NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

September 16-17, 2010

NASA Headquarters
Washington, D.C.

MEETING MINUTES

_____ _____

Alan Boss, Chair — Hashima Hasan, Executive Secretary

Table of Contents

Prepared by Elizabeth Sheley
Zantech Corporation

September 16, 2010

Introduction and Announcements

Dr. Alan Boss, chair of the Astrophysics Subcommittee (APS), convened the meeting by welcoming those present. Due to the large number of attendees, he did not have the usual round of introductions. Dr. Boss reminded APS members that they are subject to Federal Advisory Committee Act (FACA) rules. This meeting included a public comment period each day. Otherwise, only APS members were to participate in the discussion. In addition, he asked that each member state whether he or she had a conflict or potential conflict with any of the agenda items. Drs. Chris Martin and Ron Polidan agreed to withdraw from discussion of the James Webb Space Telescope (JWST).

APD Update

Dr. Jon Morse, Director of the Astrophysics Division (APD) of the Science Mission Directorate (SMD) provided an update on Division activities. He focused on four areas: science highlights, the astrophysics portfolio, accomplishments and significant events, and topics and context for astrophysics discussion.

Science highlights

The gravitational lensing observation with the Hubble Space Telescope Advanced Camera for Surveys (HST-ACS) was used to probe dark matter and discern its behavior. There is much more going on than any single waveband can indicate. NASA is using the Spitzer Wide Area Infra-Red (SWIRE) survey to look at distant galaxies, offering an interesting picture of what JWST will see. Dr. Morse also discussed the recently completed Wide-Field Infra-Red Survey Explorer (WISE) survey of the entire sky in four mid-infrared wavelength bands. Preliminary data will be released in spring of 2011.

Astrophysics portfolio and programmatic update

Dr. Morse presented a timeline of APD mission events. Near-term mission launches include the Stratospheric Observatory for Infra-Red Astronomy (SOFIA) early observations, planned for November 2010, and NuSTAR and LPF/ST-7, scheduled for February and June 2012, respectively. Due to a failed launch in Australia, the balloon campaign schedule has been pushed back until the investigation is complete. The total portfolio includes 15 missions, some of which are operating, with the others under formulation and development. Most involve international collaborations.

Accomplishments and significant events

Dr. Morse listed a number of APD accomplishments. SOFIA completed its replan Agency Program Management Council (APMC), provided full science operational capability with four available instruments, completed flight envelope testing to 45,000 feet and 40 degree telescope elevation, and completed FORCAST instrument line operations as the precursor to an early science mission planned for November.

In addition, NuSTAR's first flight x-ray optics module assembly was completed in August, the Astro-H science working group design meeting took place on September 7 in Japan, and the Wilkinson Microwave Anisotropy Probe (WMAP) completed nominal science data collection in August prior to the end of mission observing mode testing and the decommissioning review.

The Sagan, Einstein, and Hubble Fellowships solicitations are out. JWST is advancing in a number of ways, and the Large Binocular Telescope Interferometer (LBTI) is scheduled to achieve first light in October. Press releases are issued almost daily, indicating a level of productivity that should continue for the next several years.

Discussion topics

Dr. Morse presented the discussion topics, beginning with an overview of the Division budget and the Astro2010 Decadal Survey. Other items included basic research and enabling technology review, and the program analysis

groups (PAGs), which were to give updates and suggest agendas for their upcoming meetings. The Chandra Users Committee is scheduled to meet on October 25 in Cambridge, MA; the results of that discussion will be transmitted to APS.

APD strategic planning seeks to discover how the universe works, explore how it began and evolved, and search for Earth-like planets. The management strategy supports the priorities established in the National Research Council (NRC) decadal surveys. Each SMD Division has to manage its portfolio within its existing budget envelope. Projects in development must be managed to a life cycle cost (LCC) consistent with a 70 percent joint-cost-and-schedule confidence schedule, so that projects are planned realistically in terms of costs and can therefore stay on schedule, while using the workforce efficiently and optimally.

In "Optimizing the Science Program" the division seeks to maximize the science return from the resources allocated toward achieving NASA's strategic goals. This involves a balance of mission sizes. Success is measured by how many missions are launched and how many are doing high impact science, not simply how many projects get started.

The overall budget has decreased from 2008 but remains stable thereafter. The APD budget over the past 25 years, in constant FY 2010 dollars, shows a peak around 2004-08, which reflected large development budgets for GLAST/Fermi, Kepler, HST SM4, and JWST. Resources then shifted to other parts of SMD and NASA, and the budget is now around the early 1990s level in constant FY 2010 dollars.

By 2016, there will be fewer operating missions than in the current portfolio. The number of future missions could change somewhat should there be more international collaborations. The launch readiness date for JWST currently remains June 2014. The engineering or verification models for the science instruments are complete and the project continues making good technical progress on critical path items. The funding profile between now and the launch strongly influences the projected available resources that would allow APD to act on new Astro2010 initiatives. The JWST budget is about 40 percent of the total division budget. Although feedback has run the gamut, Dr. Morse believes that the best way to meet the goals of the Survey is to launch JWST as soon as possible. The Independent Comprehensive Review Panel (ICRP) will provide an assessment of the JWST launch date and funding profile in early October 2010.

Dr. Morse presented a graphic comparing the Decadal Survey request and the projection of resources through 2021. The "Blue Lake" guidance supplied to the Decadal Survey is slower to rise than the Survey recommendation. The Survey was more optimistic, and the President's budget follows it, but JWST replanning is expected to reduce the available funding in the FY2011 budget request. Therefore, APD will have to make some choices about which programs to implement. A senior review of operating astrophysics programs showed that, on a science-per-dollar basis, Chandra and Warm Spitzer provide the most science to the community among missions in extended operations. Chandra has the largest budget.

Dr. Morse next presented the Decadal Survey recommendations. The highest priority large space mission is the Wide Field Infrared Survey Telescope (WFIRST), followed by Explorer Program augmentation. The Laser Interferometer Space Antenna (LISA) and the International X-ray Observatory (IXO) are contingent on technology readiness and the European Space Agency (ESA) L-class mission prioritization. The Energetic X-Ray Imaging Survey Telescope (EXIST), and Space Interferometry Mission (SIM) were deemed not as compelling as other priorities and were not included in the Astro2010's recommended program for the decade. Another recommendation was to charter a Decadal Survey Implementation Advisory Committee (DSIAC). A concern is that advisory committees might give conflicting advice, and NASA is coordinating a response. The Decadal Survey also did not recommend any missions in the medium category, rather two technology development programs.

APD will soon move forward with WFIRST planning, with scientists representing all of the recommended programs defining project requirements. APD will also explore interagency and international partners. The schedule for WFIRST implementation will depend in large part on JWST. In addition, the European Space Agency (ESA) invited NASA to consider a 20 percent partnership on its proposed Euclid and PLATO programs. Such participation depends on compatibility with the Astro2010 science priorities, as well as the availability of funds. NASA has found that PLATO is not well-aligned with the Astro2010 priorities and therefore will not pursue a strategic partnership.

On the other hand, NASA determined that Euclid could be well-aligned with Astro2010 science priorities and could serve as a complement to WFIRST, providing the United States with access to certain types of dark energy data before WFIRST is launched. However, Euclid does not match the scale and scope of WFIRST, and it is important that the WFIRST science goals be supported with the United States as leader.

NASA has worked with ESA representatives on a revised concept for a potential ESA/NASA Euclid partnership in which NASA participation would increase to 33 percent. Four U.S. scientists would be assigned to the Euclid science team under this agreement. NASA would contribute about $260 million over 10 years, which is slightly less than missions solicited in the upcoming Explorer Announcement of Opportunity (AO). NASA would ask ESA to consider a reciprocal, cost-neural role on WFIRST. NASA is considering a near-term solicitation for U.S. scientists to join the Euclid consortium for next phase of study, through the June 2011 down-select process.

Decadal Survey Report

Dr. Roger Blandford presented a review of the Decadal Survey Report, "New Worlds, New Horizons in Astronomy and Astrophysics." The National Research Council (NRC) charge was to survey the field of space- and ground-based astronomy and astrophysics, recommending priorities for 2010-2020 activities at NASA, the National Science Foundation (NSF), and Department of Energy (DOE). The result was a science-driven report that included an independent analysis of risk, technical readiness, schedules, and lifecycle costs. The recommended program was reviewed under different budget scenarios. The three pillars of survey were science frontiers; the state of the profession/infrastructure; and, activities/program prioritization.

Five science frontier panels were each tasked with developing four science questions and one discovery area. The committee developed a recommended science program that is organized by the three science objectives representing its scope: cosmic dawn; new worlds; and physics of the universe. Success in attaining these goals will enable progress and foster unanticipated discoveries.

Dr. Blandford reviewed some of the recommendations included in the Survey. In the area of international matters, it was recommended that U.S. investors in astronomy and astrophysics consider a wide range of approaches to realize participation in international projects, with the long-term goal of maximizing scientific output through open access. This was accompanied by a recommendation for more coordinated strategic planning.

Astro2010 also recommended that astronomers seek and receive support for greater participation in policy-making organizations. Long-term professional development among young people, especially under-represented groups, should be encouraged. The Survey included additional recommendations in the areas of theory, computation, and data, and laboratory astrophysics.

The science objectives will be key in developing the program for the next decade. Challenges will involve evaluating cost risk and technical readiness, maximizing the scientific return under constrained budget guidelines, selecting the most urgently needed activities, and considering international and private partnerships.

Key programs

The review designated four large-scale space programs that NRC believed could be executed.

As the committee's top priority recommendation, WFIRST will emphasize three highly rated science areas: dark energy, exoplanet statistics, and guest investigator enabling of survey investigations. This was initially a spare, stripped-down project that is now more ambitious, and there have been some disagreements about the program. WFIRST will officially start in 2013 and launch around 2020, for a total project cost of $1.6 billion (2010 dollars). It is gauged to be medium-low risk and will be a key element of the ground and space programs in both dark energy and exoplanets. Discussions between NASA/DOE and ESA could lead to WFIRST becoming a joint program, with the United States as the lead.

The Explorer program is a successful program that delivers high impact science. The committee saw a strong case for augmenting Explorer, and recommended restoration of the Explorer line to enable the astrophysics launch rates originally envisioned. The proposed increase for this low-risk program is from the current $40 million per year to $100 million annually.

The LISA program will enter a new area of science using long wavelength gravitational radiation to detect space-time ripples from the very early universe. This program is expected to reveal the unexpected. LISA is an ESA/NASA partnership, with a recommend U.S. share of 50 percent. A LISA Pathfinder mission scheduled for mid-2012 must be successful for the program to go forward. Another condition is that ESA designate it as a first L-class mission. The total mission cost is $2.4 billion, with a risk level of medium, and a projected 2016 start and 2025 launch.

The fourth large program recommended by the committee, IXO, is a large area, high spectral resolution x-ray observatory to explore the hottest regions in the universe. It is expected to revolutionize x-ray astronomy, and requires additional technology development in order to go forward. Should the first three programs receive approval, there will be funds only for the technology development aspect of IXO. This will be a joint program with ESA and the Japanese Aerospace Exploration Agency (JAXA), with the U.S. share at 50 percent. This is a medium-high risk program, and the recommended funding is $180 million.

Dr. Blandford explained that although the annual expenditures for IXO would qualify it as a medium-sized program, the total cost over the length of the project puts it into the large program category. The Decadal Survey committee found it could not recommend SIMLite, given the large cost, lengthy timeline, and their opinion that it was not as scientifically compelling as the other programs.

The committee did recommend two medium-scale programs: the New Worlds technology development program and the Inflation Probe technology development program. One small program, the Space Infrared Telescope for Cosmology and Astrophysics (SPICA), was also recommended. This is a joint ESA/JAXA program in which NASA will contribute a far-infrared telescope. Four ground-based programs recommended by the Survey include the Large Survey Synoptic Survey Telescope (LSST), Mid-Scale Innovations Program, Giant Segmented Mirror Telescope (GSMT), and Atmospheric Cerenkov Telescope Array (ACTA).

Summary

Dr. Blandford discussed the budgetary context for the Decadal Survey and presented an example of the phasing of NASA's recommended program. It is expected that NASA will launch WFIRST, augment the Explorers, initiate LISA, augment the core research program, contribute to SPICA, and advance IXO and Inflation Probe technology development. Lower budgets would create a scenario in which WFIRST, Explorer augmentation, and smaller core research programs are maintained as priorities, while the SPICA contribution and other less-urgent programs would be dropped. Other recommendations include stewardship of the survey, benefits to the nation, mentoring of astronomers, and lab astrophysics.

In summary, this is an extraordinary time in the study of astrophysics. The recommended program is science-driven and will open up more discovery space. A balanced program should be maintained with international, private, and interagency collaboration. A serious effort has been made to appraise activity cost, risk, and technology readiness. A mid-decade decision should be made based on the recommendations from an independent, strategic advisory committee.

Discussion

Dr. Boss thanked Dr. Blandford. He noted the synergy between WFIRST and LSST, which have similar goals, and asked why both are necessary. Dr. Blandford replied that there are four techniques that can be applied. LSST needs infrared information from space, as well as the lensing data and spectroscopy from WFIRST. WFIRST needs the ground-based visible light data from LSST. In that way, they support each other. In addition, WFIRST will depend on the visible filters. Dr. Morse explained that there is now greater likelihood of a coordinated program. The hope is that those familiar with LSST will be involved in planning WFIRST.

In response to a question about the U.S. priority in leading WFIRST, and the need to have the three tests for dark energy, Dr. Blandford explained that the United States has a heritage in some of these discoveries, has much to contribute, and is ready to go forward. A Dark Energy Task Force determined that it was important to use all three methods (measurements of weak gravitational lensing (WGL), supernova distances, and baryon acoustic oscillations (BAO)). There is the possibility of testing theories of gravity, and it is important to examine its properties. This and other possibilities will only be determined through proper measurement, requiring a rich sweep and need for verification. However, it is important to acknowledge that Planck could gain much of the science by virtue of being faster.

When asked for clarification of the 33 percent NASA participation in Euclid, Dr. Morse explained that NASA would have 4 out of the 12 scientists, to be selected competitively, with investigation teams behind them. Those scientists would have specific areas in which they would provide expertise. NASA will be engaged in the definitions phase, but large changes to the current configuration would be difficult without jeopardizing Euclid's standing in the Cosmic Vision competition.

In response to a question, Dr. Morse said that the pacing of WFIRST development time depends on JWST progress. Flagship programs follow other flagship programs in a balanced portfolio and cannot be done simultaneously. The Euclid proposal provides an opportunity to obtain some of the dark energy science before the WFIRST launch date. Regarding ground-based surveys of high merit, Dr. Blandford noted that there is a plan to have NSF and DOE involved in interagency collaboration, and a proposal is being submitted. He explained that the 70 percent confidence level for project cost estimates was agreed upon after a discussion of 80 percent. It can be very difficult to come up with reliable estimates for a new project.

As for the impact on science or U.S. leadership should WFIRST be postponed, the WFIRST launch date will be 2022 regardless of whether NASA participates in Euclid. Additionally, regardless of what happens with Euclid, WFIRST will be going forward. There is no point in launching a mission without added-value science. Had it been known that Euclid would fly, WFIRST might not have been the first priority, but the Decadal Survey committee operated with the information they had at the time.

<u>Euclid Mission Update</u>

Dr. Jason Rhodes, the Euclid optimization team scientist representative, discussed the Euclid mission. This project evolved from the merger of the French-led DUNE mission (WGL) and the Italian-led SPACE mission (BAO), with DUNE originating as Vis/near infrared (NIR) imaging, and SPACE as NIR spectroscopy. The project consortium has more than 200 members and is very inclusive.

Euclid has four primary science objectives: explore the nature of dark energy, explore the nature of dark matter, determine initial conditions (inflation physics), and examine modifications to gravity. Secondary science objectives are legacy science (NIR), and enabling of microlensing/planet-finding. The Euclid concept is a high-precision survey mission to map the geometry of the dark universe. Dr. Rhodes then explained the details of the science objectives.

The Euclid mission baseline elements are an L2 orbit, a 4 to 5 year mission, a three mirror anastigmat (TMA) telescope with 1.2m primary, and visible and NISP instruments. Euclid will conduct at least two surveys, one being a wide survey of 20,000 degrees that will obtain the shape measures of about 2 billion galaxies. There will also be a deep survey at the ecliptic poles. Beyond the 4 planned years, the program could do a short exposure galactic plane survey and a high cadence microlensing extra solar planet survey.

NASA only wants to do from space what has to be done from space. There are some pending ground-based projects that ESA and NASA will decide upon in the coming months. As yet, nothing is binding.

Euclid will challenge all sectors of the cosmological model and, in combination with Planck, will make a big difference in what scientists know at all levels. It will be a unique database for various fields in astronomy, and there will be synergies with other facilities.

Discussion

Dr. Rhodes addressed the impression that the scientific goals of Euclid and WFIRST are similar. Ideally, ESA and NASA would want to jointly optimize the missions to determine which aspects of each mission to keep and which to change. WFIRST can conduct a supernova survey, which is not being considered for Euclid or enabled by its hardware. Euclid, on the other hand, would be a good mission for a weak lensing survey in the visible, which will not be done by WFIRST. There is a big difference in the number of imaging pixels. Weak lensing is good at giving a growth-of-structure probe. He asked the Subcommittee to hold some questions for Dr. Fabio Favata, who was to speak the next day. Dr. Rhodes added that when the potential U.S. contribution was assessed, the list included near-infrared detectors, which are not available from European vendors. U.S. systems can also enhance the observing efficiency through settle time. The BAO science working group is looking at spectroscopy. The Euclid optical pixel size is much smaller than that proposed for WFIRST.

Dr. Boss thanked Dr. Rhodes for his presentation.

<u>JWST Update</u>

Drs. Chris Martin and Ronald Polidan had conflicts and therefore withdrew from the conference table. Dr. Eric Smith then gave an update on the JWST project, starting with a review of the timeline, which began in 1989, before the launch of the Hubble Space Telescope (HST). In 2008, primary mirror production began. The 2010 Decadal Survey includes an assumption of data coming from JWST.

Of the hardware, 76 percent is now beyond the critical design review (CDR) stage. The first flight mirror polishing is complete and gold-coating is in process. At the same time, the engineering development units are at Goddard being prepared for testing. Dr. Smith discussed the Integrated Science Instrument Module (ISIM) structure cryo test, which shows how the ISIM changes in extreme temperatures. Another important element is the 1/3 scale sunshield test. It has been challenging, and NASA had to develop technologies to control the sunshield. The Spacecraft Bus engineering model hardware elements are coming together. One goal of these tests is to avoid the Hubble error. Another issue is making the tests reasonable, neither too challenging nor too lenient.

The project received a pass on the technology review, but the budget and schedule did not match up, necessitating a Testing Assessment Task (TAT) group. One TAT finding was that during ISIM cool-down, it may be possible to conduct other tests.

The TAT made the following observations and recommendations:

- A significant level of thermal, optical, and electrical/mechanical testing is required to reach a reasonable level of risk;
- ISIM test times could be reduced by about 4 months;
- Management of the Integration and Test (I&T) program and its risks will require a clear definition of critical items.
- While relaxation of science requirements would not necessarily lead to a straightforward simplification of test plans, simplification does not mean that science requirements will not be met.

Dr. Smith explained the role of the ICRP, which has a broad charter to examine technology, management, and the root causes of cost growth and delay. The Panel will examine current plans to complete development, with special attention to the integration and test programs, and management structure. The APMC will decide in November how to move forward.

Discussion

Dr. Smith explained that the easier elements of the JWST, primarily the spacecraft, were scheduled to occur later on the timeline. The potential cost overrun depends largely on the schedule. The hardware elements are coming together and most are built, so the issue is now one of compressing assembly time in order to save money. There is little available yet regarding the mission critical design review. The reasons for having both the TAT and the APMC is that one was to have an external prompt and an internal prompt asking the same questions.

In a discussion about the confidence level vis-à-vis the amount of testing, Dr. Smith said that if testing is reduced, the confidence level is also reduced. However, there is concern about over-testing at too high a probability level. This is still being discussed. Dr. Boss suggested that the Subcommittee obtain the ICRP report, which has a target date of October 1, in order to determine how to interact with that process.

In response to a question about the timeframe for finding and correcting problems on flagship missions, Dr. Smith said that, traditionally, Phase D is most likely to reveal issues. The TAT made recommendations that will go to the science working group. That group is behind some of earliest pushes to reduce testing, as there was a sense that some tests were duplicative. TAT members were engineers with no project involvement. ICRP was appointed by another body and has one astronomer.

JWST accounts for 40 percent of the APD budget, and everything that happens with it therefore affects every other project in the division. Some in APS are concerned that they almost never see the histories of costs and overruns, despite being the science body advising APD.

Dr. Smith mentioned the "community fields" for JWST, which could be established by the astronomy community. There have been no final decisions as to whether this concept is a good idea that warrants being carried over to other missions, but there is some pressure to do this at NASA. The Guaranteed Time Observers (GTO) is an appealing principle to some APS members, but it is hard to come up with a consensus. Some believe that it is not right to say someone owns an observation; the data belong to the people. Yet there is concern about changing the playing field. There will be a conference on this in 2011.

<u>General Discussion</u>

The general discussion period continued with JWST initially. Dr. Smith explained that if there were no problems with the test plan, JWST would still not match the projected launch date, but the budget numbers remain unclear. While it is not known how much money was saved by postponing the spacecraft work, that decision was approved by NASA Headquarters in 2006.

Some on the Subcommittee expressed concern about the uncertainty regarding cost and schedule overruns, particularly with so many other projects hinging on the JWST launch. This led to a question as to the reality of U.S. participation in leading the science put forth by Astro2010. As the Survey was a 2-year, deliberative process, Dr. Blandford felt it was not possible to answer such a serious question about new conditions, on the fly. The LSST will make a major contribution to dark matter and dark energy research, but it is still necessary to have an integrated program. Dr. Morse added that NASA is seeking a program that will provide data during this decade, and it is not known when WFIRST will launch.

Dr. Morse further explained that his role is to execute the best program he can with the available resources. As the budget has gone downward, APD has adapted. His role is not to demand more money. One of the reasons for seeking the release of the Decadal Survey in August was to provide the report to the Office of Management and Budget (OMB) and the Administration in a timely manner. He added that the budget submission process is embargoed, but the Survey was considered.

The needs of JWST have gone up since confirmation and in the near term, while the budget has stayed stable. The confirmation review of JWST indicated that the plans were robust, so NASA moved forward. The launch date of 2014 has not changed. Regarding the Division budget runout in the FY2011 budget request, the Agency and Administration are saying that this is enough astrophysics to stay at the world class level and move forward.

There was considerable discussion of Euclid and WFIRST. The Decadal Survey Committee considered WFIRST as the first priority, and recommended implementing all of its elements: dark energy, microlensing, and the near-IR surveys. In terms of collaboration, the Committee recommended that U.S. astronomers have a leading role in the program to fully support all the science.

Dr. Morse explained that Euclid has not yet been finalized, and NASA and ESA have emphasized collaboration. NASA asked ESA if the organization would consider dropping Euclid and joining WFIRST as a single combined mission, if they would consider a visible only Euclid mission, and if U.S. scientists could increase their participation in Euclid's definition phase. From the response, it is apparent that the process and resource availability constitute an issue. Euclid is a mid-level project, and it is part of an ongoing competitive process in Europe. Any changes at this time would pull it from the launch schedule, and the changes NASA asked about are incompatible with the Euclid's place in the ESA science program. Euclid also has a cost cap. ESA is not in a position to change the scale and scope, and NASA cannot offer significant resources.

It was observed that for JWST there are two "special" committees, plus a standing review board, and it still seems that costs are not fully controlled. An APS member asked if there are plans to change the structure of the JWST advisory panels. Dr. Morse replied that APD must first learn what the committees recommend, then react. ICRP will be giving feedback on costs in a few weeks, and NASA will react to those.

A question was asked about the benefits of NASA spending $260 million for a 33 percent role in Euclid, which will fill the gap until WFIRST is launched. It is still not certain that Euclid will be selected, and so NASA is moving forward as if it does not exist. However, researchers will be looking at Euclid's science environment. Euclid and WFIRST have significant differences in measurements. The funds to spend on Euclid would be spent over a decade and would only cover 6 months of the WFIRST budget. Euclid involvement would not hold up WFIRST, which is behind JWST.

Dr. Morse explained that ESA is not entertaining the idea of significantly changing Euclid's scope. The discussions between NASA and ESA are about a cost-neutral plan, in which the NASA investment in Euclid and the ESA investment in WFIRST would be equal. Euclid's cost is capped, and NASA's contribution would not increase. Nor has NASA asked ESA to contribute more to JWST, even though its costs have risen.

Dr. Morse said that he and others have discussed the idea of a combined mission, which committee members referred to as"EuFIRST." NASA has had a number of talks previously with ESA regarding a U.S.-led dark energy mission. The current plan is to move forward with WFIRST as recommended. That does not mean that nothing will change. By summer of 2011, ESA will have made its downselection for the M-class Cosmic Vision missions, which will inform planning. Two other key pieces of information will come within the next year that could impact the context of NASA's response, including the FY2012 budget request and the JWST forward plan. Meanwhile, APD must move forward, ESA will go through its process, and NASA has a clear idea of what to do if Euclid is not selected.

NASA and ESA talk to each other. NASA pursued these conversations in 2009, which were derailed because of what happened here, not with ESA. Now NASA must determine what is in the best interest of the community.

The Decadal Survey is finished and reflects the best information available at the time. As for the Decadal Survey Implementation Advisory Committee (DSIAC), that should be set up as soon as possible.

Research, Analysis, and Enabling Technology Programs

Dr. Linda Sparke, Program Manager for the Astrophysics Research and Analysis Program in APD, discussed research, analysis, and enabling technology programs. She noted that the Decadal Survey suggested that APD do 25 percent more suborbital payloads. A similar increase was suggested for lab astrophysics and astrophysics theory. Another $5 million was recommended as the budget increase for theory and computation networks to tackle large simulation and computational problems.

The Space Science Research and Analysis Program was last reviewed 10 years ago. In order to respond to the NRC review of mission-enabling activities in NASA's Space and Earth Science programs, the Astrophysics Division plans to conduct a Senior Review of its research programs. The plan is to convene a non-Federal Advisory Committee Act (FACA) non-consensus panel similar to a project review board, with 8-12 members representing a wide community that includes a mix of small institutions, universities, and NASA centers; geographic and demographic diversity; and early career and established investigators. The goal is to have the first meeting by end of the year, offer a public comment session at the Seattle American Astronomical Society (AAS) meeting in January, produce an interim report in February, and report to the May AAS meeting in Boston.

The panel is charged with assisting NASA in increasing the effectiveness of its research analysis and enabling technology programs. Dr. Sparke reviewed the questions before the panel, which addressed topics such as the appropriate use of program funds, activities complementing those in the Office of the Chief Technologist, balance between suborbital flight opportunities and the development of enabling technology, and investments in technology. Dr. Sparke then described some of the specific programs under review and the questions raised by the Fisk report.

Discussion

It was suggested that the panel might be trying to do too much, too quickly. The charge is ambitious. Dr. Sparke replied that the initial meeting would address that concern. Once there is a specific charge, it might make sense to hire a professional evaluator, but not before the panel knows exactly what needs to be measured. Dr. Sparke will aim to include evaluator expertise on the panel.

Dr. Morse recommended questioning some underlying assumptions. While it might not lead to change, it would be useful to ask "disruptive questions" to elicit any bold vision and determine what provides the best science per dollar. An operating model might be the existing senior reviews, rather than NSF's committee of visitors. Another suggestion was to bring in some of the proposal reviewers, who are closest to this. Dr. Sparke wants to see where funds are really going, and whether the "small" institutions are really small. She does not see a strong tie between this effort and what comes out of the senior reviews.

It will be difficult to develop metrics that can be explained to the community and that will apply to all programs. It was suggested that the panel spend a lot of time thinking about the metrics and how they will differ by program. Dr. Sparke agreed, noting that there will be some areas in which metrics cannot be collected. Although there are concerns about people protecting their own interests, she thought the panel should have some Research and Analysis (R&A) members for their expertise. Still, there is concern about bias.

Dr. Morse would like to make the effort a regular event, more frequent than every decade. It might be possible to draw from the industry community, which is a large pool of people. The new strategic science plan does not currently reflect Astro2010. There will be efforts to develop roadmaps from the Survey, and to examine how R&A supports the strategic goals.

Dr. Boss thanked Dr. Sparke.

General Discussion

Dr. Morse explained that the Euclid mission will have hardware and software aspects that will include data elements. ESA's PLATO mission is not well aligned with the type of exoplanet investigation that the Decadal Survey advised, and NASA is not planning to support it through a strategic partnership. Dr. James Kasting agreed with that decision, as he knew something about it. PLATO is an exoplanet mission, but it is looking for transits, which NASA is already doing with the Kepler mission.

Dr. Morse confirmed that the Explorer program is formally at Goddard Space Flight Center (GSFC), though APD shares some of the funding and other responsibilities. Astro2010 recommended that APD apply some funds to future missions. In answer to a question about international coordination, Dr. Morse explained that NASA communications with ESA and JAXA are excellent, especially in astrophysics. However, coordination is difficult because it involves the allocation of government funds. Sometimes NASA might not be in position to provide support, but lets ESA know that the Agency is aware of ESA programs.

Public Comment Period and Discussion

Dr. Neil Gehrels from GSFC spoke during the public comment period. He said that Euclid is a good mission, but it is different from the WFIRST mission. For example, Euclid emphasizes visible, WFIRST emphasizes infrared. WFIRST will observe supernovae, Euclid is not well configured to do so. WFIRST will measure galaxy shapes in the infrared. The spectral dispersion in the Joint Dark Energy Mission (JDEM) Omega concept, upon which WFIRST was partially based, is 200, with 500 for Euclid. The JDEM study groups believed that 200 is adequate. The Euclid document summarizes its merit functions for dark energy for its anticipated sky coverage and depth, while JDEM Omega goes deeper over less area.

Dr. Shaul Hanany said that his sense from many APS comments is that WFIRST may be compelling and structured differently than Euclid, but much of the science will come from the earlier mission. He asked whether, keeping in mind the Decadal Survey priorities, it makes sense to proceed with two independent missions. Dr. Gehrels explained that the WFIRST measurement in dark energy is precise and superior to Euclid's. Dr. Hanany noted that people outside of APS may ask if there is a better way to achieve the goals of the Decadal Survey. He felt that the sense of the Subcommittee was to try to accomplish more with Euclid.

It was observed that proceeding with the science definitions for WFIRST is an excellent idea. However, the level of U.S. participation in Euclid was a concern. Some allege that Euclid's viability depends on U.S. participation, though ESA has indicated that NASA participation is not critical to its selection. The resident message was that there should be one mission doing many things. But while logic might indicate combining forces, NASA and ESA are separate agencies in separate cultures, which must be taken into account.

Another question had to do with whether the three different science questions to be addressed by WFIRST can be accomplished. Dr. Morse said that waiting to completely accomplish the surveys proposed by the JDEM Omega and other missions would take until the 2030s. Scientists want to have the data as soon as possible. The picture should be clearer in another year. It will be possible to talk to the WFIRST science definition team (SDT), and there will have been U.S. scientists on the Euclid program.

Dr. Morse explained that the 20 percent role on Euclid was an invitation from ESA. The Decadal Survey had indicated that that percentage is not commensurate with a leading role. Therefore, NASA negotiated a larger role at 33 percent. The increase will have to go through the ESA advisory structure as well. As far as the commitment of resources, Dr. Morse was wary of a larger cost commitment to Euclid, especially in light of plans for JWST, WFIRST, and Explorer. However, concern was expressed that the commitment to Euclid might occur too quickly. Dr. Steven Ritz suggested waiting another year to commit to Euclid. He was not convinced that it aligned with the Decadal Survey priorities.

Dr. Morse said that one reason to join the Euclid process is so that the United States can have some scientific influence on the project. Nothing is formal without a Memorandum of Understanding (MOU), which will not happen soon. NASA considered doing nothing, but that would leave the United States out of the science. Dr. Morse felt that the natural thing to do is to get the U.S. science community involved and have the science communities working together.

The plan is to help preserve options while committing to the priorities identified in the Decadal Survey. Euclid is a collaboration, but NASA wants high-value data for the scientific community. While seeking a role in Euclid, NASA is not looking for significant scope changes. ESA has been informed that NASA will execute WFIRST as recommended. It is too late to make significant changes to Euclid. Rather, the goal is to obtain access to the best data possible. It is possible that, should Euclid be selected, it could be strengthened with a U.S. presence. Dr. Morse thought it would be better to become part of it now. ESA has committed to launch targets and will stay with them as part of the ESA process.

Additional concerns were how to best proceed in order to keep the most options open, and whether enthusiasm for WFIRST would continue following a successful Euclid mission. More specifically on the latter, are the WFIRST science goals that do not overlap with Euclid compelling enough in and of themselves? Dr. Blandford said that Euclid will do a good job of weak lensing, but WFIRST's microlensing and surveys elements are not included in Euclid at all. About 18 U.S. scientists are among the 200-plus members of the Euclid project. Those scientists are not receiving NASA funding at this time. The ESA competition is still open, and there is as yet no sense of which proposal will be selected.

Dr. Ritz expressed skepticism that Euclid can be done for half the cost of WFIRST. He observed that the Decadal Survey Committee put WFIRST into NASA despite having many ways to split the costs. Dr. Morse replied that it was a matter of priorities. The Survey was very straightforward except for this project of ESA's that cannot be ignored. While the Survey Committee was not going to leave NASA with duplicated assets, NASA is coordinating with other agencies.

Dr. Boss adjourned the meeting for the day.

September 17, 2010

Dr. Boss opened the meeting by explaining that there was to be a delay in the presentation by Dr. Favata. He presented the updated agenda, which began with a general discussion session.

General Discussion

Dr. Morse began by asking that the Subcommittee review Dr. Sparke's presentation and provide feedback, including whether the charge is sufficiently comprehensive. Their comments will be embedded in the letter. The plan is to have the group meet in the fall, get input at the AAS meeting, work on the report, and give the preliminary report at the APS February meeting. The final report will follow shortly. This will allow APD to integrate any changes into the next budget cycle; APD plans the budget in the spring. The intent is to provide panel members an idea of what is wanted.

Next, Dr. Morse mentioned ESA's Euclid and PLATO programs. He said that NASA has a crisp statement on the latter about the Agency's thoughts on a strategic partnership. He asked that APS discuss whether that is a reasonable approach. There is a tentative plan for Euclid that Dr. Morse asked the Subcommittee to discuss. Many issues exist regarding the strengths and weaknesses in pursuing such a partnership, given all the uncertainty about the JWST launch date and whether Euclid will be selected. He asked whether the Subcommittee members believe that a reasonable path is to pursue the partnership option as far as NASA can before making a hard commitment that is signed by the heads of the Agencies. He noted that NASA would like to do a solicitation as soon as possible in order to meet ESA's requested timeline for embedding U.S. scientists in the consortium in the early part of 2011. ESA also should understand that NASA will continue to pursue WFIRST without delay. The resulting letter will go to the Science Committee and the SMD Associate Administrator.

After Dr. Boss said that the Science Committee wants to know if there are recommendations, Dr. Morse replied that Euclid and PLATO rise to that level of importance. However, complete information is not available, especially with regard to JWST. He wanted to capture the Subcommittee members' thoughts about pros, cons, strengths, weaknesses, where they want to be in a year, and what questions they want to be asking then.

When asked about the possibility of coordination between the WFIRST and Euclid definition teams, Dr. Morse said that that will depend on the solicitations. If NASA moves forward with the WFIRST SDT soon, there could be some flexibility, and NASA will seek members with knowledge of interdependencies, such as Euclid. Any explicit coordination would be done in the spring. There is no reason there cannot be a dialogue and communication between the WFIRST and Euclid teams.

Dr. Morse responded to a question about timelines by noting that the Joint Dark Energy Mission (JDEM) has gone through a similar process. APD is interested in learning from those experiences and the way JDEM conducted its activities. A "dear colleague" letter regarding WFIRST was to go out before the end of October, with responses due around Thanksgiving. Next will be identification of a chair. The team will be interagency and may include international participants. If NASA moves forward with the Euclid solicitation, ESA would be invited to identify a few candidates for the WFIRST SDT, who may or may not be on the Euclid team. The WFIRST team will probably include around 15 individuals. The plan is to identify them by Christmas and possibly have a teleconference to lay out activities.

Regarding Euclid and WFIRST overlap, the central point is that the WFIRST goals are broader than those of Euclid. It is unlikely that NASA will charge the SDT to think about potential mergers. The team will be asked to define requirements for design, timeline, investigations, measurements, and capabilities that are needed by WFIRST, as well as capabilities that will drive implementation. The issue of mergers would be brought to the SDT if it needed to

be considered. The charge will not include something like go out and look for ways to merge. The team will be asked to consider definitions "in context of the state of the field at the time of launch." The SDT will work for several years in a defined process and on a schedule, and will have done much work before NASA signs an MOU with ESA for Euclid. Euclid's science program will feed into how the Science Definition Team outlines the scientific approach to WFIRST.

The Euclid solicitation will solicit science investigations; the "dear colleague" letter that will go out for the WFIRST SDT will have a due date around Thanksgiving. With a 33 percent contribution to Euclid, NASA will have four scientists on the Euclid science team, chosen competitively. At this point, the smaller expenditure is for the WFIRST SDT, and the Euclid involvement for the four scientists would be larger. However, the total amount to be spent for Euclid before signing an MOU would be small. Money for Euclid is being discussed with OMB and Congress. The FY2011 budget has an undefined "future funds" pool from which Euclid would receive funds. There is not yet clarity on the budget, so there is little to discuss, although there may be a need for a short-notice meeting or teleconference to determine distribution of some outlying funds.

Program Analysis Group Presentations

Dr. James Kasting discussed the implications of Astro2010 on exoplanet research and the Exoplanet Exploration Program Analysis Group (ExoPAG). Exoplanet research is embedded into the WFIRST mission. Dr. Kasting compared the Microlensing Planet Finder (MPF) 4-year mission to a Kepler 6-year mission. This could be done with WFIRST if it has 10 years. The amount of time on WFIRST is designed to provide half the sensitivity of MPF. MPF is more sensitive to more planets at larger orbital distances from their stars. It is not clear what fraction of those planets would be in the habitable zone. Microlensing can provide information about the frequency of rocky planets far away, which can be interpolated to indicate their frequency close by.

Dr. Kasting briefly discussed the projects that Astro2010 did not select. SIMLite, a space-based astrometry mission, was the top recommendation of the 2007/08 joint NASA-NSF-NRC exoplanet task force. Small coronagraphs were also not selected, and the microlensing mission was recommended, but only if it did not interfere with funding for astrometry.

Dr. Kasting considered it good news that there is a new worlds technology development program recommended for the medium-sized missions. He described the competing technologies for a direct imaging mission. ExoPAG could assist the exoplanet program office in determining how to conduct the downselect. Another recommendation is to establish two study analysis groups (SAGs), on coronagraphs and interferometric imaging. Reports are to be written by June 2011, outlining the anticipated scientific yield of each mission and the major technology hurdles to deploying such a mission in the 2020-2030 timeframe. Remaining issues include how to determine a planet's mass now that SIMLite is cancelled.

Dr. Boss observed that the loss of SIM leaves unanswered questions. ESA had a plan that has since been set aside. Dr. Sara Heap expanded on this, stating that at a precision radial velocity workshop in August, the Europeans stated that they are proceeding on the assumption they can develop technology to measure radial velocity to 10 centimeters per second. They have built a laser frequency cone and have already done better than 1 meter per second. The precision is limited by stellar activity, though the extent remains unknown. The Europeans are exploring that now and plan to proceed until they hit a limit. They will also have a new spectrograph. The United States might be ceding predominance in this area.

Dr. Ritz provided an update on PhysPAG, which is just beginning. Dr. Rita Sambruna is assuming the position of the Physics of the Cosmos (PCOS) program scientist. PhysPAG will have its first meeting in Seattle at the January AAS meeting, possibly in conjunction with the Cosmic Origins Program Analysis Group (COPAG). Recent activities include the call for nominations for membership on the Executive Committee, of which there were 10

excellent candidates. Five are from NASA centers, three from academia, and two from for-profit institutions. He would like more, and he and Dr. Sambruna will identify gaps and potential invitees. The Group may create a website to facilitate information exchange with the science community. This site could link to the APS web page if appropriate. Dr. Ritz presented the draft agenda for the January meeting.

Dr. Morse encouraged APS members to communicate freely with the PAGs. There are many experiments that PhysPAG could do. It will be a challenge to organize and study the tasks. In answer to a question, Dr. Ritz said that the Group will stay aware of ground-based observations and activities.

Dr. John Huchra presented the COPAG update. COPAG is in a similar situation to that of PhysPAG. A call for nominations went out in July, resulting in seven or eight nominations, all from two NASA centers. He is trying to solicit additional participants. He reviewed the draft January agenda, and said that while he hopes to do much work by teleconference, he would also like to have the group meet at AAS meetings once or twice each year.

Discussion regarding the SAGs proposed for ExoPAG centered on expectations. They will cast a wide net, but it is important to avoid expecting too much from them. The new technologies will be developed through technology demonstration projects. The over-arching context is the program and the need to identify a direction. Funding will be necessary, but the SAGs will play a role in rounding out the definitions of what can be expected, while also determining if there are other tools to help inform decisions and narrow the range of what is considered.

ESA's Cosmic Vision Process

Dr. Favata discussed long-term planning for the ESA science program. The current plan, Cosmic Vision 2015-25, called for science themes in spring 2004, analyzed responses, and presented a plan in 2005 that should cover one decade. The ESA science program budget is decided at a ministerial level conference, with a 5-year horizon. The last conference was in October 2008 and established a 3.5 percent per year nominal budget increase. That was right before the global financial crisis. ESA is projected to spend about 3 billion Euros on the mission aspect of new missions from 2015-25. The current plan envisions L, M, and opportunity missions. Dr. Favata described the criteria for these categories. Large missions all assume international cooperation.

Currently, there are four over-arching themes: conditions for life and planetary formation; how does the solar system work; what are the fundamental laws of the universe; and how did the universe originate and what is it made of? Dr. Favata described the mission process. The first call for missions was issued in 2007, resulting in 50 proposals. From those, there are now three large missions: IXO, EJSM/Laplace, and LISA. In addition, ESA is studying three medium missions: Euclid, PLATO, and Solar Orbiter. The opportunity mission being reviewed is SPICA, pending evolution of the mission in JAXA.

Decisions will be made about the three medium candidates in mid-2011. Currently, definition phase activities are proceeding. There are ongoing Announcements of Opportunity (AOs) for Euclid and PLATO; responses are due at the end of October, and a NASA contribution is assumed for each.

Discussion

Dr. Boss asked what would happen if the funding for the M and L projects, which was determined in 2008, does not materialize. Dr. Favata said that flat funding might be possible for the next 5 years. He speculated that this would result in slippage of launch dates by a few months downstream, but expected no major impact. In additional speculation as a response to a question, Dr. Favata suggested that Euclid might be selected due to science priorities. ESA would like NASA help in defraying costs, but that would be relatively minor and not something that is likely to have a strong impact on the decision.

NASA contributions are assumed based on a discussion in which NASA expressed an interest in playing a role but also expressed an unwillingness to commit before the Decadal Survey results were issued. For the current stage, ESA is not assuming any NASA contribution. Any agreement would include specific items, which ESA and NASA have discussed. However, ESA must have the mission fully defined by the middle of 2011, so any partnership should be determined sooner rather than later. Dr. Favata thought it was unlikely that WFIRST and Euclid could be merged. Much work has been done on Euclid, and a merged mission would require starting over. It would also be incompatible with missions that are now in the definition phase. After the preliminary discussion with NASA, it was clear that Euclid should go ahead.

There were questions about the cost cap methodology. The ESA cost contribution is capped minus the payload, and Dr. Favata was asked how ESA defines payload, the limits on payloads, and what does and does not go into the cost cap. Dr. Favata explained that ESA members want to provide particular elements and fund them, like telescopes. ESA funds spacecraft, operations, launch services, and related overall elements. One exception is GAIA, which has no nationally funded payload. The cost cap is based on both assessment studies and previous experience.

Meeting with Associate Administrator

Dr. Edward Weiler, Associate Administrator for NASA's Science Mission Directorate, spoke about recent activities. The Decadal Survey identified clear science priorities: dark energy, explorer augmentation, LISA, and IXO. The last two are way beyond the budget horizon. Aggressive funding of WFIRST would result in a 2022 launch, assuming the economy will not decline further. In 2009, NASA learned that ESA was doing a dark energy program. Some discussions with NASA occured but had to back away due to a decision made at high levels. It is important to remember that the United States had a leadership role, and had to give it up.

NASA follows the Decadal Survey. The recent Survey, Astro2010, advised fewer mid-cost missions than expected. NASA re-established a relationship with ESA on a 20 percent share in Euclid, which will not study dark energy the way NASA wants but which will produce data. After hearing from the Astro2010 committee, NASA representatives met with ESA representatives to negotiate a larger role for NASA. ESA does not want NASA leading Euclid. ESA and NASA have a strong history of collaboration; Dr. Weiler described the Mars missions as an example. All Mars missions will be joint going forward.

David Southwood at ESA laid out a plan that if NASA were to agree, the Agency could have 4 of 12 scientists on the working group and would have access to the data right away. Therefore, the options for the U.S. science community are:

A. NASA tries to cut a deal with ESA. If Euclid is not chosen, it is meaningless. If Euclid is chosen, NASA has a 33 percent share and receives access to dark energy data. At the same time, NASA moves forward with the full WFIRST program, which is the better, more complete mission.
B. NASA tells ESA that the Agency is not interested. U.S. scientists do not have access to ESA data and instead get WFIRST data later.

NASA cannot take over Euclid. ESA is the second biggest space agency in the world and can do things without NASA.

When asked for his take on JWST, Dr. Weiler said there is a lot of frustration, with much advice from different groups. On JWST, NASA wanted to get every critical technology before Phase C and so spent close to half the run-out budget on Phases A and B due to the focus on getting the technology ready. Much work was pushed out that needs to be dealt with now. He has always been concerned, but NASA is working hard to make JWST successful. Most people on it remember the Hubble program, which was a huge embarrassment. This has led them to test and re-test repeatedly, which is the "Hubble mentality" embedded in JWST. The testing may not all be required, and it adds time and money.

Dr. Hanany repeated his question from the previous day, stating that compelling arguments have been made for moving ahead with both WFIRST and Euclid, but the community sees two missions that overlap to a large extent. It seems prudent for NASA to say that if the possibility exists to benefit from merging the two missions, the Agency would do it. Dr. Weiler explained that NASA offered that option to ESA, which rejected it. ESA and NASA have separate communities. ESA wants to see its mission happen. If Euclid is not selected, ESA might approach NASA. The concern is that NASA must tell ESA by the end of October that the Agency's involvement in Euclid does not pre-empt going ahead with WFIRST. The discussion may be academic, but NASA will implement WFIRST. NASA has a short timeframe with an imminent deadline, and is still seeking the sense of the community for what the Agency should do.

Dr. Heap explained that there is a split in sharing costs between ESA and the member states. The member states supply instruments. In the case of dark energy, the heart is the scientific instruments. She is wary about Euclid's success, as this will depend on the member states coming forward to admit any problems. Her specific concern is about the instruments, which are difficult to build and include many elements. Dr. Weiler believes that ESA can take on the tough technology challenges. He has changed his attitude in that regard, which is fortunate, as the President wants more collaborations, not fewer. NASA has excellent relationships with ESA under the current Administration.

Dr. Weiler further explained that a 33 percent involvement in Euclid is as much as he would consider. Any more than that affects downstream projects like WFIRST. The dark energy problem will not be solved with Euclid, and maybe not with WFIRST. If NASA goes forward and Euclid is selected, one of NASA's highest priorities will be to get ESA scientists on WFIRST to make it happen faster. Dark energy is the top science priority. U.S. scientists can get some data on it from Euclid in 2018, or wait until after WFIRST is launched some years later. Dr. Morse added that APD is not thinking of eliminating any programs. Euclid involvement will not affect the LISA and IXO launch dates because the pace is actually set by JWST.

Dr. Weiler noted that even the 33 percent share of Euclid will be a difficult negotiation for David Southwood, so there will not be an offer to do more. NASA had the project lead at one point, but that is past. In addition, the project needs a lead party, so NASA would not offer 50 percent. He believes the Solar Orbiter will be selected. NASA has contributed several instruments and the launch, with a project share of less than 30 percent. That is ahead of Euclid by about a year.

The planetary decadal survey is coming out in March and could complicate things. LISA and IXO are lower priorities, but ESA might want to move ahead with them faster. If LISA came out first in the L class, it could move LISA up in the NASA queue. Flagship projects delay other flagship projects, and NASA is trying to maintain balance between large and small projects.

Dr. Ritz said that sending $260 million to Europe for Euclid does not serve the purpose of making WFIRST occur sooner. Dr. Weiler replied that WFIRST's projected launch date will be 2022 if NASA does not participate in Euclid and if there are no surprises on JWST. The estimates in the Decadal Survey will be off, as will those for Euclid. The $260 million will be spread out over 10 years. If NASA receives the same amount back from Europe for WFIRST, the project becomes cost-neutral.

Dr. Blandford added that implementation is not the responsibility of the Decadal Survey. The recommendation for WFIRST to carry out three well-identified objectives with one spacecraft stands. Dr. Weiler added that it would be simpler to tell ESA that NASA is not interested in Euclid. However, NASA wants to reflect the interests of the U.S. science community, which is one reason for discussing this with APS. If he thought Euclid participation would delay WFIRST, he would not even talk about it.

Dr. Weiler explained that it would take a huge augmentation to get the budget back to where it was. Currently, it is down about 23 percent. The science budget was reduced quite a bit. NASA has not recovered, except in Earth Sciences, which had a decadal survey 2 years ago, then got a 60 percent budget increase. Earth Sciences can now execute their decadal. The Decadal Survey Committee is also aware of the dichotomy in NASA between planetary and astrophysics, which affects exoplanets. The planetary committee has the astrophysics report. There are areas of commonality. Any decision to have a larger decadal survey that covers all space science will be made by others, but such a survey could make choosing projects difficult. It would be a challenge to combine reports. Dr. Morse did not completely agree with the notion that some groups are not represented in planning. The PAGs were purposefully set up as mechanism for bringing in the community on an interdisciplinary basis. This is common at NASA.

The second priority, the Explorer program, is an interesting challenge. There will be a need to separate the budgets in order to avoid two program directors telling Goddard what to do. Dr. Weiler does not see this as a roadblock, however.

Regarding the cost neutrality of U.S. participation in Euclid, there was concern about the European commitment to WFIRST, which will occur after Euclid is launched. The issue of the United States playing a larger role in Euclid was raised again. Dr. Weiler said that if the launch dates were not an issue, NASA and ESA should do one mission, which would be WFIRST with its stronger science. In the real world, there are 200 scientists who have worked on Euclid for years and who think they will get good data several years before WFIRST. Scientists like to obtain data as quickly as possible.

Dr. Morse explained that WFIRST's broader program includes dark energy surveys. NASA wants to provide the best possible data to the science community. Euclid will get 20-40 percent of that WFIRST data to the community sooner. The most urgent issue is that NASA must inform ESA of the Agency's direction as soon as possible. The AO currently assumes a 20 percent role in proposals, and any changes in the proposals must be made before October 26. At that time, the AOs for the payloads come in. ESA needs to know everything at that time, including commitments to instruments. There will be no firm commitments either way, from NASA to Euclid or ESA to WFIRST, for some time. NASA will not be signing any MOUs for another 1-1.5 years. And NASA expects ESA to want participation in WFIRST.

If ESA does not collaborate on WFIRST, the funds assumed to come from ESA will not come out of Explorer. ESA must go through its own processes, which will take a long time. There will be negotiations of the terms of contributions, for example. The next step is on October 26, which is why NASA must have an answer by then. The plan is to tell ESA that NASA does not want to participate in PLATO, and that NASA will take a 20-33 percent share on Euclid. NASA would then participate on the science team for Euclid, with two scientists at the 20 percent level and four at the 33 percent share. This has value, especially for NIR data. The soonest NASA would sign an MOU is June 2012. The United States will provide infrared capability.

Dr. Boss thanked Dr. Weiler for his participation.

Public Comment Period

Jay Bookbinder from the Smithsonian Astrophysical Observatory spoke first. A difficulty in international collaboration on missions of opportunity is phasing. He suggested an annual call for missions of opportunity. The funding for that should increase. In addition, the Decadal Survey proposed a fully implementable sweep of science. He heard in the discussion of Euclid that it involved a significant amount of money that could affect LISA and IXO.

Dr. Morse responded by noting that Euclid is beyond the scope of Explorer. To a certain extent, it is budget-driven. APD has $55 million for missions of opportunity in the upcoming Explorer AO. This means APD must think of missions of opportunity as opposed to a mission. The budget must be raised to then raise the cost cap.

Michael Devirian of the NASA Jet Propulsion Laboratory (JPL) asked whether the U.S. contribution to Euclid would defray ESA costs or change them. After Dr. Morse said it would be the former, Mr. Devirian suggested that that might change after selection. Dr. Morse replied that that conversation could take place, but it is not consistent with ESA's process. Dr. Ritz added that a larger contribution from the United States may be possible if the mission addressed WFIRST goals, and it might be interesting to see if that has some merit.

Marcia Smith of Space Science and Technology, LLC, asked Dr. Morse what he needs from the community to feel comfortable talking to ESA. Time is short. Dr. Morse replied that everything is good right now.

Mike Werner of JPL asked if the NASA contribution to Euclid would enhance the mission, and if the support would be sent to member states. Dr. Morse said that NASA might not contribute to the spacecraft. NASA cannot change the scale or scope of Euclid, or implement a design change through an enhancement. Reciprocity on WFIRST has not yet been determined.

Michael Levy from Berkeley National Lab observed that WFIRST was based on JDEM Omega. There was new information, and the JDEM working group came up with a way to accelerate a mission. That was not available for the Decadal Survey. The microlensing aspect could still be accommodated within JDEM. He wondered if there might be a smaller mission that could be done faster. The JDEM Omega did not consider a post-Euclid world. He wondered what damage would be done to WFIRST by going with Euclid. In addition, Euclid does need the NIR focal plane from the United States, which raises the question of whether NASA would receive an adequate return on investment from that contribution. He was also concerned about what happens to Euclid scientists. There are thousands of astrophysicists waiting for the U.S. dark energy program, and he wanted to know if they would be adequately served by Euclid.

Dr. Morse said that as identified in the letter regarding the arrangement with ESA, the idea was that if anyone wants to collaborate with ESA, they can if they have access to non-NASA funding. NASA is moving forward with WFIRST, which must react to the budgetary and science environments in the process. Now LSST is in the mix. Dr. Levy said that the United States will be involved in Euclid even through the ground program. He was not sure if that is what U.S. scientists want, or if they would be better served by another program. JDEM ISWG found a faster way to go. Dr. Morse said that that will not change anything and it is unlikely that NASA will descope.

Working Lunch

During lunch, the Subcommittee continued discussion.

PAGs

The two SAGs were approved for ExoPAG. There was a suggestion that reports by June 2011 might be too soon. ExoPAG could report back at the next meeting, but COPAG would like to ask AAS members at the Seattle meeting if they would like to be involved. The PAGs are to keep APS informed, and could use its help at some junctures.

R&A Panel

Some members initially questioned the R&A Panel's schedule as possibly being overly ambitious. The metrics are still under discussion, which affects the process and whether the charge can be addressed. There will be a huge time commitment. To have the report by summer 2011 and get it into 2013 budget request, there must be sufficient staffing resources. It might be possible to obtain comments online and to draw on white papers. A moderated blog would have the benefit of facilitating comments from those not attending the AAS meeting in Seattle. There were no final objections to the schedule, and it was decided to suggest that the panel seek additional input from sources in addition to the AAS meetings.

In addition, APS endorsed the goal of diverse panel members and recommended that Dr. Sparke use a combination of active recruitment and a letter encouraging applications. The letter will not take long to create, it will encourage open government, and it will also be a way of announcing that this activity is taking place. Another option is the AAS electronic newsletter. It was decided to target potential panel members in several ways.

In reviewing the specific questions for the panel, attention was drawn to one asking if "the range of award sizes [is] suited to the theory challenges addressed." Some costs, such as that for analysis, are not included, resulting in awards that are not entirely accurate. It was recommended that there be a bullet stating that awards should be more accurate. It was also recommended that the charge to the SR should include the question "is the range of award sizes suited to the ... challenges addressed?" for the sub-orbital and lab astrophysics programs as well as for the theory program.

It was also noted that Astro2010 makes recommendations for augmentations assuming a budget profile for small programs, but not all were included or clearly addressed. There were some very specific augmentations, such as the balloon program. It was not clear how that figures into this charter if the panel is rebalancing or asking hard questions. It was decided that the charge is that NASA expects to follow the funding recommendation of the Decadal Survey.

Another recommendation was that the Origins of Solar Systems (OSS) program should be renamed, since there seems to be a significant disconnect between what the program does and what scientists propose. Dr. Boss thought that perhaps someone from OSS should provide an update to the Subcommittee. It is something APS should examine.

The Astrophysics Data Analysis Program (ADAP), theory, and archival components could be looked at jointly. ADAP is not the only way that archival funding occurs. What is presented is not sufficient, and the "what are strengths" sentence in Dr. Sparke's list of questions should be amended.

A Subcommittee member mentioned being contacted by some colleagues, because the Survey recommendation about the DSIAC is being considered. Dr. Boss replied that it should be done as soon as possible. The panel is to be appointed by an organization other than NASA, probably the NRC. The Subcommittee agreed to suggest that NRC appoint the panel.

WFIRST and Euclid

Dr. Ritz asked the APS to consider three ideas regarding WFIRST and Euclid:

1. APS should endorse the WFIRST SDT, state that it should happen as soon as possible, and encourage international participation, especially by scientists from Euclid. APS should see a draft of the call letter for SDT before it is sent.
2. The information regarding Euclid came so quickly that APS members were being asked to make decisions without time for thought and analysis. Dr. Ritz was not comfortable saying anything about the plan under those circumstances. Some specific questions included:
    a. Why does ESA need a decision from NASA by the end of October?
    b. Why are the percent shares proposed as 20 and 33 percent? He could not recall discussing this previously.
    c. Where will the money come from? APS needs to know.

    He added that the Decadal Survey said the United States should take a leading role, which to him means taking responsibility for scientific success.
3. APS should schedule a meeting soon as possible in order to learn the findings of the independent review committee on JWST.

The independent review report is not a public document, but APS should be able to obtain a report soon. It was noted that for a FACA group such as APS to meet, there is a legal requirement of 30 days notice. The meeting can be a teleconference; once announced, such a meeting is hard to cancel. Dr. Boss agreed that APS would schedule a teleconference as soon as possible. He cautioned that the Subcommittee might not receive the report, but in order to make informed decisions by the end of October, they must meet soon. ESA must have the decision as soon as possible in order to adjust the AO if necessary.

Dr. John Hughes said that the argument could be made that Euclid is poorly aligned with the Decadal Survey. It adds another mission that could affect NASA priorities. It was not clear what the United States will get back from supporting Euclid. The Survey designates WFIRST, Explorer, LISA, and IXO as the priority missions. It only mentions Euclid in the text. It was not clear why Euclid became such a high priority.

One of the issues was that APS had to react quickly or miss out on Euclid. It was suggested that if the funds went into an AO and Euclid was just one of the possibilities, APS would have had more time to consider the best path forward. Going with Euclid takes other options off the table.

Some agreed with Dr. Ritz that there are ramifications to the decision and that APS was not given sufficient time for assessment. Others felt that the only question was whether to increase NASA's role from 20 to 33 percent. APS members presented repercussions to pulling out of Euclid completely and to making the 33 percent commitment. It was suggested that APS keep to the 20 percent agreement, although it had not been discussed by APS previously. There was no commitment as yet, nor has the Euclid program been selected to go forward.

If NASA does not put out a solicitation for scientists, ESA must know that in order to adjust. The existing plan was to tell ESA that NASA does not want to put scientists on PLATO. If APS were to decide on no Euclid involvement, NASA would tell ESA that the Agency will not solicit science investigators now. If APS were to decide on a 20 or 33 percent share, NASA would issue a solicitation. One concern was that if WFIRST encountered difficulties and NASA had no role in Euclid, the United States might not have access to dark energy science. A commitment to ESA at the lower level would address that and serve the purpose of not jeopardizing future collaborations. The relationship with ESA should be encouraged, and NASA should avoid sending the wrong message by pulling out of both PLATO and Euclid.

Dr. Boss pointed out that the funds for Euclid would come from the "future missions" budget line. The $260 million is the entire commitment. Dr. Morse said that APD is looking for a strategy that offers the best science return. The efficient funding of a project, as with JWST, involves getting the most work done as efficiently and quickly as possible. The issue of balance is a difficult one. Euclid will not be a factor in Explorer, LISA, IXO, or other projects. The portfolio of projects could use more money, and APD is trying to maximize the science return for the funds that exist. Part of that involves trying to make the dark energy data available to the U.S. science community in a way that is cost neutral in the long term and that has U.S. scientists involved in another dark energy measurement project so they can have that experience. Being part of the Euclid science team is key. Euclid will launch years before WFIRST. The feedback from the Decadal Survey was that 20 percent involvement was not sufficient.

Cost neutrality means that the funds spent on Euclid will come back in the WFIRST effort. This will not affect funding of NASA projects. Certain specifics cannot be discussed, as that is part of NASA's embargoed budget process. However, there is comparable information in the FY2011 budget sent to Congress. Like the TAT report, the ICRP report to Congress will be reviewed, but it would be a good idea to do this as soon as possible due to ESA's timeline.

There was concern that money spent on Euclid would delay technology development on a project like IXO, pushing back the launch date. Dr. Morse explained that this would not happen. There is no fat in the portfolio; the budget is

flat. There are no opportunities to make advances for several years. All the programs are starved. The point of doing Euclid is that its needs are lower and that NASA can use it to get dark energy science out to the community in a cost efficient way. Looking at the entire portfolio, it becomes apparent that nothing opens up until 2013-14.

Vote on Euclid involvement

APS unanimously agreed that NASA should not participate in ESA's PLATO program. Regarding Euclid, Dr. Ritz reiterated his stance that APS could not provide high quality advice without more time to study the issue. He suggested not voting and instead having another meeting in 30 days if possible. This was not the majority position. Therefore, Dr. Boss held the first vote, on whether to participate in Euclid.

The vote was 10 yes, 2 no, 1 abstain, and 2 "unable to comply," which were counted as abstentions. (Dr. Kasting left the meeting early, but he made a point of publicly stating his support for involvement in Euclid and was therefore counted as a "yes" vote.) Therefore, APS voted to participate in Euclid.

Dr. Boss summarized the sense of the Subcommittee, that many APS members support Euclid but most had reservations. The next vote was whether to participate at the 20 percent level or the 33 percent level.

The vote was 7 for 20 percent, 4 for 33 percent, 3 abstentions, and 1 absent. (It was not clear how Dr. Kasting would have voted on this issue, and he was therefore counted as absent.) Therefore, APS voted to participate in Euclid at the 20 percent level.

The official statement was that APS recommended NASA to be involved in ESA's Euclid program at the 20 percent level.

Final Recommendations

In addition to the votes on Euclid involvement, APS developed additional recommendations.

APD should move quickly on assembling the SDT for WFIRST and ensure that the team covers all the relevant science interests. APD was encouraged to invite scientists from Euclid. APS would see the draft call letter if possible. Dr. Morse said he would look into that and possibly arrange a teleconference in late October.

Dr. Boss noted that there was support for a DSIAC.

The PAG agendas looked good, as did the request for the ExoPAG SAGs.

The R&A panel schedule was accepted, although there were questions regarding additional input. One solution might be to have a website for comments, such as a moderated blog. Because it could be difficult to find members for the panel, APS came up with recruitment strategies: a "dear colleague" letter; calls from Dr. Sparke; advertisement in the AAS newsletter and other relevant electronic newsletters. There were questions regarding the charge, such as whether the suborbital missions have award sizes sufficient to achieve what is sought, and whether it makes sense to have the OSS program as a split program. It was also noted that the ADAP and guest investigator programs were juxtaposed when they are really more in line with each other.

Dr. Boss adjourned the meeting at 3:14 p.m.

Appendix A
Attendees

Subcommittee members
Alan Boss, Carnegie Institution, *Chair Astrophysics Subcommittee*
Hashima Hasan, NASA Headquarters, *Executive Secretary*
Louis Allamandola, NASA Ames
Arjun Dey, NOAO (telecom)
Shaul Hanany, University of Minnesota
Sara Heap, GSFC
John Huchra, Harvard University
John Hughes, Rutgers University
Mary Elizabeth Kaiser, The Johns Hopkins University
Vicky Kalogera, Northwestern University
James Kasting, Pennsylvania State University
James Manning, Astronomical Society of the Pacific
Chris Martin, California Institute of Technology
Ronald Polidan, Northrop Grumman Space Technology
James Rhoads, Arizona State University (telecom)
Steven Ritz, University of California Santa Cruz
Leisa Townsley, Pennsylvania State University

NASA attendees
Linda Andruske, NASA HQ
Mave Auen, NASA SMD
Jaya Bajpayee, NASA Headquarters
Dominic Benford, NASA GSFC (telecom)
Michael Bicay, NASA Ames (telecom)
Jay Bookbinder, NASA SMD
Jeff Booth, NASA JPL (telecom)
Joan Centrella, NASA/GSFC
Mark Clampin, NASA GSFC (telecom)
Jean Cottam, NASA GSFC
Holly Degn, NASA HQ (telecom)
Michael Devirian, NASA/JPL
T. Jens Feeley, NASA HQ
Chris Flaherty, NASA HQ (telecom)
Jonathan Gardner, NASA GSFC
Charles Gay, NASA SMD
Neil Gehrels, NASA GSFC
Kevin Grady, NASA HQ (telecom)
Matthew Greenhouse, NASA GSFC (telecom)
Richard Griffiths, NASA HQ (telecom)
J.D. Harrington, NASA HQ (telecom)
Ilena Harris, NASA HQ
Clifton Jackson, NASA GSFC (telecom)
W. Vernon Jones, NASA HQ (telecom)
Deidre Jurand, NASA SMD

Louis Kaluzienski, NASA HQ (telecom)
Chryssa Kouvelrotou, NASA MSFC
Jeff Kruk, NASA GSFC (telecom)
Thierry Lanz, NASA HQ (telecom)
Roger Lee, NASA JPL (telecom)
Jack Leibee, NASA HQ (telecom)
David Leisawitz, NASA SMD
John Mather, NASA GSFC (telecom)
Julie McEnery, NASA GSFC
Mark Melton, NASA GSFC (telecom)
Jon Morse, NASA Science Mission Directorate, *Director Astrophysics Division*
Malcolm Niedner, NASA GSFC (telecom)
Marian Norris, NASA HQ
Anne-Marie Novo-Gradac, NASA HQ (telecom)
Bill Oegerle, NASA GSFC
Cathy Peddie, NASA GSFC (telecom)
Jason Rhodes, NASA JPL (telecom)
Wilton Sanders, NASA HQ (telecom)
Eric Smith, NASA HQ (telecom)
Linda Sparke, NASA HQ
Ray Taylor, NASA HQ (telecom)
Harley Thronson, NASA GSFC
Stephen Unwin, NASA JPL (telecom)
Michael Werner, NASA JPL (telecom)
Michael White, NASA GSFC
Greg Williams, NASA SMD
Jennifer Wiseman, NASA HQ (telecom)
Geoffrey Yotz, NASA HQ

Other attendees
Charles Baltay, Yale University (telecom)
David Bennett, University of Notre Dame (telecom)
Roger Blandford, Stanford University
Francesco Bordi, OCE
Kimberly A. Briggman, OSTP (telecom)
Robert Cahn, Lawrence Berkeley National Lab (telecom)
Don Cohen, Science News
Dom Conte, General Dynamics
Randall R. Correll, Ball Aerospace
Ron Cowen, Science News
Lamont Di Biasi, Southwest Research Institute
Fabio Favata, European Space Agency (telecom)
Kathryn Flanagan, Space Telescope Institute (telecom)
Carl Gelderloos, Ball Aerospace
Daniel Golombek, Space Telescope (telecom)
John Grunsfeld, STSCI
Heidi Hammel, Space Science Institute (telecom)
Michael Hauser, Space Telescope Science Institute (telecom)
Craig Hogan, University of Chicago (telecom)

Cary Ludtke, Ball Aerospace
Amy Klamper, Space News (telecom)
Dan Lester, University of Texas
Michael Levi, Lawrence Berkeley National Lab (telecom)
Adam Mann, Nature Publishing (telecom)
Celinda Marsh, Office of Management & Budget
Gary Matthews, ITT Geospatial Systems
Stephen Murray, Johns Hopkins University (telecom)
John McCarthy, Orbital Sciences Corporation
Stephen Merkowitz, OSTP
Michael Moloney, National Research Council
Matt Mountain, Space Telescope Science Institute
Saul Perlmutter, University of California, Berkeley (telecom)
Phil Puxley, NSF (telecom)
Miriam Quintal, Lewis-Burke Associates, LLC
Adam Reiss, Space Telescope Science Institute/ Johns Hopkins (telecom)
Sun Rhie, University of Notre Dame (telecom)
Ed Seidel, National Science Foundation
Donald Shapero, National Academy of Sciences (telecom)
Nigel Sharp, NSF (telecom)
Elizabeth Sheley, Consultant, Zantech
Marcia Smith, Space and Technology Policy Group, LLC
Robert Smith, University of Alberta (telecom)
Connie Spittler, NGAS
Massimo Stiavelli , Space Telescope Science Institute
Michael Thornton, NAC Science
Kathy Turner, Department of Energy
James S. Ulvestad, National Science Foundation
Ann Wehrle, Space Science Institute (telecom)
Ana Wilson, Harris Corp.
Roger Windhorst, Arizona State University (telecom)

Appendix B
NAC Astrophysics Subcommittee Members

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

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

Louis J. Allamandola
NASA Ames Research Center

Arjun Dey
Associate Astronomer
National Optical Astronomy Observatory

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 Huchra
Robert O. & Holly Thomis Doyle Professor of Cosmology
Senior Advisor to the Provost for Research Policy
Harvard-Smithsonian Center for Astrophysics
Harvard University

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

James G. Manning
Executive Director
Astronomical Society of the Pacific

Chris Martin
California Institute of Technology

Ronald S. Polidan
Director, Advanced Systems
Civil Systems, Space Systems Division
Northrop Grumman Aerospace Systems

James Rhoads
Physical Sciences F-251
Arizona State University

Steven Ritz
Santa Cruz Institute for Particle Physics
University of California

Leisa Townsley
Department of Astronomy & Astrophysics
Pennsylvania State University

Appendix C
Presentations

1. *Astrophysics Division Update*, Jon Morse
2. *Decadal Survey Report,* Roger Blandford
3. *Euclid Update,* Jason Rhodes
4. *JWST Update,* Eric Smith
5. *R&A Update,* Linda Sparke
6. *ExoPAG/PhysPAG/COPAG Updates,* James Kasting, Steven Ritz, John Huchra
7. *European Space Agency's Cosmic Vision Process,* Fabio Favata

Appendix D
Agenda

Agenda		
Astrophysics Subcommittee		
September 16-17, 2010		
NASA Headquarters Room #3H46 (Sep. 16); Room # 5H45 (Sep. 17)		
Thursday 16 September		
8:30 a.m.	Introduction and Announcements	Alan Boss
8:40 a.m.	Astrophysics Division Update	Jon Morse
9:45 a.m.	Break	
10:00 a.m.	Decadal Survey Report	Roger Blandford
11:30 a.m.	Discussion	
12: 00 noon	Break for lunch	
12:15 p.m.	Working Lunch/Euclid Update (via telecon)	Jason Rhodes
1:00 p.m.	JWST Update	Eric Smith/Geoff Yoder
2:30 p.m	Discussion	
3:00 p.m.	Break	
3:15 p.m.	R&A Update	Linda Sparke
4:00 p.m.	Discussion	
4:30 p.m.	Public Comment Period	
5:00 p.m.	Wrap up for Day 1	Alan Boss
Friday 17 September		
8:30 a.m.	Discussion	
9:00 a.m.	ExoPAG/PhysPAG/COPAG Updates	Jim Kasting/Steve Ritz/John Huchra
9:45 a.m.	Break	
10:00 a.m.	European Space Agency's Cosmic Vision process (via telecon)	Fabio Favata
10:30 a.m.	Meeting with AA	Edward Weiler
11:30 a.m.	Discussion	
11:50 a.m.	Public Comment Period	
12:15 p.m.	Working Lunch	
1:30 p.m.	Discussion, Recommendations, Actions	Alan Boss
2:30 p.m.	Brief to Morse	Alan Boss
3:00 p.m.	**Adjourn**	