Minutes of the Meeting of the
Astronomy and Astrophysics Advisory Committee
27 June 2018
Teleconference

Members attending:

Dieter Hartmann
Buell Jannuzi (Chair)
Kelsey Johnson
Brian Keating
Eliza Kempton
Shane Larson
Rachel Mandelbaum (Vice Chair)
John O'Meara
Constance Rockosi
William Smith
Martin White

Agency personnel:

Richard Green, NSF-AST
Diana Phan, NSF-AST
Chris Davis, NSF-AST
Elizabeth Pentecost, NSF-AST
Richard Barvainis, NSF-AST
Matt Benacquista, NSF-AST
Donna O'Malley, NSF-AST
Paul Hertz, NASA
Hashima Hasan, NASA
Kathy Turner, DOE
Eric Linder, DOE
Brian Morsony, DOE

Others:

Rachel Osten, STSci
Rachel O'Connor, Smith College
Jason Kalirai, STScI
Laura Delgado Lopez, OSU
Valerie Connaughton, USRA
Naomi Webber, Lewis-Burke
Kelly Holley-Bockelmann, Vanderbilt
Janet Kozyra, NASA
Bruce Macintosh, Stanford
Alan Boss, Carnegie
Mihir Desai, SwRI
Paul Cassak, WVU
Andy Lankford, UC Irvine
Megan Donahue, Michigan State
Victoria Meadows, U of WA
Garth Illingworth, UCSC
Charles Lawrence, JPL
Alexandra Witze, *Science News*
Ashlee Williams, AAS
Sarah Lipscy, Ball Aerospace
Thomas Hams, NASA
Ben Kallen, Lewis-Burke
Eric Mamajek, Univ. of Rochester
Leonidas Moustakis, NASA
Paul Scowen, ASU
Sarah C. Brothers
Wil Thomas
Patrick Stockton
Jane Gillette, NASA
Jim Klimchuk, NASA/GSFC
Marshall Perrin, STSci
Jim Lancaster, NAS/BPA
Rhonda Stroud, NRL
Andrew Connolly, U of Washington

MEETING CONVENED 12:00 PM, 27 JUNE 2018

The Chair called the meeting to order.

The Chair led a discussion on selected recommendations from the 2017-2018 annual report in response to specific requests from the agencies for clarification or expanded discussion about selected recommendations. The agencies had sent their list of recommendations they wanted to discuss in advance of the meeting.

Regarding the recommendation that the three agencies coordinate, and where possible, standardize the guidelines and expectations for releases of data sets, data products, data access tools, and related software used to produce future surveys, astrophysical simulations, and missions, the AAAC's assessment is that a good job is being done regarding the public release of data, but more could be done to release the software used to generate the released data and to create the derived data products. In the case of future surveys, the AAAC anticipated that making early versions of mission/survey software available during the development of the mission/survey would enable the community to plan/optimize their own use of the data products that would be forthcoming. Having the software available helps everyone understand what was done and has near and long-term scientific benefits. The intent was that reasonable costs be supported (funded) and that some effort be made among the agencies to make it possible for tools to be shared. Coordination between the agenecies is expected to be beneficial. The recommendation is not a demand or mandate to revise or rescope existing missions and surveys.

Paul Hertz commented that he believes the three agencies are already coordinating these efforts on releasing data sets, data products, etc. and requested clarification or better description of where the agencies are falling short and how they can improve since the AAAC thought it was important enough to make a recommendation. Buell Jannuzi noted that it was in the area of releasing/providing well documented versions of the software used to generate data products that the greatest future improvement is anticipated and encouraged the agencies to work together on finding ways to share the recognized added burden and costs. Connie Rockosi commented that this recommendation came out of discussions about the complementarity of some of the missions and projects and how to work together; making it easy to collate and match the catalogs, etc.

Paul Hertz commented that from a funding point of view, if NASA were to make it a requirement on a project they they meet certain standards for release of data and/or software and/or archiving, then they would have to build that activity into their budget and put it in their request and that would increase the cost of the project. For example, WFIRST has built into its plan pipelining, archiving and release of its data and Paul would have to ask them for the cost of the software. Jannuzi acknowledge that there would be increased cost, but also increased value and impact of the missions/surveys. He stressed that AAAC was recommending that this be done "where possible." The value of the releasing the software is high, which generated the recommendation. The cost is recognized to be non-zero, which led the AAAC to qualify the recommendation with, "where possible," to provide the agencies the flexibility to evaluate the value vs. cost on a mission/survey basis.

Regarding the recommendation that 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, the AAAC recommends that 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. Possible agents for meeting this recommendation might include the NSF-funded national facilities for operations at radio and optical wavelengths. Prior to the discussion on the electromagnetic spectrum at the January meeting, the AAAC were only loosely aware of the issues behind spectrum management. The committee ended its discussion with the consensus view that the astronomical community should be more informed about how the electromagnetic spectrum access is managed and that there is a role for the agencies to play in not only spectrum management at the federal level, but also in educating the astronomical community so that members of the community will be more informed advocates for protection of access.

John O'Meara commented that yes, this is important. Members of the committee realize that the community can interact with Congress and other stakeholders in ways the agencies cannot, but can only do so if they know what they are fighting for. He did not previously know much about spectrum

management. This issue needs to be highlighted to the broader community in ways beyond just the presentation at the meeting.

Regarding the recommendation that NSF and NASA should continue to carry out and evaluate their strategies for reducing proposal pressure, reporting to the community for feedback on their evaluation strategies and the results, the AAAC wanted to encourage both NASA and NSF to continue to build upon their past experiments with requests, reviews, and the awarding of proposals in order to reduce the work load (on the community preparing/submitting proposals, the agencies managing reviews of the proposals, and the community participating in these reviews) and to increase success rates. These included the NSF going to rolling proposals (no deadlines) for the Solar and Planetary grants and the NASA ATP (theory) grants moving to an every other year proposal cycle. The AAAC expects continued evaluation of the outcomes, including not only whether success rates go up and workloads decrease, but also whether the demographics and other characteristics of supported programs change and in what ways.

Paul Hertz commented that NASA will continue to report about the issues of workload and issues of selection rate outcomes because NASA can do that.

Regarding the recommendation that all current and planned surveys should publicly release their data with suitable access tools and documentation. This is consistent with the AAAC Principles of Access recommended by the AAAC in their 2013-2014 annual report. In addition, the surveys should release the source code, where possible, used to create the data products. Surveys supported in part or entirely by the federal government through its agencies should work to include funding enabling adequate public access to the data, software, and data products produced through these surveys. The consensus of the AAAC is that in addition to surveys making their data (and software) publicly available, they should also provide (fund) tools to access these data, documentation, and software. The AAAC acknowledges that this would require funds.

Kathy Turner asked whether the committee had an idea of the costs associated with this recommendation. Buell Jannuzi replied no, the AAAC has not and is not in a position to do a cost assessment on a missions/survey by mission/survey basis, but noted that, for example, LSST, has already released some early versions of software to be used to process the LSST images into stacked/combined images so that it could be tested on other survey data sets. Similar efforts/releases might be affordable in the future and should be considered. For projects ending, it would be unrealistic to go back and re-do the scope of the effort.

AAAC Annual Report - Agency Response

Paul Hertz (NASA) and KathyTurner (DOE) provided feedback on the AAAC Annual Report.

NASA

The AAAC recommended that all current and planned surveys should publicly release their data with suitable access tools and documentation. NASA releases all its data to the public through its Astrophysics archives and will continue to do so. Tools and documentation are provided. Funding to analyze data in NASA's Astrophysics archives is provided through open, peer reviewed solicitations. Interoperability between the NASA archives and with non-NASA archives worldwide is provided through the NASA Astronomical Virtual Observatories (NAVO), using International Virtual Astronomical Observatories (IVAO) protocols. NASA continues to engage with NSF and DOE on the coordination of processing and archiving data from WFIRST, Euclid, and LSST. A joint processing working group is conducting a detailed study over two years to assess the benefits, approach, and cost of implementing joint processing. A final report to the Agencies is expected in 2019.

The AAAC recommended 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. The agencies should continue to prioritize a balanced portfolio, and in particular maintain a viable research and analysis program, using existing mechanisms familiar to the community such as the portfolio reviews and pacing of the early funding and review milestones for new projects. The agencies should communicate clearly with the community as these processes evolve to match the pressures on their programs. A balanced portfolio of missions (large, medium, and small), technology development, archives, and research and analysis is essential for a healthy science program. NASA remains committed to working to keep projects on schedule and on budget. NASA will continue to use the Senior Review process to assess the value of continued operation of missions. NASA looks to NAS studies and its advisory committees to assess the balance between missions, technology, archives, and research. NASA communicates its strategy to the scientific community and seeks input through a variety of public forums, including its Astrophysics Implementation Plan, advisory groups, working groups, Town Hall meetings, and newsletters.

The AAAC recommends that all three agencies, in recognition of the compelling science opportunities provided by the emerging field of multi-messenger astronomy, do their best to support the capabilities, facilities, missions, and programs on which progress in this area depends. For the NSF, multi-messenger astronomy is a well-recognized high priority. We recommend that DOE and NASA stay in close communication with NSF to avoid inadvertently hindering, through actions affecting their own programs or missions, this high priority of their partner agency. NASA and NSF have formed an Interagency Taskforce to look at current state-of-the-art collaboration opportunities to support multi-messenger astrophysics. Specifically, this Taskforce will look at current models of collaborations to identify gaps and best practices and will then recommend actions to the two Agencies.

The AAAC recommended that 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. Efforts, ideally coordinated among all three agencies, should be made to increase awareness of spectrum management issues among astronomers, the general public, and government agencies. Possible agents for meeting this recommendation might include the NSF-funded national facilities for operations at radio and optical wavelengths. The draft U.S. Spectrum Policy decision memo does not include the use of spectrum for observational radio astronomy, a unique key to understanding our universe highlighted by the National Academies reports. It is important that we preserve scientifically important bandpasses because once they are gone, they are nearly impossible to reinstate. NASA suggests that, if they have not already been engaged, NSF be given an opportunity to provide additional text addressing this omission in the draft policy decision memo.

The AAAC supported the recommendations of the 2017 WFIRST Independent External Technical/Management/Cost Review (WIETR) report and the subsequent process implemented by the NASA Associate Administrator in October of 2017 for realizing the science that would be delivered through the Wide-Field Infrared Survey Telescope. The AAAC agreed with the need to maintain cost containment for the WFIRST mission, and supports a rigorous cost assessment and mission review prior to WFIRST entering Phase B. The WFIRST scope has been reduced, and other changes have been made, to align WFIRST with a $3.2B cost target. WFIRST recently was given approval to begin Phase B with explicit direction to maintain the $3.2B cost target. 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*, the AAAC recommended that the NASA budget be increased above the Presidents' 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. The House and the

Senate marked the NASA astrophysics budget above the request, including directed appropriations for continuing the development of WFIRST.

The AAAC supported the recommendations of *NWNH* and *NWNH-AMA* that the NASA Astrophysics Division execute at least four Announcements of Opportunity for the Explorer program this decade, followed by Mission of Opportunity calls and mission selection, to preserve this valuable program of agile, low-cost missions in space. AOs followed by selections have been released in 2011 (TESS, NICER), 2014 (IXPE, GUSTO), 2016 (mission candidates in competitive Phase A), and 2019 (planned). The AAAC supported the NASA Astrophysics Division CubeSat initiative and recommends it continue to execute Announcements of Opportunity to determine the viability of CubeSats as a valuable component of NASA's efforts in astrophysics. CubeSats continue to be solicited as part of the ROSES NASA Research Announcement. NASA is allocating $5M per year for CubeSats.

DOE

In response to the AAAC recommendation that all current and planned surveys should publicly release their data with suitable access tools and documentation, the DOE response was that current/planned surveys that DOE/HEP is supporting (eBOSS, FGST, DES, DESI, LSST) all will release their data publically. The agencies have a Tri-Agency Group (TAG) to investigate the needs and costs of joint processing of the data (LSST, Euclid, WFIRST). There is a study going on to assess the details which will help to support planning the program activities going forward.

In response to the AAAC recommendation 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, DOE has responded by indicating that participation by DOE in LSST is to get at the dark energy science. DOE is amenable to include other topics in the Tri-Agency Group when NSF and NASA are ready. There is a detailed study going on now to investigate costs, which will help to support the planning of program activities going forward.

A balanced portfolio that continually produces world-leading science aligned with DOE's mission goals is important for DOE/HEP and informs the program planning. There are a number of mechanisms for community input and advice including HEPAP and AAAC and their subpanel studies (e.g. HEPAP's 2014 P5 strategic plan and the 2018 Portfolio Review), the NRC's Decadal Survey, and specialized workshops and community studies. DOE/HEP keeps NSF and NASA, as well as international partners apprised of upcoming reviews and studies. HEP works with the experiments and its partners to keep them apprised of results and to minimize impacts. DOE/HEP charged HEPAP to carry out a Portfolio Review subpanel study of currently operating experiments; the report was approved in May 2018. HEP is carrying out experiments and projects to address the P5 science goals in support of the DOE mission. Many of these (e.g. FGST, HAWC, VERITAS, DES, DESI, LSST) have broader science goals than those aligned with the HEP program. HEP is amenable to enabling these by their participation in project fabrication and operation. They remain in close contact with the other agencies regarding these activities.

The AAAC urged NSF and DOE to put in place a long-term operations plan and research plan that would, while maintaining a balanced overall portfolio, ensure that the US science community could capitalize on the substantial investment in LSST. DOE is responsible for the 3-billion pixel camera project and will also partner with NSF in supporting the LSST operations. A joint review of the operations proposal was held in December 2017. The program is supporting activities for LSST Dark Energy Science Collaboration (DESC) in order to address science aligned with the P5 goals. The DESC operations plan had its 2nd peer review in May 2018. HEP support for scientist participation (for university grants and lab

programs) in camera fabrication and commissioning, LSST operations, and the DESC is determined by peer review.

The AAAC thanked DOE and NSF for the report of the CMB-S4 CDT, which they found clearly communicated the results of the CDT's efforts to respond to the charge they were given. The AAAC was confident that it will meet the needs of the agencies to inform funding and programmatic decisions in the near term regarding CMB-S4. In response, the DOE found the study and report very helpful and it will provide important input to inform program planning towards CMB-S4.

HEP noted that the MIE and operations budgets for the projects are planned to be fully supported in the President's Request. As a mission agency, research support (at labs and university grants) is prioritized for efforts to carry out the projects and experiments in a program within budget constraints.

Agency Program Updates

NSF

Richard Green provided an update on AST activities. NSF continues to cooperate and collaborate with NASA and DOE on shared scientific priorities. Current examples for NASA include co-sponsorship of the Decadal Survey, cooperation on space weather and solar research, joint ground-space observations of astrophysical objects, e.g., neutron star mergers, collaboration on the exoplanet research program, cooperation on NEO detection and characterization, search for techno-signatures, and semi-annual joint NSF-NASA staff meetings. Current examples for DOE include the DECam, DESI, LSST, and the CMB Task Force.

AST has a high demand in its individual investigator programs. There are a suite of optical/infrared, radio, and solar telescopes being supported in the Division. DKIST and LSST construction is being done through the MREFC line of funding. AST is reorganizing its management of NSF's OIR facilities to optimize time-domain science. AST is also divesting of facilities given lower priority by the external review process to accommodate operations of new facilities and to maintain programmatic balance.

AST receives approximately 1,000 proposals a year, mainly in its Astronomy and Astrophysics Research Grants program. For 2016, the AAG budget was $48.4M, with a proposal funding rate of 20.9%. DKIST and LSST are currently under construction and full operations are expected in 2020 and 2022, respectively.

The National Center for Optical-Infrared Astronomy (NCOA) will integrate the NSF-funded entities-NOAO, Gemini, and LSST operations, under a single organization framework, managed by one management organization. NCOA is on schedule for October 2018. LSST operations is on track for initial funding in FY2019.

Currently NSF is waiting for Senate approval of its final execution plan. News is generally very good, with an increase in the Research & Related line of ~5% over the enacted 2017 budget; AST anticipates a favorable allocation with respect to that increase.

AST is participating in several of the "Big Ideas" being proposed by NSF, specifically *Windows on the Universe: The Era of Multi-messenger Astrophysics*, and *Harnessing the Data Revolution*. The FY 2019 President's Budget request allocates $30M each for Windows on the Universe and Harnessing the Data Revolution and $60M for mid-scale projects. These programs can support the mix of ground-based data acquisition, development of systems and structures for end-user data science and the theoretical modeling required for interpretation and prediction. These investments in key future directions result in a ~8%

reduction of core funding for AST in the PBR, given the flat top line request. Astronomers are well positioned to compete and win a larger total of research support than a flat-funded core grants program.

Because of the major changes to the operations of several of AST's facilities, NSF has embarked on formal Environment Impact Statements (EIS) as part of the decision-making process for three facilities; Arecibo, Green Bank, and Sacramento Peak. With regard to divestment:

- For Arecibo Observatory, a new award for operations was given to the University of Central Florida, in partnership with Universidad Metropolitana, and Yang Enterprises. The 5-year performance period began on April 1. There was a smooth transition of technical staff but there were more issues with scientific staff. There has been routine observing, but limitations in planetary and atmospheric radar due to hurricane damage. $14.3M of hurricane relief funding was appropriated; the highest priority is power stability with generator repairs and installation of a backup solar system as first actions.
- For Green Bank Observatory, the Draft EIS was released on November 10 with public meetings held on November 30; the public comment period ended in early January with a Final EIS anticipated in Fall 2018 and a Record of Decision in early 2019. NSF is currently working to secure additional funding commitments. The current cooperative agreement will be extended until October 1, 2019.
- For Sacramento Peak Observatory, the draft EIS was released on February 8 with no preferred alternative, with a public meeting held on February 28. NSO will manage the Sacramento Peak facilities as long as there is operation of the Dunn Solar Telescope; New Mexico State University proposes to lead a consortium to operate the Dunn Solar Telescope while NSO continues to support the infrastructure at SacPeak. The EIS process for Sacramento Peak is expected to conclude in the second half of 2018.

Planning is now underway for input into the next Decadal Survey. NSF/AST and NASA Astrophysics Division are the primary sponsors of the survey. DOE Cosmic Frontier in the Office of Science is also a sponsor. The Agencies and the National Academies are now converging on a statement of task. NAS will submit a proposal for NSF's share, anticipated to be received next month; the proposal will be reviewed jointly by NSF and NASA. NSF will be including all ground-based astrophysics for project priorization, not limited to AST. In preparation for the survey, NRAO has held a series of three Kavli-sponsored workshops to identify and prioritize the key scientific problems the RMS community would address in the next decade. NOAO is coordinating with the TMT and GMT projects to develop a community science case requiring time on both telescopes; the approach will be based on key science programs requiring substantial allocations of time.

NSF does not have a final execution plan for FY18. There is also increasing agency concern about sharing non-public data. For example, current or future year data that are not part of publicly released plans or requests are strictly embargoed; detailed data not publicly available underlying publicly accessible numbers now require special permission, i.e., proposal success rates. Buell Januzzi noted that there is always a tension between the operations costs of the centers and protecting the grants program, and one of the ways of knowing that there is balance in the portfolio is to be able to assess what is happening in that portfolio. If the Committee doesn't know what the proposal pressure is like or what a typical grant request is like, it makes it difficult to provide advice on the balance. Richard Green commented that it was good to hear that from the committee since it helps him in making sure that information is available. Martin White agreed that the information was critical, but realizes that it takes some time to gather the information.

DOE

Kathy Turner gave an update on DOE activities. The FY19 High Energy Physics (HEP) PBR ($770M) is guided by priorities set by the Administration, the DOE Office of Science, and the P5 plan. The FY19 PBR reduces near-term science (research and operations) for P5-guided investments (projects) in the mid- and long-term program. All projects continue, some with delays. The Administration and Congress support the overall P5 strategy. The final FY2019 appropriation will define the continued pace of P5 project execution.

Projects fully supported in FY19 include Muon to Electron Conversion (Mu2e), the High-Luminosity Large Hadron Collider (HL-LHC) accelerator upgrade project, LUX-Zeplin (LZ), and SuperCDMS (Cryogenic Dark Matter Search)–SNOLAB, and DESI. The LSST Camera project received its final funding in FY18. HL-LHC ATLAS and CMS detector upgrade projects are new start MIEs in FY19. The FY19 request for research and operations was adjusted in order to maintain project support. Higher priority is given to research activities at labs and universities that are critical to executing the P5 recommendations.

In FY18, the enacted budgets for HEP and the Cosmic Frontier were $908M and $121.25M, respectively. In the FY19 PBR, the budgets are $770M and $75.45M, respectively; a significant difference for both. The final FY18 funding for the Cosmic Frontier may be different depending on Early Career awards, etc.

HEPAP was charged in October 2017 to carry out a Portfolio Review, modeled on NSF's Portfolio Review and NASA's Senior Reviews. This was an independent peer review of currently operating experiments supported by HEP. The review focused on scientific impact and productivity of HEP-supported contributions with narrow emphasis on P5 science drivers. HEP was to use the results to define a detailed implementation plan for a P5 strategic vision in the FY19 to FY22 timeframe. The report was delivered to HEPAP in May and was accepted. Moving forward, HEP will prioritize ongoing support for top tier projects and lower tier projects will be ramped down over a few years depending on budgets, partnerships, and external factors. HEP is now discussing the report with its partners and will be sending out guidance letters to each experiment.

Quantum Information Science (QIS) has been identified as an important cros-cutting topic with potential impact across all DOE Office of Science (SC) program offices. A Dear Colleague Letter was issued in November 2017. For HEP, the emphasis is on the HEP mission, science drivers, and advancement of QIS in the context of the broader SC initiative. The FY18 budget approved support for QIS at ~$15M. A funding opportunity announcement for universities and DOE labs was released in February; awards will be made by the end of the FY. The request for FY19 is ~$27M.

HEP initiated a consultative process with the HEP community to more accurately capture the larger than expected computing needs and look for opportunities where economies of scale and optical use of resources could close the gap. Meetings are being held that focus on hardware, software, and personnel needs for the next decade as well as identification of common elements in software and workflows, HPC applicability, and other initiatives.

HEP is pursuing four of the five science drivers from the 2014 P5 strategic plan: to study dark energy (LSST, eBOSS, DESI), search for dark matter (SuperCDMS-SNOLAB, LZ, ADMX-G2), study cosmic acceleration through cosmic microwave background (CMB-S4), and study high-energy cosmic-ray and gamma-ray particles (HAWC, Fermi/GLAST, AMS). All the experiments and projects have international partners or contributions and some also have private contributions.

HEP is maintaining the core of the DOE Science Mission, and that is reflected in the FY18 current plan and the FY19 Request. HEP is looking forward to participation in the National Academies 2020 Astronomy and Astrophysics Decadal Survey.

NASA

Paul Hertz provided an update on JWST. In March, NASA announced a delay of the launch of JWST. The SMD Associate Administrator appointed an Independent Review Board (IRB) to review the work to go on JWST and to make recommendations to NASA as to what work still had to be done to ensure that NASA was doing everything necessary to maximize the probability that NASA would attain mission success. The IRB reported their findings to NASA at the end of May and since that time NASA has been working on a replan of the program that incorporates the IRB findings. The replan has been submitted to OMB and Congress, and is being made public today. The IRB unanimously concluded that the science for JWST remains world-class and compelling, and that mission success is the driving consideration going forward. The IRB noted that many technical complexities have impacted the development schedule that has led to the delay and has caused this replan. Many of the complexities include first-of-a-kind developments and many of the avoidable technical errors included human errors and embedded problems, some of which occurred years ago but came to light during integration and testing at the spacecraft and observatory levels. Based on the report of the Standing Review Board (SRB) and the Independent Review Board (IRB), NASA has focused on the replan and schedule and recommendations for mission success. The Science Mission Directorate accepted the IRB recommendations and NASA and Northrup Grumman have initiated the process controls and corrective actions to address the IRB recommendations. The revised schedule and cost reflect an 80% confidence level which is consistent with the SRB/IRB; it is conservative in the way it accounts for how long future work will take and takes into account inefficiencies for the remaining work. The replan includes adequate reserves (UFE, unallocated future expenses) that may be applied to future issues that are unknown right now. The new proposed launch date commitment is March 30, 2021 and the proposed cost through development, launch and commissioning is $8.803B and the lifecycle costs increases to $9.66B.

JWST has four themes which drive the science: history of the universe and first light; the assembly of galaxies and how galaxies came to be after the early universe; the study of the formation of planetary systems; and, the study of planets and the search for life on exoplanets by studying their atmospheres. All four are more compelling now that when JWST was conceived in the 1990s.

The IRB was asked to evaluate all of the factors that would influence JWST's success and was appropriate for NASA's next flagship observatory. The IRB concluded that JWST is an observatory with incredible capability, scientific potential, and significant complexity and risk; integration and testing is complete and has demonstrated exceptional science capability. In their report, the IRB indicated that significant launch date delays and resulting costs were caused by human errors, embedded problems, excessive optimism in integration and testing planning, lack of sunshield experience and system complexity, and small I&T problems that can have a major impact on schedule and cost. They concluded that implementing all recommendations contained in their report will contribute to maximizing the probability of mission success; mission success must be the highest priority and must drive the project forward. The IRB believes that JWST should continue based on its extraordinary scientific potential and critical role in maintaining US leadership in astrononomy and astrophysics.

All of JWST has been built; all parts, all systems and subsystems are in one place at Northrup Grumman. The telescope has been integrated with the science payload, and the spacecraft has been integrated with the sunshield. These two major assemblies have to be integrated with each other and tested together and then shipped to the launch site in French Guiana (the launch will be provided by European partners) where it will be launched to Sun-Earth L2; commissioning will take 6 months. There are many "firsts"

for JWST, including no legacy for the sunshield, no experience with actively controlled segmented mirrors in space, first launch of a NASA payload on an Ariane 5 rocket, a spacecraft transported to the launch site by water, spacecraft processing and launch in French Guiana, flights operations conducted by STScI, and complex observatory operations at L2.

The IRB found that there had been human-induced errors that had a significant impact on the launch schedule including propulsion system problems and fastener problems. These problems need to be minimized; though they cannot be eliminated they need to be caught before they impact the project. The contractor will establish corrective actions to catch and avoid these human errors. NASA will provide an additional level of oversight. There were also some embedded problems that were not detected until testing on the spacecraft, i.e., a propulsion valve problem, and the fastener issue that was not detected until the acoustic test. NASA and Northrup Grumman will conduct additional audits including forensic engineering, hardware assessment, and drawing checks to identify potential embedded problems. Verification will be done through means other than testing as you fly which cannot be accomplished after the observatory has been completely assembled (there is no chamber large enough for environmental testing). There were some findings and recommendations regarding commissioning of the observatory. The IRB recommended that the position of Commissioning Manager be established. This person would have responsibility for commissioning success. Mission success is critical for the project so NASA, Northrup Grumman and STScI generated a list of items (prioritized) that could be implemented to decrease risk and increase mission success if cost and schedule were not constraints; NASA and Northrup Grumman are implementing many of the items on the list.

The cost to complete development has grown by $805M. Existing operations budget through FY21 is ~$310M, so the project needs ~$490M additional funding in FY20-FY21. It is uncertain now how this increase will be accommodated in the FY20 budget; NASA will submit its FY20 budget request to OMB in the Fall and the President will release the FY20 budget request to Congress in February 2019. It is believed that the anticipated cost growth of JWST will likely impact other science missions. If this cost growth were to come from the Astrophysics budget, then the Probe-class missions outlined in the FY19 budget plan could be delayed by three years and that could free up ~$350M that would be used for JWST; additional $140M reductions (across 2 years) against the Astrophysics portfolio would have to be absorbed by other programs within the Division.

John O'Meara asked how these developments will impact any advice you get from the next decadal survey; will today's announcement about the JWST launch delay impact how NASA approaches the next decadal survey? Paul Hertz replied that it doesn't impact how NASA approaches the next decadal survey; NASA's vision and priorities remain clear and NASA plans to institute its astrophysics program (that will include JWST and the highest priorities of the next decadal survey). By February, NASA will be discussing the impact JWST's delay will have on other elements in the NASA portfolio, with some impacts on the Astrophysics portfolio; all of this will be discussed with the decadal survey committee.

Buell Jannuzi asked if the replan included keeping the instrument teams going through commissioning after launch. Paul Hertz replied that the replan includes keeping all of the necessary teams going; everyone is necessary to make sure that NASA maximizes the probability of mission success; it includes instrument teams and JWST staff at STScI who will continue working on mission and science operations.

Paul Hertz was asked how cost growth will be accommodated and will it impact other divisions. There could be an impact but it is unknown at this time.

Decadal Survey Planning and Timeline

The three agencies are in the planning stages for the next Decadal Survey. The statement of task is almost finalized. The Academies consulting group will look at the statement of task and get back to the agencies soon; the Academies Board meets in July to decide on the scope and shortly thereafter submit their proposals to NSF and NASA. NSF and NASA plan to fund the proposals with current year funding. The kickoff for the Survey will happen either at the end of this calendar year or early next year; there will be a Town Hall at the AAS meeting in January, the first public kickoff for the community. The Statement of Task includes the committee writing recommendaitons to the agencies, including state of the profession (e.g., future workforce and increasing the diversity of the astronomical community).

Gemini, Blanco and SOAR Telescopes Science Evaluation Subpanel Discussion

NSF, DOE, and NASA requested that the AAAC establish an ad hoc subcommittee to consider the evolving roles of the Gemini, Blanco, and SOAR telescopes in the era of multi-messenger astronomy. As emphasis on time domain and multi-messenger science increases and the LSST comes on line, the role and utility of the Gemini telescopes and the complement of southern hemisphere moderate aperture ground-based optical/IR telescopes will be evolving. The 2015 NRC Report on *Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System* recommended that NSF should direct its managing organizations to enhance coordination among the federal components of medium- to large-aperture telescopes in the southern hemisphere, including Gemini South, Blanco, SOAR, and LSST. This suite of ground-based telescopes could serve multiple scientific purposes by offering synergies with LSST for broader time-domain investigations and DOE dark energy studies; provide hemisphere-specific applications, such as local group galaxies and specific star-forming regions, or optimizing sky coverage with respect to ALMA and LSST; support NSF's current priority of multi-messenger astrophysics, combining electromagnetic detections with gravitational waves and energetic particles; and, provide an all-sky capability to maximize the return from NASA astrophysics missions.

Although the upcoming Decadal Survey will define the scientific priorities for the field for the next ten-year timescale, processes internal to the Gemini and SOAR partnerships dictate the need for advice on a shorter timescale. The partners must express their intentions about renewing the Gemini International Agreement in November of this year, so that they are in a position to negotiate a new agreement for operations and development of both Gemini-North and Gemini-South telescopes post-2021. By late 2019 the NSF will need to determine its position on supporting operation of SOAR beyond 2020. For DOE, it is a need and priority for use of these facilities to enhance Dark Energy science investigations with these facilities.

The subcommittee was requested to report its preliminary findings to the AAAC at a meeting in November, 2018, with a final report to be presented at the meeting in February, 2019.

Richard Green asked the committee for suggested names for membership on the subcommittee.

Bill Smith noted that this study is very much focused on the constellation the telescopes in the south. He asked if the subcommittee is to consider Gemini completely split with priorities already defined for Gemini South without having to worry about partnerships and how Gemini North could evolve. Chris Davis commented that the Gemini Board, in its strategic vision, has suggested that the two Gemini telescopes should be allowed to diverge, so the idea of "One Observatory, Two Telescopes," is something that the observatory could move beyond; the telescopes, at least from the US perspective, should be allowed to diverge.

Dieter Hartmann asked if the role of the subcommittee is assessment and advice only; should they take a

look at the existing use of the telescopes and how they fit into the plan for multi-messenger and other science. Richard Green replied that NSF would consider advice from the subcommittee, and if they see these telescopes as still high priority, then this is good advice for NSF to help make decisions.

Connie Rockosi suggested broadening the language on mulit-facility modes stated in the charge a little more to get persons thinking about the most effective use of these facilities given the landscape. The subcommittee should consider all possible operating modes.

The Committee spent some time in closed session discussing the election of a new chair/vice chair.

MEETING ADJOURNED AT 4:00 PM, 27 JUNE 2018