Minutes of the Meeting of the
Astronomy and Astrophysics Advisory Committee
3 June 2019
Teleconference

Members Attending	Agency Personnel	Others
John O'Meara (Chair)	Richard Green, NSF-AST	James Lochner, USRA
Ian Dell'Antonio	Ralph Gaume, NSF-AST	Eric Mamajek, JPL
Andrew Connelly	Edward Ajhar, NSF-AST	Rachel Osten, STScI
Dieter Hartmann	Richard Barvainis, NSF-AST	Joel Parriott, AAS
Kelsey Johnson	Christopher Davis, NSF-AST	Steve Thompson
Eliza Kempton	Donna O'Malley, NSF-AST	
Shane Larson	Elizabeth Pentecost, NSF-AST	
Mansi Kasliwal	Joseph Pesce, NSF-AST	
Brian Keating	Diana Phan, NSF-AST	
Petrus Martens	Vyacheslav Lukin, NSF-PHY	
Constance Rockosi	Chris Smith, NSF-MPS	
	Reba Bandyopadhyay, NSF-NSB	
	Daniel Evans, NASA	
	Hashima Hasan, NASA	
	Paul Hertz, NASA	
	Kathy Turner, DOE	
	Tricia Crumley, DOE	

MEETING CONVENED 12:05 PM, 6 JUNE 2019

The Chair and Richard Green called the meeting to order.

NSF

Richard Green provided an update on NSF's Division of Astronomical Science (AST) activities.

The image of M87 was shared from the Event Horizon Telescope (EHT). NSF is very proud of this achievement because AST invested approximately $28M in EHT research over the past 20 years. This included hardware and algorithm development as well as theoretical modeling. There was strong international collaboration on the EHT project due to the NSF Partnerships for International Research and Education (PIRE) program that allows for US-led international collaborations.

The Large Synoptic Survey Telescope's (LSST) 8.4m telescope and 3.2Gpix camera, which will produce images for a peta-scale database, have many critical activities that have been recently completed:

- Successfully transporting the M1M3 mirror to the summit where it is now safely in storage;
- Testing, disassembling, and shipping the mount;
- Installing an 80-ton lift for transporting heavy equipment into the dome;
- Completion of the dome's steel super-structure; and
- Delivery of the coding chamber and the secondary mirror (M2) on the summit. Commissioning has begun for the coding chamber.

NSF's total project cost for LSST will be $473M and the camera itself is an additional $168M. As of March 2019, 69% of NSF's construction phase has been completed. Survey production is scheduled to begin in October 2022. Currently, the cost and schedule are tight but on track.

The Daniel K. Inouye Solar Telescope (DKIST) is also on schedule and it is within its funding contingency. The total NSF project funding for DKIST is $335M, and project completion is at 90%. The Gregorian top-end is in place with the secondary mirror, and the primary cooling unit is now connected to the secondary and tertiary cooling unit. The heat-stop and wavefront sensors have also been installed at the Gregorian top-end in anticipation of 'first sun' early this summer. The current challenges include the completion and delivery of the instruments and the details of the corresponding data policy.

The approach of AST has been to divest or transition facilities that were identified as being less aligned with the 2010 Decadal Survey recommendations, and the last facility in the formal compliance process is the Green Bank Observatory (GBO). When the Director or her designee signs the GBO Record of Decision (ROD) that will conclude the compliance process for the National Environmental Policy Act, Endangered Species Act, and National Historic Preservation Act with regards to GBO. The ROD will choose the agency preferred alternative, which is to collaborate with interested parties for the continued science and education-focused operations at GBO with reduced NSF funding. The Cooperative Agreement with Associated Universities, Inc. (AUI) for management and operations of GBO is up for renewal at the end of this fiscal year.

It was mentioned that AST does not have the FY2019 budget numbers yet. The budget request has been submitted to the Office of Management and Budget (OMB), and AST is waiting for approval from both houses of Congress before operations plans are made public. An update will be provided at the next AAAC meeting.

In FY2018, the Individual Investigator Programs (IIP) had a success rate of more than 20% for the first time in a while. The two mid-scale programs, MSRI-1 and MSRI-2, that are being funded by the top of the foundation, are on schedule. Initial proposals for MRSI-1 were received and reviewed, and a few astronomy teams were invited to submit a full proposal for the program. The full proposals have been received and the review process is underway. MRSI-1 is supported by FY2019 funds so this program is proceeding with pace. For MSRI-2, full proposals are due August 2nd and will be funded with FY2020 dollars.

In the FY2020 President's budget there is a 13% budget decrease for research and related activities (R&RA) from the FY2019 budget, while the House budget markup is a 9% increase from last year. The House budget bill included specific language about producing a "comprehensive and prioritized list of large-scale facilities requested by NSF-supported science disciplines," and included a mandate to fund all NSF facilities operations at FY2019 levels. The challenges of funding all NSF facilities at FY2019 levels are:

1) In FY2019, substantial supplements will keep certain facilities at very high amounts; and
2) AST would like to adopt a model for partner cost sharing, but this House Committee language does not allow that. This language has NSF maintaining a flat budget for all facilities and AST will need to wait for the Senate budget bill to determine how these challenges will be resolved.

Dr. Green presented a sand chart that did not include the FY2019 numbers, but included the numbers from the President's budget request, and shows the FY2021-FY2024 budget distribution under the assumptions that:

1) no facility reductions occur beyond collaborations already in place; and
2) the total AST budget grows by 2.5% per year beyond FY2020.

The outcome of the congressional budget process has resulted in an increase in R&RA in comparison to the President's budget, so the flat line in the sand chart is conservative. If all facilities grow with inflation and AST reduces the IIP budget amount and redistributes the savings to facilities, the IIP budget by 2024

will only be 6% of the division budget, which is not a model that is consistent with the AAAC recommendation to better balance facilities and grants.

Ralph Gaume presented on LSST data rights and the framework for a funding model, a presentation previously given by Robert Blum, the Acting Director of LSST Operations, at the LSST@Asia Conference in Sydney, Australia. The presentation outlined the tentative agreement that NSF and DOE reached on the LSST data rights and the funding model framework, however, the details are not complete at this time. The agencies agreed to release an initial framework because there was conflicting information about what the agencies had adopted.

Previously, the model focused on monetary contributions to operations. The new partnership model will now be focused on in-kind contributions. LSST will continue to maintain the proprietary period for LSST data, and international participants can have the same data access rights as US scientists in exchange for in-kind contributions to LSST construction, facility operations, and/or related astrophysical resources. To oversee and coordinate the in-kind contributions, NSF and DOE will lead a LSST Resource Board. Details about the roles of the Resource Board will be developed within the next year.

International participants who have signed Memorandums of Agreement to contribute to LSST will have their status remain unchanged for two years—through June 30, 2021; however, NSF and DOE's intent is to have international participants retain their statuses through new agreements.

In-kind contributions by international participants that offset NSF/DOE operations costs in exchange for rights and access to LSST proprietary data is NSF's and DOE's top priority. The agencies are also looking for science multipliers to expand resources available to the US astronomy and high energy physics communities. Other in-kind contributions may include: software development staff or computing resources that offset LSST operational costs, or access to complementary datasets for follow-up facilities.

Additionally, there will be no monetary exchange for data rights; all in-kind agreements will go through NSF, DOE, AURA, and/or SLAC as appropriate, not the LSST Corporation. Additionally, there will be a new point-of-contact (POC) for international participants, with the POC drawn from either NSF, DOE, AURA, or SLAC.

John O'Meara asked about the timeline for the agencies to develop the rest of the details for the LSST data rights and funding model. Edward Ajhar explained that this can take months to coordinate between the two agencies and the agencies will try to update people as best they can.

Mansi Kasliwal wanted to know more about the composition of the LSST Resource Board, how the Resource Board will evaluate proposals, and how they will interact with LSST science and operations. Edward Ajhar emphasized that details are still being worked out and noted that the Resource Board will not decide on what is an acceptable contribution. That will be determined by NSF and DOE.

John O'Meara was interested in knowing what prompted the agencies to start this process and what the need was for this change. Ralph Gaume noted that the original model was outdated, and the changes were due to the changing needs of the agencies. The original model had 25% of operations funding provided by international participants. This was not fully realized. Kathy Turner mentioned that DOE is working closely with NSF to move things forward as quickly as possible. Edward Ajhar added that there will be an NSF/DOE joint oversight committee in place to discuss the details.

John O'Meara asked Richard Green how many proposals received during the first round of the MSR-I program belonged to AST, to get a sense of the demand from the Astronomy community. Richard Green responded that he cannot provide any information until an official report about the program is produced,

however, he mentioned that there was a "very strong showing from AST." O'Meara asked if a number can be reported at the September meeting. Green will find out if it will be possible.

Andrew Connelly noted that the sand chart shows a "flatter costing" of major facilities and asked if the changes will apply to all facilities or all MREFC programs. He wanted to know if there is a timeline of when these costs will be flattened. Richard Green commented that funding decisions are made year-to-year and he cannot provide a definite answer. Green also added that two facilities at least, Gemini and ALMA, negotiate with their international partners in advance so they are more likely to have an increase and not be flattened because of their more complex relationship with NSF. Should the agency start to exercise implementation of the NSB report about cost sharing for operations for expensive facilities, that will be done more strategically, and we will know farther in advance the share they are more likely to take. Connelly probed further about the timeline for decisions on cost sharing among the facilities. Richard Green and Ralph Gaume commented that currently there is no timeline about when a decision will be made, but there is certainly a lot of discussion about this topic.

DOE

Kathy Turner provided an update on DOE's activities.

There is a new director at the DOE's Office of Science. Chris Fall was confirmed on May 23, 2019 and was sworn in on May 31, 2019. The Office also released a statement on diversity, equality and inclusion, and updated their website.

The DOE Office of High Energy Physics (HEP) fulfills its mission by building projects that enable discovery science, operate facilities that provide the capability for discoveries, and support a research program that produces discovery science. HEP receives advice from several advisory committees including the High Energy Physics Advisory Panel (HEPAP), which is jointly chartered by DOE and NSF to advise both agencies and subpanels such as Particle Physics Project Prioritization Panel (P5). For example, the P5 produces a strategy report that HEP plans to implement.

The P5 strategy report continues to define investments in the future of the field. Language in Congressional appropriations reports has consistently provided strong support for executing the P5 strategy report. In the last three to four years, there has been a growth of 20-25% in the HEP budget and most of the HEP budget growth is for the fabrication or construction of projects like the High Luminosity LHC. The FY2020 budget request included funding for new initiatives, such as the Machine Learning & Artificial Intelligence initiative, etc.

In FY2018, the actual HEP budget was $908 million. The FY2019 enacted HEP budget was $980 million. For FY2020, the Presidential budget request is $768 million to support a balanced program of world-leading research, facilities, and projects like Quantum Information Science (QIS), Artificial Intelligence-Machine Learning research, etc., and continuation of CMB-S4 research and development. However, the Presidential budget request is usually very low compared to the actual congressional appropriations. The House committee marked up $6.87 billion for DOE's Office of Science—$1.32 billion above the FY2020 Presidential budget request—and HEP's portion of the House Committee budget is $1.045 billion with $814 million for HEP's core programs and $231 million will go towards HEP's construction line items. There is also specific language by the House committee that strongly urges HEP to maintain a balanced portfolio of small, medium, and large-scale experiments, and to ensure adequate funding for research performed at universities and national laboratories.

Balancing research and experimental operations with projects is a challenge for HEP because it requires careful planning and consideration due to several efforts:

- Costs have significantly increased over the years. This reduces buying power.
- The community has grown, leading to more competition.
- Research efforts necessary to support large projects are increasing.
- Operations costs are increasing as projects are successfully completed and begin to collect data.

In the FY2020 budget request, funds in HEP, Basic Energy Sciences (BES), and Advanced Scientific Computing Research (ASCR) included one jointly-supported and multidisciplinary QIS Center, as required by the National Quantum Initiative Act, which was signed into law on December 2018.

On May 20, 2019, DOE published a notice in the Federal Register with two components:

1) A notice of intent (NOI) indicating that DOE is considering the issuing of a funding opportunity announcement in FY2020 for QIS Centers,
2) A request for information (RFI) seeking stakeholder input on the topic areas, organization, requirements, review criteria, and assessment process for prospective QIS Centers.

Comments are due on or before July 5, 2019.

The Cosmic Frontier Experimental Research Program was discussed next. This program area studies the nature of dark energy by searching for particles that make up dark matter. Primarily, this is done through direct detection searches for dark matter particles. Within the Office of Science, this program has strong interactions with offices such as Theory, Detector R&D, Computational HEP, and QIS. DOE also continues to have strong interagency coordination with the NSF by holding two full-day meetings a year to discuss topics related to the Cosmic Frontier. DOE currently does not have ongoing programs with NASA, but DOE will meet and coordinate with NASA as needed. The interagency coordination between DOE, NSF, and NASA is called the Three Agency Group (TAG).

DOE, NSF, and NASA partner with DOE on several projects including the Dark Energy Survey (DES), the fabrication of the LSST camera, DESI, and eBOSS. The search for dark matter is done through direct detection experiments over a wide mass range that include LZ, SuperCDMS-SNOLab, and ADMX-G2. The study of cosmic acceleration at energies near the Planck scale and neutrino properties through the Cosmic Microwave Background (CMB) will be done with new generations of the South Pole experiment and next generation CMB.

A few highlights:

- The Dark Energy Survey (DES) completed its observations on January 9, 2019. Many cosmology results have been released because of DES, including the combined analysis of DES-Y3 supernovae (SNe), DES-Y1 photometric baryonic acoustic oscillation (BAO), and DES-Y1 weak lensing + galaxy clustering (3x2pt) detected Dark Energy at 4σ from the DES alone.
- The High-Altitude Water Cherenkov (HAWC) Experiment started in early 2015. Testing the Lorenz Invariance with the Highest Energy gamma rays at HAWC have led to many results.
- The Axion Dark-Matter eXperiment Generation 2 (ADMX-G2) experiment uses strong magnetic field and resonant cavity to convert dark matter axions into detectable microwave photos. Operations were approved to cover the 0.5-2 GHz range. Run 1A (2017) and Run 1B (2019) both reached “invisible” axion (DFSZ model) sensitivity. Run 1C will start soon.
- For LSST, the LSSTcam project is in the fabrication phase and is 93% complete. Deliverables will be completed in February 2021. The sensors have been completed and delivered. The science rafts are ready for installation and commissioning of the camera is going through its final testing. Shipment of the camera will be at the end of June 2019.
- For DESI, the project is 88% complete and deliverables will be finished in February 2020. Activities for installation and commission have been started and full dark energy survey

operations will start in FY2020. Recently, the sixth spectrograph was completed and tested, and the assembly of the tenth spectrograph was completed as well.
- Other projects in the fabrication phase include LZ (86% complete) and SuperCDMS-SNOLab (76% complete).

For future planning, DOE has established a Dark Matter New Initiative to investigate small projects that would have high science impact. In March 2017, there was a community-led workshop, and in 2018/2019, there was a basic research needs study that identified three priority physics research directions (PRD):

1) Create and detect dark matter (DM) at accelerators
2) Detect Galactic DM underground
3) Detect wave DM in the laboratory

The funding opportunity announcement was released a few months ago and proposals are due soon for the PRDs. The call for proposals asks proposers to design small projects that support the PRDs, and at the end of the award period, they should be ready to be considered for project fabrication.

DOE is participating in the SPT-3G experiment for the Cosmic Microwave Background. DOE is also participating in the CMB Stage 4 (CMB-S4) experiment. This is the last remaining P5 implementation project to start. Coordination planning will be with HEP and NSF-AST/OPP/PHY.

The CMB-S4 collaboration is progressing. There is continuing work on science, design, and project development and the collaboration is focusing on submission(s) to the Decadal Survey. Preparations for the project are also in progress. Following the Concept Definition Taskforce (CDT), the pre-Project Design Group (pPDG) was formed. Currently, the Integrated Project Office (IPO) has been formed to look at detector fabrication and readout issues. The interagency (NSF-DOE) coordination group meets bi-weekly to share information, monitor, and review the progress.

DOE is using Basic Research Needs Studies/Workshops (BRN) to aid in shaping various aspects of DOE's programs. A primary goal of the Basic Research Needs Studies/Workshops is to develop case(s) for additional HEP funding to support such new initiatives in the future. The BRN process does not recommend certain projects, and it is not for strategic planning but is more for tactical purposes. It looks at the scientific research directions DOE should pursue. The next HEP BRN will focus on opportunities in detector R&D.

Before concluding her presentation, Dr. Turner mentioned that the P5 recommended a program of challenging scientific experiments that have equally challenging computing needs. For example, 2019 NERSC requests were up 50% over 2018. ASCR's Exascale Computing project will play an important role in satisfying this demand, but much of the HEP code is not ready for Exascale. The HEP Computing Infrastructure Working Group was formed in 2017 to develop a strategy for meeting these computing needs. Successfully addressing these computing challenges will require continued effort from the community and coordination with ASCR and NSF's Institute for Research and Innovation in Software for High-Energy Physics (IRIS-HEP), which is tackling similar issues from the university perspective.

After Kathy Turner's presentation, John O'Meara asked if there is something in place at DOE to inform the decommissioning of facilities or changes in facility operations like the Portfolio Review at NSF. Kathy mentioned that, last year, DOE had a science review of their operating experiments. This helped DOE outline operating plans for their experiments.

NASA

Paul Hertz provided an update on NASA's Astrophysics Division activities.

The FY2020 Presidential budget request for NASA Astrophysics, which includes the James Webb Space Telescope (JWST), is $1.197 billion. This is a 14% decrease from what the division was appropriated for NASA Astrophysics in FY2018 and a 20% decrease from the FY2019 appropriation.

The FY2019 Presidential budget request included funding to begin an announcement to begin funding an astrophysics probe mission. The beginning of any potential probe mission has been deferred until no later than 2022, as the FY2020 Presidential budget request reprograms the funding for the probe mission to the JWST re-plan.

SPHEREx will begin within the Explorers program as the next Astrophysics MIDEX. The SOFIA mission will be extended beyond its 5-year prime mission, which is completed in 2019, however, details of the extension are pending independent reviews that are ongoing right now. The FY2020 Presidential budget request does not include funding for WFIRST.

The House CJS Appropriations Subcommittee marked up the FY2020 budget request with an augmentation for WFIRST of $510.7 million. This is the amount of funding that is needed in FY2020 to keep WFIRST on track for a launch in 2025 or 2026. The Subcommittee also augmented the funding request for SOFIA to $85.2 million, $12.2 million above what was requested. If the House budget markup were to be adopted, there would be no impact of these augmentations on the rest of the Astrophysics Division in FY2020.

The Administration's supplemental FY2020 budget request would provide an increase of $1.6 billion for NASA above the President's initial $21 billion budget request. This $1.6 billion augmentation in FY2020 is required for NASA to accelerate the lunar human exploration program, named Artemis, to achieve a 2024 human mission to the Moon. No money is proposed to be taken from existing NASA programs to fund the Artemis program. One billion dollars of the augmentation would be used to accelerate the development of a transportation system to take astronauts to the surface of the moon and back. Six hundred fifty-one million dollars of the augmentation would go towards accelerating the completion of the Space Launch System (SLS) and the Orion capsule to support a 2024 landing on the moon. One hundred thirty-two million dollars of the augmentation would go towards new technologies to help astronauts live and work on the lunar surface and deep space. Ninety million dollars of the augmentation would be directed into science for additional the robotic exploration of the Moon in advance of astronauts.

The notional plan for the Artemis program is as follows:

- The first launch, Artemis 1, will be an unmanned mission to cislunar space.
- The second launch, Artemis 2, will take the first humans to cislunar space and back in the same capsule.
- The third launch by 2024, Artemis 3, will be the one that takes humans to the gateway, where they will transfer to the lunar descent element for the descent to the moon, followed by return to Earth.

Prior to the human return, there will be a series of robotic science and robotic technology test missions.

Last week, NASA announced the selection of three commercial lunar payload service providers to carry the first science and technology payloads to the surface of the moon. The payloads will be announced later. The Artemis 3 launch in 2024 will begin a period of sustained human exploration of the moon and

cislunar space. The program will enable science opportunities across the breadth of NASA's science program.

There were updates from the astrophysics missions:

- Integration and testing on the spacecraft system of the James Webb Space Telescope (JWST) is continuing. It is now being prepared for its return to the clean room where post-testing will be conducted. Once testing is complete this fall, the telescope element will be integrated with the spacecraft element to create the full observatory. The launch of JWST is still scheduled for 2021.
- The first of five Wide-Field Infrared Survey Telescope (WFIRST) preliminary design reviews (PDR) took place last week for the instrument module. Throughout the rest of 2019, there will be a PDR for the telescope, the wide-field instruments, the coronagraph instrument, and then the mission itself. Following the mission PDR, there will be the confirmation review and the beginning of Phase C in early 2020. By the mid-2020s, WFIRST will launch.
- The Spectro-Photometer for the History of the Universe Epoch of Reionization and Ices Explorer (SPHEREx) will survey the entire sky. It will observe hundreds of millions of galaxies. The team lead by James Bock (CalTech) will conduct three key science projects: 1) measure the redshifts to probe the distribution of inflationary ripples; 2) measure the spatial fluctuations in the Extragalactic Background Light to support studies of the origin and history of galaxy formation; and 3) survey Galactic Molecular Clouds for water and organic molecules.

John O'Meara asked Paul Hertz to clarify that the CGI was explicitly stated in the markup of the House budget. Dr. Hertz confirmed that the House budget specifically stated that $65 million will be allocated in FY2020 for the continued development of the coronagraph tech demo instrument. This is the amount that is required in FY2020 for WFIRST and the CGI to remain on schedule.

NASA is continuing to release the four Explorer Announcement of Opportunities (AO) per decade recommended by the Decadal Survey. The 2019 AO was just released. It is a Small Explorer AO and proposals are due August 1, 2019. Parallel to this, NASA released an Explorer Mission of Opportunity AO that includes contributions to the partner mission, small Complete Mission on the ISS, Small Sat Secondary Payloads, and opportunities enabled by the Project Artemis.

Several Astrophysics missions are in development, all of which are approaching key milestones:

- TESS has been launched.
- JWST's re-planned System Integration Review (SIR) will now be in September 2019.
- IXPE passed KDP-C. The Critical Design Review (CDR) is in June 2019.
- GUSTO passed KDP-C. CDR will be in July 2019.
- The XRISM mission passed PDR in Japan. The Resolve instrument is currently in integration and testing at Goddard Space Flight Center.
- For Euclid, 20 SCEs were delivered, which is about a year early. This will complete NASA's delivery of hardware for this mission.
- SPHEREx was down selected in February 2019.
- WFIRST's mission PDR will be conducted in October 2019.

The Senior Review is reviewing eight operating missions—Hubble, Chandra, XMM-Newton, Gehrels Swift, Fermi, NuSTAR, ISS-NICER, and TESS. Spitzer is not in the Senior Review. SOFIA has been excluded from the Senior Review through Congressional direction, however, there will be two external reviews of SOFIA.

TESS is in the middle of a two-year prime mission. Over 600 planet candidates have been identified and 15 new planets have been confirmed. There are also 130 publications – 56% of the publications are

related to exoplanets and 44% pertain to other areas of astrophysics.

Elizabeth Pentecost asked when TESS was launched to which Ralph Gaume responded that it was launched in April 18, 2018. Paul Hertz added that the science mission started in July.

John O'Meara asked Dr. Hertz what the difference was between the reviews for SOFIA and the Senior Review. SOFIA has been excluded from the Senior Review through Congressional direction. Two independent reviews of SOFIA were planned to find recommendations on how to improve SOFIA's science output. The first review was a review of SOFIA's aircraft operations and maintenance and this has been completed. The second review is of the science program and the plans for its future science program. The second review has been completed but the final report has not been submitted. The reviewers felt that SOFIA's science productivity was not where it should be for an observatory of this magnitude, but they are confident that with appropriate changes, SOFIA could be more scientifically productive. Currently, there are discussions about how to implement the recommended changes. Once finalized, it will be shared with the community.

Paul Hertz then responded to the recommendations in the 2019 AAAC report:

- Recommendation #5: All current and planned surveys supported by NSF, NASA, and DOE/Cosmic Frontier should publicly release their data with suitable access tools and documentation.
    - NASA response: NASA concurs with this recommendation. SMD data policy is consistent with this recommendation for data and tools. NASA recently sponsored a NASEM report, *Open Software Policy Options for NASA Earth and Space Sciences*, and NASA is currently assessing the recommendations of this study and formulating a response and policy for open source code
- Recommendation #6: The three agencies should coordinate on the guidelines and expectations for the public releases of data sets, data products, data access tools, and related software used to produce future surveys, astrophysical simulations, and missions.
    - NASA response: NASA will work with NSF and DOE to respond to this recommendation. There already exist data standards (VO protocols) and tools that are built on top of these protocols.
- Recommendation #11: We continue to recommend that the three agencies either broaden the current discussions or create parallel discussions to consider broadly the costs and benefits of coordination on the science areas of interest to both the Euclid and LSST communities.
    - NASA response: NASA concurs. We are awaiting the final report from the joint Agency detailed study over two years to assess the benefits, approach, and cost of implementing joint processing.
- Recommendation #14: Given their common interests in access to the spectrum, NASA and NSF should enhance their collaboration with each other and with other groups, including international agencies and commercial interests, to protect the accessibility of essential astronomical wavelengths to researchers.
    - NASA response: NSF has the lead on spectrum management for radio astronomy. NASA will work with NSF.
- Recommendation #15: Efforts, ideally coordinated with all three agencies, should be made to increase awareness of spectrum management issues among astronomers, the general public, and government agencies.
    - NASA response: NSF has the lead on spectrum management for radio astronomy. NASA will work with NSF.
- Recommendation #17: The AAAC continues to recommend ongoing cost assessment and mission review of the Wide Field Infrared Survey Telescope (WFIRST) prior to and after Preliminary

Design Review.
    - NASA response: NASA concurs. NASA policies and procedures require this. An independent standing review board evaluates the WFIRST mission throughout its lifecycle at significant gate reviews. The upcoming PDR includes a major cost and schedule assessment to inform NASA of the estimated cost-to-complete at that point. There is also an internal review team that evaluates the project on a monthly basis. Finally, the Astrophysics Strategic Missions Program (ASMP) office is responsible for the day-to-day oversight and insight. The ASMP participates in all the monthly and lifecycle processes as well as assessing progress and analyzing technical and programmatic trends on an ongoing basis.
- Recommendation #22: In order to maintain a balanced investment in astrophysical research while continuing to support WFIRST, the highest ranked priority for NASA by the most recent decadal survey, NWNH, we recommend that the NASA budget be increased above the President's request to allow a funding level for the astrophysics division that would enable the funding of WFIRST to continue in the context of a balanced portfolio of investment.
    - NASA response: Congress appropriates the NASA budget and provides spending direction.
- Recommendation #28: NASA should continue to allocate resources to successfully launch JWST at the earliest possible date.
    - NASA response: NASA concurs. The NASA FY19 appropriation provides adequate funding to support JWST development during FY19. The budget required for a March 2021 launch has been allocated to JWST in the NASA FY20 budget request and its runout.
- Recommendation #29: The AAAC recommends to Congress that SOFIA's prime mission be considered complete at the end of FY2019, and that SOFIA undergo senior review in the next regular review cycle, in line with normal NASA review procedures.
    - NASA response: NASA has conducted two independent reviews of SOFIA during 2019 to inform a more productive extended mission for SOFIA. NASA plans to review SOFIA again in 2022, after three years of extended operations.
- Recommendation #55: The AAAC urges Congress to increase the proposed FY 2020 appropriation for NASA above the Administration's request to continue to provide a balanced program within astrophysics in line with the recommendations of NWNH.
    - NASA response: Congress appropriates the NASA budget and provides spending direction.
- Recommendation #59: the AAAC recommends that the annual report deadline be changed from a fixed date to a deadline 45-60 days following the submission of the President's budget, to enable sufficient opportunity for the committee to interact with the funding agencies, understand the impact of the President's budget, and formulate recommendations. The AAAC would endeavor to still meet the current deadline of March 15th when possible.
    - NASA response: NASA endorses this recommendation.

Paul Hertz emphasized that the missions recommended by the Decadal Surveys have been the most impactful missions that NASA has launched and operated. NASA is looking for the same kind of impactful recommendations for the 2020 Decadal Survey.

NASA is supporting the study of probe mission concepts because NASA believes that a medium-sized mission is needed for a balanced program. Costing offices from GSFC and JPL have been requested to perform independent assessments of the probe mission concepts that used the resources of their respective centers. To provide an independent assessment of the costing offices' results, NASA is assembling an independent Probes Concept Assessment Team (PCAT) to validate the cost estimates provided by the

costing offices, design labs, and PI-led studies. This will provide NASA Headquarters with confidence in the science, technical, cost, and risk conclusions of the Probe Mission Concept Reports that will be presented to the Decadal Survey.

For large mission studies, the National Academy study on Large Strategic Science Missions recommended that NASA conduct robust mission studies prior to the Decadal Survey. A Large Mission Concept Independent Assessment Team (LCIT) was assembled to conduct a technical, risk, and cost assessment for four large-scale mission concept studies. The purpose of LCIT is to:

1) Provide feedback to the STDTs that can be used to improve the Final STDT Reports that will be presented to the Decadal Survey
2) Provide NASA Headquarters confidence in science, technical, cost, and risk conclusions of the Final STDT Reports that will be presented to the Decadal Survey

A chart of the recent history of NASA Astrophysics Program budget shows appropriations up to the current year (FY2019). The current program including Webb operations and four Explorers is about $900 million per year. The runout of the President's FY2020 budget is $1.1 billion. If NASA's budget in the next decade is about that level, there would be about $2 billion per decade for new strategic initiatives following the launch of JWST. If Congress continues to appropriate funding for WFIRST, then the NASA Astrophysics budget will be about $1.45 billion. This will give NASA Astrophysics about $5 billion per decade for new strategic initiatives beyond the launch of WFIRST. If the Federal budget includes inflationary growth in the outyears, NASA Astrophysics might see a budget of $1.8 billion by the end of the next decade, which will allow for $7 billion per decade for strategic initiatives beyond WFIRST. Therefore, NASA's highest aspiration for the 2020 Decadal Survey is to be ambitious. The important science questions require new and ambitious capabilities because ambitious mission prioritized by previous Decadal Surveys have always led to paradigm shifting discoveries about the universe. If the Decadal Survey has great visions for the future and lays out a program that is visionary in its approach of the science, this can both justify and inspire the investments that the country would need to make to attain those science capabilities.

John O'Meara asked Paul Hertz if any additional guidance will be given to the Decadal Survey about Artemis. Paul Hertz responded that he does not believe the Decadal Survey needs additional instructions. The current Statement of Task for the Decadal Survey already directs the Decadal Survey to consider the capabilities that are made available through the human exploration program of the moon. This was before the announcement of Artemis.

Mansi Kaswali inquired about NASA's probe missions and whether one of the 10 ongoing probe missions will get selected by the Decadal Survey. Hertz explained that the Decadal Survey has many options for recommending how NASA should implement a probe mission. NASA received more than 10 proposals, but only the 10 that did well in peer review were selected. Dr. Hertz speculated some recommendations that the Decadal Survey may recommend.

Other Discussions

The AAAC was tasked to review the document on the principles and best practices for large projects in terms of data access for discussion at the next AAAC meeting.

The next meeting of the AAAC is scheduled for September 26-27, 2019; this will be an in-person meeting. There will be five new AAAC members to succeed the 5 AAAC members who will rotate out in July 2019. During the September meeting, dates will be selected for the January 2020 in-person meeting.

The Committee spent the remainder of the time discussing the annual report and writing assignments.

MEETING ADJOURNED AT 3:00 PM, 3 JUNE 2019