussion

Dr. Boss read from the 2010 letter on which APS voted regarding participation in Euclid. The great majority of APS voted to collaborate with ESA on Euclid, and more wanted 20 percent than 33 percent involvement. However, the NRC went in a different direction. Dr. Kasting said that NASA should participate in Euclid. It does not make sense to do WFIRST afterwards, Kasting said, as NASA would retread a lot of ground while there are other flagships waiting to fly. The duplication of something that will be done reasonably well by Euclid did not sit well with him.

It was added that in 2020, it seems unlikely that WFIRST will still be compelling. Dr. Ritz said that he would vote for Euclid participation this time because he wants to see the science done. There are two issues. The first is opportunity costs and what will not happen if certain missions are funded. The second is that they must keep the DS process valid, as it has kept NASA effective. APS should encourage NASA to explore ways to broaden the science of Euclid without a change in hardware.

It was noted that at the time of the vote, the DS had just been issued. Dr. Ritz said the APS should make a recommendation that will not be shot down because it conflicts with the DS. Dr. Heap, who abstained in the first vote, said she would like to vote for Euclid participation now. It could be that the United States will not need WFIRST if NASA partners on Euclid. This goes against the DS grain, but that was based on a 2009 timeframe, which was before Kepler. Now they see that Kepler produces wonderful results on the frequency of Earth-like planets, which reduces the need for a microlensing survey as well. Dr. Kasting agreed, adding that the European High Accuracy Radial Velocity for Planetary Searcher (HARPS) survey is producing ground-based estimates of the frequency of super-Earths. Another member called attention to the augmentation of the Explorer program element of the DS, planning for which is underway in the APD.

Dr. Marybeth Kaiser maintained that much has changed since the DS, and suggested that one option might be to raise the ceiling for mid-Ex missions. Dr. Dey advised looking at the DS more as identifying the key science, with less emphasis on specific missions. APS could recommend determining whether NASA could accomplish that science through participation in Euclid, which could enable U.S. science on a mission that accomplishes part of WFIRST. Another idea was empowering NASA to explore a Euclid collaboration that might extend Euclid or put WFIRST science on smaller platforms.

Dr. Ritz did not recall the DS stating that dark energy was the highest priority science; it said that the combination of the three missions made WFIRST the highest priority project. He would need time to think through the comment about the Explorer missions. That is why opportunity costs and having CAA look at this are both important. Dr. Gary Bernstein said that NASA's participation in Euclid should have little to do with what WFIRST will or will not do. It is an opportunity to invest toward achieving the highest science goals. NASA could participate in Euclid at less than 20 percent. The consideration should be what NASA, ESA, and the science community wants to know. Dr. Kasting said there was also a broader context of pulling in ESA and possibly JAXA participation on a future flagship mission.

Dr. Boss confirmed that the consensus was that Mr. Yoder should be amenable to Euclid participation. He asked Dr. Ritz to write a statement on that for the next day. He asked about percent involvement. Dr. Kasting said that 20 percent was the right figure, but NASA should not give it away for nothing. NASA should get a say that does not include hardware changes but does direct some of the observations to be performed.

Mr. Yoder reminded APS that his upcoming ESA meeting was a fact-finding mission to learn what was possible. Dr. Ritz suggested that he learn what it would take to expand the scientific goals and what can NASA do to make that happen. Dr. Kaiser agreed, saying Mr. Yoder should determine the easiest achievable change with the biggest impact. NASA should be a credible partner and show an interest in collaboration. Dr. Bernstein noted that Euclid is

an 800-person collaboration, so NASA will have to target its participation. NASA cannot make significant changes and should make sure the Agency can do its science within what has been defined. Mr. Yoder said that he would find out what was possible. He sought to keep stakeholders in the loop.

Dr. Boss adjourned meeting for the day at 5:31 p.m.

October 20, 2011

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

ExoPAG Activities Report

Dr. Kasting reviewed activities since the previous meeting. The focus has been on whether there could be a flagship mission for exoplanet UV/O discoveries. ExoPAG is considering two different mission designs and is developing science requirements that exclude neither. The Group has been a bit slow due to personnel issues, but that is not a problem since the NASA imaging performance study has been postponed due to budget issues. Dr. Heap had previously asked questions about the SAGs, which will be reported on within the next couple of months.

In addition to concerns about the existence of a flagship mission in the 2020-30 timeframe, a growing community of young astronomers must have access to new exoplanet data, and that is an issue. In addition, while some activities can be done from the ground, others must be done from space. ExoPAG plans to collaborate with the Cosmic Origins Program Analysis Group (COPAG) and possibly the Physics of the Cosmos Program Analysis Group (PhysPAG).

The good news is the science: exoplanets are being found all over the universe. A question about European exoplanet opportunities was answered by a NASA employee, who said that an exoplanet characterization mission, FINESSE, is in competition in the M3 class, and it is similar to Spitzer. Dr. Kasting explained that a few weeks before the meeting, a paper was published summarizing observations of 822 stars over 8 years. More than half of these stars were observed to have at least one planet of any mass with orbital periods up to 100 days. The analysis indicates that low-mass, rocky planets are around most stars, with high-mass planets only around the metal-rich stars. Dr. Kasting presented a table of the occurrence frequency of stars with at least one planet in the defined region. The Sun is a typical G star, and about 70 percent of F and G stars have a planet with a period of up to 100 days. This analysis technique does need some improvement due to the noise factor.

Another table showed detected planets with less than 50 days orbit, from the somewhat less sensitive η_{EARTH} survey by Andrew Howard and colleagues that is similar to the previous analysis. (Both surveys were done using the radial velocity technique.) A figure presented the occurrence rate of short-period planets (<50 days). Other data from NASA's Kepler Space Telescope indicate that rocky, Earth-like planets are abundant. These do not include small planets with longer orbits, which would be more difficult to detect, and the data do rely on some extrapolation. The planets most like Earth are the hardest to see. Dr. Kasting showed that there are multiple types of planets, currently divided into Earths, super-Earths, Neptunes, and gas giants.

Kepler is making great progress, and even those not on the team are using the data. Two different estimates of the parameter η_{Earth} have now been published based on the February 2011 Kepler data release. (η_{Earth} is the fraction of stars that have at least one rocky planet within their habitable zone.) One is 1-3 percent, the other is 34 percent ± 14 percent. The difference has to do with whether one assumes that the data are complete for orbital periods greater than 42 days. They obviously are not, so the second estimate is arguably better. This shows the need to see a longer Kepler dataset. The data release is being accelerated, according to Dr. Boss, who added that there are so many candidates that the Kepler team cannot to do it all, and non-team members are finding things as a result. Dr. Kasting

said that as Kepler goes to longer orbital periods, they will be sampling planets close to higher mass stars, more like our Sun, and the result is less error. NASA may have erred in canceling SIM, because the noise put out by the stars makes it difficult to find nearby Earths around Sun-like stars using radial velocity. However, based on the new RV and Kepler data, a direct imaging mission should have many targets, so such a mission need not be large and expensive. It should be a high priority for NASA.

PhysPAG Activities Report

Much work occurred after the last APS meeting, mostly by the TechSAG and the Inflation Probe (IP) SAG. Dr. Ritz explained that the TechSAG had prepared material for an upcoming NRC study, with the focus on PCOS technology assessment, which had gone out for comment. TechSAG also coordinated with IPSAG to develop the IP near-term and future technology requirements. Overall, the emphasis was on information gathering rather than prioritization. Updates were being made in response to comments on the PCOS technology assessment, which was divided into two categories: technology in support of the NWNH goals, and advanced technology for future possibilities. With APS concurrence, PhysPAG will formally provide the materials to the PCOS office for posting them online. Similarly, the IPSAG established a committee to define a roadmap, developed a 10-page roadmap document, and did some prioritization The action item here is to seek APS concurrence for submitting the roadmap to PCOS and post it online.

A new SAG focusing on gamma-ray science will be formed soon; a written 1-page proposal is in progress, led by Dr. Hays. The gamma-ray community will be presented with the proposal to encourage members to join the GammaSAG.

The next face-to-face meeting of the PhysPAG will be on Sunday January 8, 2012, at the start of the winter American Astronomical Society (AAS) meeting. The meeting will feature invited speakers on various areas of PCOS interest. A special session on Tuesday January 10, 10-11:30am, will be held jointly by the three PAGs. The next meeting of the PhysPAG could be held at the American Physical Society meeting in April 2012, though no date has been set yet.

Discussion

Dr. Chris Martin asked the extent to which IP is driven by systematics and technology development. Dr. Ritz replied that the systematics must be understood better before embarking on a large mission, and some technology development would be necessary. He noted that the January AAS meeting will address input from NASA, as much of the technology was based on LISA and IXO technologies, but there are also push technologies and systems that LISA and IXO need that any other mission would need as well. These were all gathered as inputs.

Dr. Boss asked if there was anything that APS explicitly needed to approve. Dr. Ritz explained that the action items were more to inform APS, but that choosing priorities will be necessary.

COPAG Activities Report

Dr. Martin explained that COPAG had been busy with its technology roadmap. Tasks for 2011 included the SAG1 science objectives for a next generation UVO-IR flagship mission; SAG2 determining the technology focus areas for a monolithic 4m aperture UV/Optical/NIR mission with internal coronograph for exoplanet imaging; SAG3 identifying the technology focus areas for a segmented 8m aperture with external occulter for exoplanet imaging; and SAG4 selecting the technology focus areas for future far IR instruments.

COPAG has had several meetings, including a community meeting in September. A draft memo captures the community and COPAG distillation of the inputs. Dr. Martin hoped to send this document to APS, then provide it to

the community a month before the January 8 AAS meeting. The workshop summarized the science objectives for future cosmic origins missions and discussed high-level mission concepts. Among the latter were probes, which are preferred to flagship missions due to the long timelines of the latter. For far infrared, SPICA is slipping but still has a potential role. There was also discussion of the Cryogenic Aperture Large Infrared Space Observatory (CALISTO) and the Submillimeter and Far-Infrared Experiment (SAFIRE). The COPAG Executive Committee discussed technology assessment and prioritization, technology roadmapping, probes, and the need for a balanced program.

For the COPAG technology assessment, Dr. Martin showed an example of a science objective, that of tracing the flow of baryons from the Intergalactic Medium (IGM) to galaxies. The example incorporated the objective, capability, sample investigations, and technology requirements. Dr. Martin also presented a table from the draft memo, in which the science measurement requirements are mapped into technology requirements. The technology Figures of Merit are: 1. Current and projected performance; 2. Implementational and operational issues and risks; 3 cost/time to get to technology readiness Level 6 and leverage; 4. Relevance to and impact on possible future missions. The idea is to balance the finite pool of resources.

Dr. Martin next reviewed the cosmic origins technology priorities. The first category is technologies that are "mission enabling" and are the highest priority for immediate investment. The second category is "mission enhancing" and should be considered for investment contingent on science and mission prioritization. Finally, the third category is "interesting" but subsidiary to other needs, though some are also basic research.

COPAG requests to APS were to: 1. Approve the process; 2. Approve the technology assessment priorities; and 3. Approve the roadmap format.

Discussion

In regard to the timing of the downselect. Dr. Martin explained that these choices will be revisited at the next DS, creating a need for balance while not closing off promising avenues. As far as what might be lost in making the choices on a timeline, Dr. Martin said that the answer would be specific to the technology. This effort addresses higher level funding to provide more significant resources that can bring the technology to maturity and move a mission forward. Dr. Kasting added that ExoPAG and COPAG are partners. They hope to make the downselect by 2015 in order to have a technology focus, but there are delays. Dr. Heap said that the imaging performance study that was stopped has been controversial. The purpose was to help choose the right technology to put forward for investment. There is a large school in the exoplanet community that thinks a purely theoretical study will simply reflect the inputs, and that the only way to do a proper downselect is based on testing and performance. That school wants more funds for technology development. Dr. Kasting replied that the imaging performance study would not make the downselect. The question is whether that decision must be made by 2015.

Dr. Boss suggested APS approve the three requests. Approval was unanimous.

<u>Astro-H X-Ray Observatory</u>

Dr. Richard Kelley, a Research Astrophysicist at GSFC, explained that Astro-H is a JAXA mission with major U.S. participation. The mission, which is much bigger than Suzaku, will launch into lower orbit in 2014. The projected lifetime is 3 years, and the instruments include hard and soft x-ray telescopes, hard x-ray imagers, and soft x-ray detectors, along with a microcalorimater that the United States is providing. This is a broadband imaging spectroscopy project. Dr. Kelley briefly described each of the key hardware elements.

The x-ray calorimeter will be of most use to the U.S. scientific community. It is an attractive approach because it can provide extremely high resolution and offers a major advantage over dispersive spectrometers. The first flight array has been complete, tested, and accepted. Testing at Goddard indicates what the data will look like. It is a definite

improvement on Suzaku. The soft x-ray mirror for the x-ray calorimeter was also tested at Goddard and is now in Japan for further measurements.

Figures of merit for spectroscopy indicate that Astro-H will complement the dispersive spectrometers on Chandra and XMM-Newton. Dr. Kelley showed examples of what will be seen from Astro-H, comparing clusters of galaxies with what the HST produces. He also showed what the data would look like.

Both ground and especially in-flight calibration is necessary for success. Calibration is needed for the detector and mirror system, and flight calibration sources are installed as part of a filter wheel to ensure both gain stability and energy scale accuracy. Various filters on the filter wheelwill allow views of a very bright source. Dr. Kelley showed an example of a high-resolution image of filters that are internal to the dewar system demonstrating that they can be assembled without contamination. Half of the guest observer time will be for U.S. scientists. Data from all of the instruments, not just the x-ray calorimeter, will be archived for 1 year, then made available to anyone. Upcoming events are CDRs and engineering model tests over the next several months. Flight hardware will go to Japan in 2013, and the launch is in August 2014.

In answer to questions, Dr. Kelley said that the Guest Observer split has been approved for Phases 2 and 3, and the heaters will be tested on the ground. NASA's percent contribution to the mission is estimated to be about 20 percent of the total, which comes to around $60 million. (I would add that: A similar investment will be made for the US GO program). There is good synergy here, because NASA provides instrument expertise in exchange for a good deal on observing time.

NuSTAR

Dr. Fiona Harrison of the California Institute of Technology gave a status report on NuSTAR, which is the next astrophysics mission to be launched by NASA in March 2012. It will be the first focusing high-energy x-ray telescope, with much greater capabilities than CHANDRA and XMM-Newton. Dr. Harrison presented details of the project's elements and strengths, including the mega-sensitivity, imaging, field of view, timing, and spectral response. The energy resolution is much stronger than any other mission in this band by a factor of five or six.

This will be a Pegasus launch, no earlier than the first week of March 2012, when it will go first into lower orbit. NuSTAR will deploy a 10-meter mast one week later. Some of the ground operations will be conducted in partnership with Italy, and some through the University of California at Berkeley. There will be no proprietary data for the team. Instead, data will go into an archive for the community to use within a month, though the mission begins with a 6-month calibration period.

Dr. Harrison described the four key objectives, which will make up two-thirds of the observing time, with emphasis on extra-galactic and galactic surveys. The performance in the galactic surveys should be especially strong compared to current missions, and will provide a great deal of information on neutron stars, black holes, and white dwarfs. Extragalactic surveys will be the first sensitive surveys of their nature, and will show how black holes grow as function of redshift, independent of absorption; whether the obscured Active Galactic Nuclei (AGN) fraction increases with redshift; and whether heavily obscured AGNs reside in specific host galaxy environments.

Much additional science is planned or contemplated, and those projects are being selected. New developments now have the mission looking at the Sun. Dr. Harrison described the optics, focal plane, and mast. Thermal vacuum and vibration testing have been completed, as have acoustics and shock testing. Other tests, including the first motion test, are scheduled.

Issue and concerns include the first motion test, the original of which was aborted. There is also concern about the launch vehicle schedule, which was affected by the Glory/Taurus failure, as well as the launch schedule and the timing of the Senior Review.

Discussion

In answer to a question, Dr. Harrison said that there was an issue with one of the detectors, and two new ones were built to substitute the defective ones. They have been calibrated and are waiting for the first motion test, at which point the team will put in the two new detectors, realign, and proceed. NuSTAR was designed to be modular and easily refurbished.

There were plans to put test data out pre-launch so that the community can develop familiarity in working with the data, but the program team involved is small, so this could slip. Dr. Sambruna asked about the synergistic proposals with CHANDRA and XMM-Newton. Dr. Harrison replied that she had just submitted five XMM-Newton proposals for joint observations.. There are some agreements with PIs of other missions and ESA for joint calibration processes.

Dr. Mike Warner of JPL asked Dr. Harrison to compare NuSTAR to Astro-H. She explained that they are complementary. Astro-H has a hard x-ray telescope co-aligned with a spectrometer and is driven by spectroscopy. The sensitivities are comparable, but Astro-H emphasizes high-resolution spectroscopy in 2—19 keV with the calorimeter, while NuSTAR is focused on imaging and spectroscopy above 10 keV.

OCT Fellowship Programs

Ms. Claudia Meyer, Space Technology Research Grants Program Executive in NASA's Office of the Chief Technologist (OCT), spoke about the OCT fellowship program. The inaugural class of 80 students for the NASA Space Technology Research Fellowships (NSTRFs) represents 37 universities across the United States and includes 17 women. Under the fellowship, these graduate students will conduct space technology research. The program goal is to create a pipeline of highly skilled engineers and scientists. They are supported generously so that they can focus on their studies and research. Another type of "grant," the Early Stage Innovation-Space Technology Research Opportunities (ESI-STRO), will support low Technology Readiness Level (TRL) research in advanced space technology. This solicitation has not yet been issued, but the plan is to eventually award about 100 each year. The NASA fellowships are unique in that each student is paired with a professional mentor who follows and collaborates with the student over course of the fellowship.

Ms. Meyer explained that the NSTRF program seeks to form relationships with the students early. For NSTRF11, the requirement was that the student had to be within 12 months of starting his/her advanced degree program, whether it be an MS or PhD. There are many straight-to-PhD graduate programs, so OCT will probably revisit this. Currently, the PhD students receive 4 years of support. Some applicants had just received or were about to receive their Bachelor's degrees. Ms. Meyer reviewed the proposal components, such as transcripts and letters of recommendation, and went over the technology area breakdown structure. The evaluation criteria were merit, relevance, and academic excellence.

Broken out annually, the awards include $9,000 for the faculty advisor, a $10,000 on-site research allowance, $1,000 for health insurance, and $10,000 toward tuition and fees. In addition, M.S. students will receive a $30,000 annual stipend, while PhD students will have a stipend of $36,000. The expectation is that the total amount spent on the awards could go up to $20 million per year, with annual calls. Not all of the fellows will take 4 years of support, some may leave the program and some may even choose to switch over to another fellowship. Federal agencies convene monthly to discuss their practices in granting fellowships. The OCT fellowships may not be combined with another Federal fellowship or training grant, cannot be used for overhead at universities, and are not to be applied toward the purchase of equipment. While the tuition allowance may appear low, many schools waive the difference.

At this point, the geographical distribution may seem weighted to the Northeast, but that reflects the applicant pool. OCT awarded fellowships to approximately 22 percent of the applicants. It is likely there will be more applications in the future; this was the first year, and the call went out late due to the Continuing Resolution. Science-only proposals were noncompliant.

Of the 14 technology areas for the fellowships, the most awards were for in-space propulsion, robotics, and scientific instruments/sensors, with none in ground operations. The fellowships are not organized according to the NASA centers, but instead consist of small teams comprising a faculty advisor, NASA mentor, and fellow. Some students have expressed interest in getting in touch with other student/faculty advisor/mentor teams with whom they might collaborate, and the NSTRF team is working on a web-based tool to facilitate collaboration. Students will also meet at conferences in their technical areas.

Mentors can come from the NASA Centers and non-profit R&D laboratories. The inaugural class of NSTRF fellows features one mentor from the National Institute of Standards and Technology (NIST) and another from the Aerospace Corp. For non-NASA mentors, NASA pays the costs of the training grant, but the mentor's organization is expected to cover the costs associated with hosting the student. All mentors are expected to provide input to the Program.

Discussion
The review/selection process is organized by technology area. At least three people saw each proposal.

In answer to a question about long-term assessment, Ms. Meyer explained that OCT will try to track the fellows after they leave the program, which can be difficult; OCT is engaged in conversations with the Office of Education on long-term tracking of students. Some will remain in academia, but in the past, she has seen NASA-supported students pop up in all sorts of exciting places.

Dr. Dey noted the number of women fellows and suggested that OCT see how that correlates with the applicants. Dr. Ritz added that OCT could consider reaching out to schools that serve underrepresented communities. Many of these are near the "big" schools. Another thought was to make the students aware of international cooperation and issues. Ms. Meyer said that the program did not preclude participation in an overseas conference.

It is still not clear when the next announcement will come out. Dr. Oswalt asked if a mentor based somewhere other than at a NASA center or non-profit R&D laboratory would be acceptable. Ms. Meyer said that at this time, OCT is not sending the students to for-profit companies. Geographic proximity is not the driver, which is why the program includes $10,000 for the on-site experience.

<u>JWST Science Talk</u>
Dr. Kalirai noted that the JWST mission has been the focus of much discussion about policy and budget. His presentation updated APS on the science aspects of the mission, which is to be NASA's next great observatory. Astronomy is largely a photon-limited science, and in that regard JWST is much stronger than HST and Spitzer. Diffraction-limited science is another area in which JWST will provide a much broader range of new science insights. The mission's high-resolution instruments will provide the opportunity for some unique science. Dr. Kalirai showed the deepest image taken by HST compared to a simulated JWST image, in which the latter provides a much stronger resolution. Dr. Kalirai went on to provide details of the instrumentation, such as the NIRCam, NIRSpec, MIRI camera, NIRISS, and FGS.

A frontier science program at STScI gave nearly 200 participants the opportunity to discuss many of the science opportunities that JWST will present or enhance, such as lensing, redshift galaxies, star formation, and a wealth of other topics covering the spectrum of astronomical research today. In the planetary sciences area, JWST will observe solar system objects, provide long-term monitoring of the Mars atmosphere, and identify Kuiper Belt objects and dwarf planets, among many other capabilities. Kepler is currently discovering and characterizing exoplanets to a certain extent. JWST will expand on those capabilities significantly. An exciting application is the transit spectroscopy of Earth-like planets. Depending on the amount present, JWST will be able to detect water vapor on a planet, and thus provide important information about, for example, habitable-zone super-Earths.

Dr. Kalirai explained what JWST will be able to do with resolved stellar populations in the Milky Way. This is the first rung on the ladder that interprets our ability to understand the nature of the galaxy. The mission will be the first high-resolution infrared imager with wide field capability. The stellar population will come in much faster than it does now via HST; JWST will measure v = 30 M dwarfs in 10 minutes and will measure stellar mass function to the H burning limit in stellar populations out to 25 kiloparsecs in less than 3 hours.

Its spectroscopy instruments will enable JWST to measure simultaneous spectra for multiple objects, either randomly or targeted. The NIR imaging will complete the stellar inventory. There is synergy between the wide-field ground-based imaging, HST ultra-deep imaging, and 10-m spectroscopy. JWST will be able to directly measure the ages of stars beyond the local group, which cannot yet be done, while also measuring the extended star formation history. Dr. Kalirai explained that JWST will show galaxies in the first billion years, which are the seeds of today's galaxies. There are hints that the first big change in the Universe occurred about 500 million years after the Big Bang, and JWST will show a robust picture of that. A lot of research and ground-based work will be necessary before the data can be analyzed.

Another anticipated breakthrough for JWST will be in what it tells observers about the first supernovae. Dr. Kalirai showed what the light curves look like and how the infrared light dominates spectrum. JWST will provide new measurements of dark energy, and will characterize Cepheids in further galaxies. Dr. Kalirai ended his presentation by listing many other likely discoveries that he lacked the time to fully explain. As occurred with the HST, scientists could very well end up learning things that they do not anticipate.

Dr. Sambruna asked whether JWST and WFIRST will be redundant or complement each other on dark energy. Dr. Kalirai said that it depends on the metric. Dr. Dey noted that WFIRST and Euclid will look at dark energy differently from each other, and improve the constraints on dark energy parameters. Dr. Sambruna cautioned that funding entities will ask about the differences. Dr. Kaiser said that there are different constraints on different drivers. Euclid is not strong on the NIR, and WFIRST would be better than Euclid if it were a longer mission. Dr. Bernstein added that JWST will not be as strong on supernovae as WFIRST, as it will not provide the same kind of information about expansion history. Dr. Sambruna agreed that that was the case unless one checked the BAO constraints, where it will not have the same precision. Dr. Dey pointed out that the real issue is that the physics of larger distances are not well understood at this time.

Public Comment Period

Mike Warner from JPL addressed the previous discussion. He explained that Dr. Wendy Friedman of the Carnegie Institute has been leading a large project on Spritzer that looks at IR techniques to improve the Hubble constant. The first results are about to be published, and part of it relies on the Cepheids, as Dr. Kalirai said. There are things in the distance ladder that are much better done in the infrared than the visible. For both the Cepheid relationship and the Tully-Fisher relationship, the brightness of the infrared compared to the visible is absolutely extraordinary. Another limiting step in this process is determining the distance to the nearby Cepheids.

Discussion/Pending Issues/Meeting Report Writing

Euclid participation

Dr. Boss asked the Subcommittee to discuss advice to NASA regarding Euclid participation. The previous day, they had unanimously agreed that collaboration on Euclid is worthwhile and that Mr. Yoder should talk to ESA about the available options. No Subcommittee member had second thoughts about that advice.

Mr. Yoder also sought input on the 20 percent involvement figure. The Subcommittee had decided that the main value should be the payoff for the investment. Given that NASA cannot exceed 20 percent involvement, Dr. Boss wanted to know if the investment should be less than that. Dr. Kaiser thought that NASA should see what the options are before committing to a percentage, because it would be important to know the boundaries on any hardware upgrades or opportunities. If 10 percent ends up being optimal, for example, that is what NASA should commit. Dr. Boss said that the options will be presented at the November 21 teleconference.

Dr. Kaiser cautioned that the timeline creates urgency, due to the need for State Department approval. APS can make its decision, but other entities need to understand and act upon the relative immediacy of the situation. Dr. Kasting agreed, and suggested that Mr. Yoder also consult with the WFIRST team for their input regarding what might be improved on Euclid. Dr. Dey was concerned about what 20 percent really meant, noting that one can imagine a financial contribution or an instrument, but there is also value in the intellectual effort that has already gone into studying dark energy, and that is hard to quantify. Dr. Paul Ray pointed out that the 20 percent investment was Option C in the NRC post-DS report; he thought they should be consistent with the NRC report. Dr. Bernstein countered that APS should make it clear that there is no feasible way forward that is consistent with the NRC report. His concern was clarity in the arrangement, and he maintained that the United States should advocate having scientists involved in the analysis, ensuring that U.S. scientists get full and equal rights. Dr. Boss agreed that Mr. Yoder should keep that in mind.

Dr. Ritz observed that Option B in the NRC report is a joint mission. Much has evolved since the NRC report was issued, but it serves NASA well to stay as close to it and the DS as circumstances allow. From that standpoint, continued discussion with ESA is very important, and it would be productive to somehow achieve more WFIRST science goals in any collaboration. That leads to asking what ESA wants or needs in order to broaden Euclid. NASA should also inform ESA that the CAA is being stood up as quickly as possible. Dr. Vicky Kalogera asked if CAA requires a formal request. Dr. Boss explained that CAA takes precedence over the DS, as it is effectively the DSIAC called for in the DC

Dr. Martin asked whether NIR detectors that Euclid might use are a proprietary technology of the United States. Dr. Boss said that ESA is not requiring the detectors, but they had considered using them, and this constitutes a possible U.S. contribution. Dr. Martin thought that it was important to obtain community agreement to this as an option, though Dr. Boss believed that the APS meeting itself and the CAA both pulled in some community representation. Dr. Sambruna was concerned that an effort for community input would delay a CAA decision when the timeline is already very tight. Dr. Martin held that there are technical issues involved and differences of opinion about the observational approach. He has heard the WFIRST people say that Euclid cannot accomplish certain tasks, meaning that there are technical issues to address. He wondered if the U.S. community can have enough influence to make the design more successful, and therefore thought that a more expert group might be most appropriate to address technical issues. He urged the highest contribution possible.

Mr. Yoder reminded APS that the Euclid science team has established what the mission will do, and that NASA cannot redefine the science architecture. That is a constraint. Dr. Dey observed that there is a difference between changing and improving the mission. There might be better ways of doing some things. Dr. Hughes pointed out that the mission is highly refined and that it is extremely impractical to think about improving it. APS needed to decide how to advise NASA and to think about what the Agency can contribute. NASA will need higher-level advice to go

forward with this, and the CAA may not come on in time. He advocated proposing that CAA convene an ad hoc meeting to make that decision quickly. Dr. Boss agreed.

Dr. Ritz asked what specific question CAA was going to answer. He said that it was important to be mindful of the reality of science to be obtained in the next decade. It might be possible that Euclid's observing plan can be modified to evaluate the science better. He wanted to get the technical issues and uncertainties out of the way, and find out from ESA what is and is not frozen. Those two inputs are critical, and should be sought in parallel. Dr. Heap said that APS had come full circle on the discussion and should wait until Mr. Yoder reports back from his ESA meeting, at which point they can give more intelligent advice.

[The meeting was disrupted for about 20 minutes by a fire alarm and mandatory evacuation of the building.]

Mr. Charles Gay, Deputy Associate Administrator for SMD and Acting Associate Administrator for SMD, joined the meeting briefly. He had just spoken with NASA Administrator Charles Bolden about the appointment of the new SMD Associate Administrator, and was told the position would be filled within weeks. Mr. Gay meets with the Administrator at least three times per week. He explained that, in regard to the funding of JWST, the decision to spread half of the funding across SMD was an Agency decision, for which he did not foresee seeking APS input. The Senate language on controlling the future costs of JWST was not unexpected. It reinforces the requirement to manage efficiently.

In returning to the previous discussion, Dr. Boss asked whether there should be a formal group to handle the U.S. share of any collaboration on Euclid. This would not be an SDT, but it struck him that NASA should have active scientist participation. Mr. Yoder thought it would depend on the nature of the partnership. If there were to be a linkage between Euclid and WFIRST, such a group might be an option. However, he wanted to wait until after his return from Europe. Dr. Ritz suggested engaging the groups already thinking about the WFIRST SDT. Those with deeper technical expertise should be involved. There are questions about the WFIRST science goals and what can be accomplished with Euclid.

Dr. Bernstein said that despite the constraints, Euclid will require many decisions to be made in the future, and therefore the size of the U.S. voice will be in proportion to U.S. leverage. He suggested that there be a group of Euclid/WFIRST scientists in order to have a fully engaged science team and move into long-term planning. Although the Euclid science team has been chosen, there are a few Americans on it.

Dr. Boss asked if there should be a recommendation that the WFIRST SDT consider how they would redefine that mission's goals in light of the Euclid mission. Dr. Heap disagreed with this, saying it was premature to consider these teams. The future of WFIRST is in doubt. It will have to be reformed due to both Euclid and financial issues, and because the promise of Kepler is quite high, which the DS did not anticipate. She felt the scientific justification for WFIRST to be in question and advised letting the CAA sort it out. She noted that the CAA, DS, and APS are all on the same side, in that they all desire the best space science. However, the charge to APS is to give NASA the best advice, not to restrain themselves by the DS. APS should offer that advice independently of CAA.

Dr. Ritz said that in order to charge the WFIRST SDT with anything, the parameters of the launch timeframe and total cost are necessary. Cost determines design and timeframe, so thought must be given to that. Dr. Oswalt agreed, adding that some may construe enthusiasm for Euclid as undermining WFIRST, and APS should continue to endorse WFIRST at some level. Dr. Ritz said that fortunes change for missions, and this is a complex business that requires open minds. Dr. Kaiser disagreed with Dr. Heap's statement that the APS charge is to see that the best science gets done regardless of the DS. She advocated stating a justification for any deviation from the DS. Dr. Boss said that APS would hold its decision as a pending item.

Other missions

Dr. Ray returned to the discussion of having medium-class missions when larger missions are unlikely. One idea was to look at larger mid-Explorer class missions, or doing a mission in the $300 million range. The Falcon 9 launcher is versatile and might be available. Dr. Boss wanted more information before adding that to the letter report, but thought it would be a good agenda item for the next meeting. Dr. Kalogera asked if there could be a comment about further strengthening of launch vehicles, since this was a significant issue. Dr. Boss asked her and Dr. Ray to craft a paragraph on this topic.

Dr. Ritz thought they should mention that NASA's proposed offsets for supporting JWST will be painful but understandable. With the future of the plan unknown, he did not want to give the faintest hint of nonsupport for JWST. However, as members of the astrophysics community, APS members need to advocate that APD funding is way too low already. He had no proposal, but thought this was the time to say that things are already bad and that a large impact on APD would have terrible consequences. Dr. Heap disagreed, as they had been told that the JWST offset was being worked on and they would hear about it soon. She thought they should be quiet, and could not think of a helpful statement they could make. Dr. Ritz understood her point, but still thought they should bring this up.

Dr. Hughes described efforts to get university signatures to support the Senate budget instead of having costs come out in this way. The community is very aware of this situation and wants to support Mr. Howard's approach. If APS is silent, it will come across as negative. Dr. Bernstein agreed, saying that he would find it odd if they were silent in the face of a disaster and a possible disaster to come. They have seen missions shut down. There might not even be the nominal level of support for APD. He thought they should at least point that out without being judgmental about JWST. Dr. Ritz added his assent, stating that this was in the APS purview. They should express their concern.

Dr. Boss said that he learned that the issue with regard to re-starting the CAA is not NASA, it is the NRC. The CAA is a standing NRC committee. To write a report, there are many steps to go through, and they must have meetings. The feeling is that the CAA will not be able to respond quickly. The alternative track, to spin off an ad hoc group at NRC, can be painful. There is no clear path forward involving NRC. Dr. Sambruna also understood that to be the case. She found that CAA has no urgency and no missions, which endangers the Euclid timeline. Dr. Ritz repeated his call to make a statement.

Mr. Yoder did not believe that a comment or the lack of one would have an effect. JWST is in the APD sphere, so showing support would be a good gesture, but he is reluctant to mention costs. Dr. Kalogera was concerned that if APS says nothing, they could see APD gutted of other programs. No one wants to give up everything for JWST. Dr. Hughes thought that APD was getting a great deal from the division of costs and that APS should support the FY12 plan. Their counterparts in planetary sciences and heliophysics will not be making such a statement.

Dr. Ritz offered to draft a statement for APS approval. He proposed stating that APS had heard about the replan and appreciated the cost-sharing plan for this fiscal year, and that going forward, there is already insufficient budget to do most high-priority things in all divisions. Therefore, APS is extremely concerned about the budget situation. It was agreed that Dr. Ritz would write it and APS would discuss it, as some members thought it might be too negative while others wanted it to be more forceful. Drs. Ray and Kalogera were to assist Dr. Ritz with the statement, then send the draft to the other APS members for feedback. Dr. Kaiser recommended that they acknowledge the cost sharing but be cautious otherwise. The belt-tightening is not news, and she would stay away from that. She also thought they should avoid comments about the impact of JWST on the portfolio. This could be a no-win situation. Dr. Boss noted that Dr. Shaul Hanany had already drafted text about the impact of JWST on funding, and he suggested that it be considered in drafting the statement. In addition, Dr. Dey had sent an email about Euclid that Dr. Boss was going to review in order to determine where it might belong.

Dr. Boss reminded APS that they had approved the action items from the PAGs; the letter would include language about that. There will be a phone call about the PCOS roadmap. Dr. Heap had sent an email about the roadmap for exoplanets in which she said that APS recommends that planning include exoplanet exploration. He was going to put that into the draft letter so that members could react to it. Dr. Heap clarified that the exoplanet roadmap discusses only a certain portion of the exoplanet exploration theme, that of long-term goals. She wants to broaden the roadmap to include all exoplanet exploration.

Dr. Boss sought additional input on developing metrics for postdoc programs. They could assume that postdocs are successful based on whether they land a stable job and how many papers they publish, along with citations and invited talks. Dr. Gonzalez advised looking at the history of the person and where they started in terms of the institution in order to gauge the differential progress. Dr. Oswalt suggested including demographic diversity and the success of proposals. The applicant pool needs to be improved in terms of geographic diversity. Dr. Bernstein recommended constructing a control group from applicants who did not receive fellowships, to see what the program adds. Another recommendation was the number of years it takes to graduate. Dr. Boss observed that APD does not pay for the OTC fellowships. Mr. Yoder said that the metrics were needed regardless. Dr. Oswalt discouraged putting too much weight on publication, as two-thirds of research astronomers are not in academia. Mr. Yoder agreed. Dr. Sparke said that her program was told to be careful with metrics. NSF has a strong database of this type of data, and while it is hard to identify and collect, that does not mean they should not do it. Dr. Oswalt had a list of alternative metrics.

Briefing to Division Director

Dr. Boss led a quick review of comments to Mr. Yoder. Regarding the Senior Review, Mr. Yoder clarified that he had asked the projects going into the Review what they would do with augmentation funds. The Review will deal with FY13 and FY14. Much of this will be based on the President's FY12 budget request and the actual funds for FY11. Dr. Heap asked for a more detailed explanation of why certain things are postponed, which Dr. Yoder said he would provide at the November teleconference. He thanked APS for the active dialogue and discussion in which they helped APD think through some of the hard questions. Dr. Sambruna thanked him for stepping up at a difficult time and providing a tone of rational, calm engagement.

The meeting was adjourned at 4:09 p.m.

Appendix A
Attendees

Subcommittee members
Alan Boss, Carnegie Institution, *Chair Astrophysics Subcommittee*
Rita Sambruna, NASA HQ, *Executive Secretary*
Gary Bernstein, University of Pennsylvania
Arjun Dey, NOAO
Gabriela Gonzalez, Louisiana State University
Sara Heap, GSFC
John Hughes, Rutgers University
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 HQ
Jaya Bajpayee, NASA HQ
Richard Capps, JPL
Ruth Chiang Carter, NASA/GSFC
Joan Centrella, NASA/GSFC
Mark Clampin, NASA/GSFC
Chris Davis, NASA HQ
Michael Devirian, NASA/JPL
T. Jens Feeley, NASA HQ
Megan Gallagher, NASA/JPL
Jonathan Gardner, NASA/GSFC
Charles Gay, NASA SMD
Neil Gehrels, NASA/GSFC
Pam Horor, NASA HQ
Illana Harrus, NASA
Rick Howard, NASA SMD
Doug Hudgins, NASA HQ
Louis Kaluzienski, NASA
Beth Keer, NASA/GSFC
Richard Kelley, NASA/GSFC
Raymond Kinzer, Jr., NASA/GSFC
Lia LaPiana, NASA HQ
Peter Lawson, NASA/JPL
Claudia Meyer, NASA HQ
Mike Moore, NASA HQ
Marian Norris, NASA HQ
Anne-Marie Novo-Gradac, NASA HQ
Mario Perez, NASA HQ
Trent Perrotto, NASA HQ

Wilton Sanders, NASA HQ
Mark Sistilli, NASA HQ
Eric Smith, NASA HQ
Linda Sparke, NASA HQ
Tina Swindell, NASA HQ
Felix Threat, GSFC
Jackie Townsend, NASA HQ
Glenn Wahlgren, NASA HQ
Michael Werner, JPL
Greg Williams, NASA HQ
Geoff Yoder, NASA HQ, Science Mission Directorate, *Acting Director, Astrophysics Division*

Other attendees
Francesco Bordi, Aerospace
Kaitlin Chell, Caltech
Anne Connor, House Science, Space, and Technology Committee
Randall R. Correll, Ball Aerospace
J.P. Gallagher, Gallagher Group
Jason Kalirai, Space Telescope Science Institute
Dan Leone, Space News
Steve Price, LM
Eva Proszkow, NGC

Webex
Kenneth Anderson
Steve Benner, NASA/GSFC
Michael Bicay, NASA Ames
Joy Bretthauer, NASA HQ
Carol Christian, STSCI
Jean Cottam, NASA Goddard
Vince Elliott, NASA/GSFC
Kathryn Flanagan, STSCI
Dave Gallagher, NASA/JPL
Dan Golombek, STSI
Kevin Gredy, NASA/GSFC
James Green, University of Colorado
Richard Griffiths , NASA
Shaul Hanany, University of Minnesota
Fiona Harrison, CalTech
Hashima Hasan, NASA
Ingolf Heinrichsen, JPL
Bethany Johns, AAS
Chryssa Kouveliotou, Marshall
Jeff Kruk, NASA Goddard
David Lang, NRC
Stephen Leete, NASA/GSFC
David Leisawitz, NASA
Dan Lester, University of Texas

Marie Levine, JPL
Stephan McCandliss, Johns Hopkins
John McCarthy, Orbital Sciences
Julie McEnery, NASA/GSFC
Dwayne McMann, NASA HQ
Jon Morse, Rensselaer
Stephen Murray, Johns Hopkins
Cathy Peddie, NASA Goddard
Thai Pham, NASA GSFC
Jason Rhodes, NASA/JPL
Norman Rioux, NASA/GSFC
Paul Schechter, MIT
Ken Sembach, STSI
Marcia Smith, spacepolicyonline.com
Robert Smith, University of Alberta
Massimo Stiavelli, STSI
Mike Talley, NASA
Ray Taylor, NASA
Kathy Turner, NASA
Stephen Unwin, Jet Propulsion Laboratory
Lisa Wainio, NASA HQ
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. *FACA Briefing,* T. Jens Feeley
2. *Astrophysics Division Update*, Geoff Yoder
3. *JWST Program Status,* Rick Howard
4. *Astrophysics Research Programs,* Linda Sparke
5. *Astrophysics 2012 Senior Review Presentation to AAS,* Jaya Bajpayee
6. *WFIRST Project Office Update,* Neil Gehrels
7. *Exoplanet Exploration Program "New Worlds" Plans and Risk Mitigation,* Michael Devirian
8. *Program Status of PCOS and COR*, Mansour Ahmed
9. *ExoPAG Report*, James Kasting
10. *PhysPAG Status*, Steven Ritz
11. *COPAG Report*, Chris Martin
12. *The Astro-H X-Ray Observatory,* Richard Kelley
13. *NuSTAR,* Fiona Harrison
14. *Space Technology Research Fellowships, Claudia Meyer*
15. *Frontier Science with the JWST*, Jason Kalirai

Appendix D
Agenda

Astrophysics Subcommittee meeting
October 19-20, 2011
NASA Headquarters
AGENDA

Wednesday, October 19
Location: 9H40 (PRC)

8:30 – 8:35	Welcome and Conflict of Interest Review	A. Boss/R. Sambruna
8:35 – 9:00	FACA Rules	D. Rausch/OGC
9:00 – 10:30	APD Programmatic Update	G. Yoder
10:30–10:45	Break	
10:45 – 12:30	JWST follow-up	R. Howard/E. Smith
12:30 – 1:30	Lunch	
1:30 – 1:50	R&A Update	L. Sparke
1:50 – 2:10	Senior Review Preparations	J. Bajpayee
2:10 – 2:45	WFIRST Project Office Update	N. Gehrels
2:45 – 3:15	Break	
3:15 – 3:45	Exoplanet Roadmap	M. Devirian
3:45 – 4:15	PCOS Roadmap	M. Ahmed
4:15 – 4:45	COR Roadmap	M. Ahmed
4:45 – 5:15	Q&A session/Discussion	
5:15 – 5:30	Summary Day 1	A. Boss
5:30	Adjourn Day 1	A. Boss

Thursday, October 20
Location: 7H45 (Mic7)

8:30 – 9:00	EXoPAG Activities Report	J. Kasting
9:00 – 9:30	PhysPAG Activities Report	S. Ritz
9:30 – 10:00	COPAG Activities Report	C. Martin
10:00 – 10:30	Break	
10:30 – 11:00	ASTRO-H	R. Kelley
11:00 – 11:20	NuSTAR	F. Harrison
11:20 – 12:00	OCT Fellowship Program	C. Meyer
12:00 – 12:15	Q&A session	
12:15 – 1:30	Lunch /JWST Science Talk	J. Kalirai
1:30 – 1:45	Public Comment Period	
1:45 – 3:30	Discussion/Pending Issues/Meeting Report Writing	Committee members
3:30 – 4:00	Briefing to APD Division Director	A. Boss
4:00	Adjourn Meeting	A. Boss