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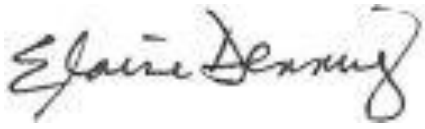
MEETING REPORT

Bradley Peterson, Chair



Elaine Denning, Executive Secretary

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Opening Remarks

Ms. Elaine Denning, Executive Secretary of the Science Committee (SC), called the meeting to order, described the nature of FACA regulations, and made administrative announcements, after which Committee members introduced themselves around the table. Ms. Denning then introduced Dr. Bradley Peterson, Chair of the SC, who then opened the meeting.

Discussion with SMD Associate Administrator

Dr. Thomas Zurbuchen, Associate Administrator (AA) of the Science Mission Directorate (SMD), joined the committee to provide an overview of SMD activities and discuss the day's agenda. Dr. Zurbuchen presented science and mission highlights including progress toward spacecraft integration of the James Webb Space Telescope, environmental testing of the Parker Solar Probe, completion of the Cassini mission, discovery of the first interstellar asteroid, and the Total Solar Eclipse of 2017. He noted updates on personnel, schedules and partnership activities. Lastly, he covered newsworthy events such as the launch of the Joint Polar Satellite System-1 (JPSS-1), now known as NOAA-20, the launch readiness of the Total and Spectral Solar Irradiance Sensor (TSIS-1), and the capabilities that SmallSats and CubeSats have contributed to science, among other matters.

In the question and answer period, Dr. Jeffrey Hoffman asked how SMD coordinates science requirements with the Human Exploration and Operations Mission Directorate (HEOMD) with regard to the instruments that will be on the International Space Station (ISS). Dr. Zurbuchen noted that using ISS as a platform for science started long ago but that it was exciting to see the science that is being produced now, for instance on space radiation that is related to human exploration. SMD works closely with ISS staff at Marshall Space Flight Center and Johnson Space Center; efforts include the exchange of personnel.

WIETR Discussion

Dr. Zurbuchen addressed the recently completed report of the Wide Field Infrared Survey Telescope (WFIRST) Independent External Technical/Management/Cost Review (WIETR). Let the record show that Dr. Peterson, Dr. Kathryn Flanagan, and Dr. Scott Gaudi had conflicts due to their involvement with the mission or the organizations developing the mission, and summarily recused themselves. However, all three were permitted to ask objective questions about issues that had no material bearing on either the mission or Committee deliberations.

Dr. Gaudi, Chair of the Astrophysics Advisory Committee, asked whether the science needs of the future direct-imaging missions, the Habitable-Exoplanet Imaging Mission (HabEx) and the Large UV/Optical/IR Surveyor (LUVOIR), had been taken into consideration during the WIETR deliberations, which had presented an option of building the coronagraph as strictly a technology demonstration. Dr. Paul Hertz, Director of the Astrophysics Division, responded that the coronagraph is treated as a technology demonstration, not science, thus the requirements are technological. Both the HabEx and LUVOIR teams were asked which technologies would be most useful in retiring risk and then that input

was used as input for setting the requirements for the coronagraph. Dr. Gaudi asked for clarity on a Class A versus Class B designation for WFIRST. Mr. Orlando Figueroa, Chair of the WIETR, fielded the question. He first noted that the WIETR report had been requested by the SMD AA to determine whether WFIRST as currently planned was well understood in terms of scope, resources, and executability. The report contains multiple options that take into account these three parameters. Mr. Figueroa added that the WIETR took the stance that WFIRST should be viewed either as a Class A mission that must "work its way down" to accommodate available resources, or as a Class B mission that must "work its way up." Dr. Gaudi asked if the WIETR had considered the coronagraph as a present investment that would pay off in the future, by buying down technology risk for direct-imaging missions. Mr. Figueroa said the WIETR had considered these aspects, and had also involved the participation of Dr. David Spergel, a WFIRST Science Definition Team (SDT) member, as well as others.

Dr. Peterson and several members raised why the WFIRST cost cap had been determined so early in mission formulation, citing this as unusual for a Flagship mission. Dr. Zurbuchen noted that lingering concerns about the cost and scheduling issues associated with the James Webb Space Telescope were a primary motivator behind the timing of the cost cap determination. He added that smaller PI-led missions, which are fiscally restrained *ab initio*, are performing very well in terms of cost containment, and that the hope is that similar practices could help rein in cost growth for larger missions. In addition, the unusual nature of WFIRST's provenance (pre-existing optical assets) played a role in altering NASA's usual approach to large-mission planning. Since changing the management processes, strategic scale missions after KDP-C performed on par with PI-Class missions. Thus, the focus of cost-control should be pre-KDP-C, where WFIRST is. Dr. Zurbuchen pointed out that similar cost control practices were used for other strategic missions, including Europa.

Dr. Flanagan commented that a delay in WFIRST (or any mission) in order to accommodate the re-vectoring of mission requirements and instrumentation, carried a real risk of doubling or tripling the costs of some instrument formulation and development. Dr. Peterson concurred with this caveat. Dr. Walter Secada inquired whether the decisions were still in play, and Dr. Hertz noted that was the case and that a set of descopes had been discussed. A first round of decisions would be discussed which would allow the team to modify the designs and have the cost of the modified design assessed.

Science Activation Showcase

Ms. Kristen Erickson introduced a series of Science Activation projects, focusing on Science, Technology, Engineering and Mathematics (STEM) education and outreach. These projects are the result of a 2015 NASA Cooperative Agreement, which resulted in the selection of 27 proposals with five-year contracts. The projects are widely diverse and involve NASA centers, universities, museums, and school systems throughout the United States. Ms. Erickson also announced NASA's new Science Activation Hotline, which puts requesters in touch with NASA subject matter experts (SMEs) to answer specific questions in an online format. (https://science.nasa.gov/contact-science-activation)

Ms. Kristen Weaver presented a video of Global Learning and Observations to Benefit the Environment (GLOBE) activities. GLOBE is an international program that is sponsored by NASA and the National

Science Foundation (NSF), and receives support from other federal agencies. GLOBE is integrally connected with the NASA Earth Science Division (ESD) as well. Ms. Weaver presented a video of students engaging with NASA data in various ways, in particular from the GLOBE Cloud Protocol that enables observations of clouds from NASA satellites, and the ground. She discussed numerous activities, taking place worldwide that involved data from the Global Precipitation Mission (GPM) satellite, including students making rudimentary climate observations, soil moisture observations, etc., while learning about atmospheric science.

Dr. Alex Young, from NASA's Space Science Education Center, presented some video highlights from the year, including media coverage of the total solar eclipse of August 2017, which was a record-setting social engagement phenomenon for NASA. It is estimated that 150 million Americans travelled to view the eclipse. He presented a video depicting a visually impaired student interacting with a spacecraft module, using Virtual Reality (VR) equipment. The VR apparatus enabled the student to see objects in great detail. Dr. Young commented that such experiments can lead to adaptive technologies in other areas.

Dr. Denise Smith presented a video from the Universe of Learning partnership that provides learners with a direct connection to science and subject matter experts across the full range of NASA's astrophysics missions. NASA's Universe of Learning is a unique partnership between the Space Telescope Science Institute (STScI), Caltech/IPAC, the Jet Propulsion Laboratory (JPL), the Smithsonian Astrophysical Observatory, and Sonoma State University. The video featured a dynamic and easy to understand portrayal of the electromagnetic spectrum, and illustrated how astronomers use NASA observatories to learn about our universe. The video is disseminated through the team's ViewSpace platform. ViewSpace is a self-updating, multimedia exhibit used in over 200 museums, planetariums, libraries and colleges worldwide. The team also is adding interactive content to the ViewSpace platform that enables audiences to compare images of celestial objects as observed at different wavelengths.

Dr. Rachel Connolly presented a video "Bringing the Universe to America's Classrooms" featuring teachers explaining how using data science products is an innovative teaching tool. Science products were used to explain the observation of wind, monsoons, global ocean currents, and atmospheric CO2, as well as subduction zone processes. The video depicted students at a number of grade levels benefiting from the NASA observations, from kindergartners drawing accurate pictures of the sun and its corona, thereby displaying a deeper understanding of the sun as a star, to middle school and high school students interacting with the data with increasing levels of sophistication.

Dr. Rosamond Kinzler, from the American Museum of Natural History (AMNH), introduced a demonstration by Mr. Carter Emmart from AMNH of a software package called OpenSpace. OpenSpace is a beta version of an open-code, open-source graphics program that simulates the placement of all the bodies in the known universe, including exoplanets, stars, asteroids, comets, small bodies, etc. The 230MB platform runs in concert with data streams from numerous space assets, and depicts a truly remarkable range of views, in three dimensions, of such items as planets and their orbits, the movement of constellations, individual stars and galaxies. It gives a clear picture of how, among many other perspectives, the Solar System moves relative to its Milky Way galaxy. The package itself will be

available in an extended beta version on January 1, 2018. The interactive package is suited to many venues, including planetariums, classrooms, and museums.

SC members made comments about the high quality of these teaching tools. Dr. Doug Duncan noted the great emphasis on collaboration and cooperation in the STEM activation effort; rarely is such synergy seen. Dr. Secada, who was familiar with the Science Activation effort from the beginning, said that the activities are having high payoff. Dr. Anne Verbiscer noted that the outreach for the solar eclipse was excellent, and asked if anything was being planned for the New Horizons flyby of the Kuiper Belt objects in one year. Ms. Erickson noted that NASA will engage with the entire outreach network established during the solar eclipse, including 700 library partners, on the view of the objects. In addition, a naming contest activity is occurring.

R&A Charge Update

The Committee briefly discussed progress on a charge that had been given them by the SMD AA, to examine how the four divisions in SMD are choosing high-risk, high-payoff proposals in the Research and Analysis (R&A) program. Given that R&A panels typically have a significant degree of risk aversion built into their selection processes, Dr. Zurbuchen had expressed interest in whether proposals being selected contained a sufficient number of high-risk, high payoff science investigations that could open new avenues for significant evolution of missions and the science questions themselves.

Dr. Jill Dahlburg commented that in her experience at the Naval Research Laboratory, high-risk, high-payoff proposals tended to be very new concepts, and accordingly were often graded "bimodally," i.e. either excellent (because they were high-payoff) or middling (because they were high-risk), and suggested that a more detailed exploration of such proposals, after initial reviews, might yield promising proposals after the fact. Dr. Peterson agreed that such "high dispersion" was a signal for such concepts, and felt that a year-long pilot program based on these assumptions might yield some successes. Dr. Michael New, speaking primarily for the Planetary Science Division, said that the selecting officer is typically well aware of these issues and scrutinizes proposals in a similar manner, although the practice is not encoded as a formal policy. Dr. Verbiscer agreed that informal Q&As were frequently carried out in the proposal review process. Several members observed that the presence of subject matter experts (SMEs) on review panels was critical to identifying these high-payoff proposals; Dr. Dahlburg added that sometimes the reviewer with the most familiarity with a mission concept's science/technical characteristics could also be the most conservative grader on the review panel because they are the most cognizant of the risks. Dr. Secada noted that taking intellectual risks is key; it is important that young people get a chance as they are not as weighed down by past failures and are more likely to challenge conventional wisdom. Dr. Peterson concluded the discussion, as it was deemed unready to be the subject of formal findings or recommendations.

Astrophysics Division Update

Dr. Paul Hertz provided an update on Astrophysics Division (APD) activities, first offering a "big picture" look at the FY18 budget, which at roughly $1.35B, including funds for JWST, represents a generally flat trend in funding for APD. The FY18 budget supports a 2019 JWST launch, continued

formulation of WFIRST, Explorers mission development, and increased funding for the R&A program. Operating missions, suborbital missions and new capabilities, and technology development and mission studies are also well supported. The FY17 appropriation was below the APD request, and therefore some reductions will be necessary at the end of the fiscal year. The FY18 President's Budget Request (PBR) aims to balance current science and future missions, but is subject to potentially significant Congressional markups. NASA however has been able to implement the missions recommended by the 2010 Decadal Survey, and has also received affirmation of this progress through the National Academies of Science (NAS) 2016 Midterm Assessment report. As previously discussed, the WIETR report has resulted in design changes to WFIRST in order to keep it within its original cost target.

The APD Spring 2016 Senior Review (SR) recommended continued operation of all missions that are currently in extended phase: Chandra, Fermi, Hubble, Kepler, NuSTAR, Spitzer, Swift, and X-ray Multi-Mirror Mission (XMM)-Newton. Dr. Hertz noted that a Request for Information (RFI) is out on Spitzer, seeking a non-NASA sponsor interested in operating the telescope in its "warm" incarnation beyond 2019, which is when NASA funding is due to cease. Responses to the RFI to seek a private sponsor for Spitzer's warm operations are due in December of this calendar year. In addition, an October Request for Information (RFI) was released to solicit information on novel astrophysics science that could be accomplished with small satellites (SmallSats). The Neutron Star Interior Composition Explorer (NICER) was successfully launched to the ISS in June, and the Cosmic Ray Energetics and Mass (CREAM) instrument was similarly emplaced on the ISS in August of this year. Aside from WFIRST, launching in the mid-2020s, other notable missions under development include the Transiting Exoplanet Survey Satellite (TESS) (2018), Imaging X-ray Polarimetry Explorer (IXPE) (2021), and Galactic/Extragalactic ULDB (Ultra-long Duration Balloon) Spectroscopic Terahertz Observatory (GUSTO) (2021). APD continues to conduct large- and medium-mission concept studies for the 2020 Decadal Survey.

The James Webb Space Telescope continues to progress to its 2019 launch. The spacecraft was integrated with its sunshield, forming the spacecraft (SCE) element, and the first avionics-driven sunshield deployment was carried out. The science payload underwent a successful cryovacuum test. Thirteen proposals have been selected for Early Release Science through the Webb Director's discretionary program. In 2018, the science payload will be integrated with the SCE, and further environmental testing will be performed. WFIRST is moving forward after accommodating modifications in response to the WIETR report, and is scheduled for its System Requirements Review (SRR)/Mission Design Review (MDR) in February 2018, followed by Key Decision Point-B (KDP-B) in March/April 2018. The Explorers program is resuming a high cadence. In addition to TESS, NICER and GUSTO, the 2016 mid-sized Explorer (MIDEX) call resulted in the selection of three missions to conduct competitive Phase A studies: Arcus, Field Investigations to Enable Solar System Science and Exploration (FINESSE) and Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx). The next small Explorers (SMEX) call is planned for 2019.

The Astrophysics budget for FY18 is still in Congressional deliberation. Both the House and the Senate markups provide support for the Decadal Survey missions, JWST, and STEM Activation, but earmarks by

both chambers threaten APD projects, programs and activities with a $54M shortfall. In addition, the Senate has added language on $10M worth of support for "life detection technology," a term that has yet to be defined.

Dr. Hertz reviewed some of APD's responses to Astrophysics Advisory Committee (APAC) requests, findings and recommendations. He indicated that a requested briefing on the Internal Scientist Funding Model (ISFM) would take place at the next APAC meeting, as would a requested update on JWST, and the Spitzer private-funding RFI. Furthermore, APD has agreed to delay the deadline for proposals for Cycle 1 of JWST's General Observer program, as recommended by APAC. APD also accepted the APAC recommendation to retain the ROSES-17 Strategic Astrophysics Technology (SAT) call.

Dr. Mihir Desai asked Dr. Hertz to explain how targets could be found for an interstellar probe. Dr. Hertz cited that Congressional language has directed NASA to send an interstellar probe to explore exoplanets by 2069. A roadmap would be prepared by the Space Technology Mission Directorate (STMD) to develop propulsion systems capable of achieving 10 percent of the speed of light. It is envisioned that the targets would be found by WFIRST, but Dr. Hertz had doubts that those could be found by a 2.4 m telescope. Dr. Hoffman asked about if there is an activity to think about what can be done in the future large programs of astrophysics using the capabilities of the Falcon Heavy and Space Launch System (SLS). Dr. Hertz replied that the suite of potential launch vehicles is being examined by all of the large mission concept study teams; some missions are enabled by and all are informed by these planned large launch vehicles. There is a HEOMD workshop in February on how the Deep Space Gateway could be used, for instance, to enable very large telescopes.

Astrophysics Advisory Committee Update

Dr. Gaudi introduced his committee report with science highlights. Fermi and the Laser Interferometer Gravitational-Wave Observatory (LIGO), along with other telescopes, observed a gamma ray burst and gravitational wave simultaneously, resulting from the collision of neutron stars (a "kilonova"), marking the first time a gravitational wave had been observed along with an electromagnetic radiation signal. Hubble resolved a high-redshift (z=2.5) star-forming region. Chandra provided data to refine a three-dimensional model of a white dwarf explosion. Hubble also observed a "pitch-black" exoplanet, WASP 12-B, which orbits so closely to its star that its atmosphere is thought to be continually pulled away, resulting in a body that has very little albedo. ISS-NICER is functioning well and investigating equations of state for neutron stars, and a NASA citizen science project, *Backyard Worlds: Planet 9*, resulted in the discovery of a brown dwarf, using data from the Wide-field Infrared Surveyor Experiment (WISE).

Dr. Gaudi briefly reviewed the APAC roster and told the SC that Dr. Feryal Ozel will soon be his successor as committee chair. The last APAC meeting was held in October, and covered a number of topics, including some concerns with the TESS mission, and the charge to identify high-risk, high-payoff science in the R&A program. In addition to the responses to APAC detailed in Dr. Hertz's presentation, APAC also recommended that APD try to minimize science loss and to adhere as closely as possible to the Decadal Survey, and to maintain its emphasis on R&A, in light of the anticipated FY18 budget. The

APAC also closed out its Exoplanet Science Analysis Group (ExoSAG) 14, the Characterization of Stars Targeted for NASA Exoplanet Missions.

Public Comments
No public comments were noted.

Planetary Science Division Update
Dr. James Green briefed the SC on the Planetary Science Division (PSD), first noting the termination of the Cassini mission in September, and the great success of NASA's Eclipse 2017 activities. In May 2018, InSight, a seismic and thermal experiment, will be launched to Mars; and the Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx) spacecraft will arrive at asteroid Bennu in August. In October 2018, the European Space Agency (ESA) will launch BepiColombo (carrying a NASA instrument) to Mercury. On January 1, 2019, New Horizons will fly by a Kuiper Belt object that lies beyond Pluto and Charon.

The Discovery program has been quite active. Psyche and Lucy, two asteroid exploration missions, are scheduled to launch in 2022 and 2021, respectively. Psyche will explore a "metal world" asteroid, while Lucy will survey the Trojan asteroid system. The New Frontiers 4 Announcement of Opportunity (AO) resulted in twelve proposal submissions from six target destinations including a Saturn Probe, Trojan Tour and Rendezvous, a Venus In Situ Explorer, Ocean Worlds (Titan, Enceladus), Lunar South Pole-Aitken Basin Sample Return, and Comet Surface Sample Return. Step-1 selections are due to be announced in December and will be downselected for flight in July 2019, with a Launch Readiness Date (LRD) of no later than December 31, 2025.

The third Planetary Decadal Survey is due in 2023. The Midterm Evaluation is due in March 2018. PSD has completed studies in anticipation of the new Survey, including a Mars orbiter, Uranus and Neptune (ice giants) systems missions, a Europa lander, and a Venus orbiter/lander (Venera-D), the latter of which is a joint U.S.-Russian effort. The Committee on Astrobiology and Planetary Science (CAPS) has identified other areas for further study, including a dedicated space telescope for Solar System science, Io science, and Mars medium-class missions.

Dr. Peterson noted that the Mars notional sample return architecture presented was very exciting, and asked how planetary protection is considered in it. Dr. Green noted that there must be a thorough analysis of how to handle planetary protection as part of the mission architecture and develop the security necessary to bring samples to Earth in a capsule. One aspect is the idea to land the capsule without a chute which eliminates the risk that a chute will not work. Dr. Desai asked if there are any plans regarding Uranus and Neptune, and Dr. Green noted that the ice giants are ripe for discovery, and the current science is comparable to what we knew about Saturn before Cassini. In fact, the launch opportunity with a Jupiter and Saturn gravity assist is in the 2028-2032 timeframe; two spacecraft could be used to go to both planets. Dr. Dahlburg asked if cubesats could be used for Mars communications, and Dr. Green replied that JPL has developed such a cubesat that can be jettisoned from a larger craft that brings it to the right area.

Big Data Task Force Final Report

Dr. Charles Holmes presented the final conclusions of the Ad Hoc Big Data Task Force (BDTF), a SC subcommittee commissioned by the NASA Advisory Council (NAC) to study the implications of the growing data glut and its ramifications for NASA. In addition to the four recommendations presented to the SC in July, Dr. Holmes presented four white papers that contained observations made over the previous fifteen months, as well as implicit findings and recommendations stemming from these observations. Dr. Holmes briefly reviewed BDTF's original work plan and summarized the four study topics, which had been selected from a list of roughly 30 areas of interest. The topics were data accessibility, improved data/science analysis methodologies, modeling workflows, and server-side analytics (SSA).

Dr. Holmes addressed Server-side Analytics (SSA) first, noting that BDTF felt this issue was one of the most important for NASA to consider. Server-side analytics, or "bringing code to the data," is a means of providing more efficient access to large volumes of data. Because reading data over the Internet is much slower than reading data from a local file, it would behoove researchers to adopt SSA. A BDTF member's personal experience with populating a petabyte data storage system was illustrative of the problem: it was estimated that downloading the datasets from three remote locations would take more than four months. Processing data at the server location has many benefits aside from greatly reducing data transfer times, including speeding up scientific discoveries and improving interoperability of heterogeneous datasets. Dr. Holmes noted that two of JPL's missions: SWOT and NISAR are planning on implementing SSA architectures for serving their data to users. BDTF recommends that NASA utilize NSPIRES (NASA Solicitation and Proposal Integrated Review and Evaluation System) to query the community as to where SSA is available for NASA research, hold community workshops on SSA, and open a ROSES solicitation for SSA demonstrations. BDTF also recommends that SMD become a leader in implementing new SSA architectures for high-priority projects.

The second white paper on modeling workflows contains two findings: first, that NASA and other federal agencies are using outmoded, decades-old techniques to model complex systems such as Earth, Earth-Sun, astrophysics, planetary science, etc. The BDTF recommends that NASA make prioritized investments in computing and analysis hardware, workflow software, and education and training to improve modeling workflows; to take the lead in modernizing software and providing opportunities to develop new data analysis paradigms; and to join workshops, scientific conferences and journal special collections, so that the community can benefit from advances in workflow development and management.

The third paper on data accessibility at NASA was based on the BDTF's review of NASA's data archives, which the task force generally found to be robust and well-curated. However, BDTF found that metadata standards tended to be variable in quality and non-uniform in application, with negative implications for efficient data analysis. Based in part on the experience of a BDTF member who has a long history with the Cassini mission, the BDTF recommends, when nearing completion of a mission's prime phase, that NASA review the quality of the mission's data as well as the quality of the metadata associated with

mission science, and complete user's documentation to the data. Doing so would improve the usability of the data and would contribute to extended value of the prime mission.

Dr. Flanagan commented that metadata is a challenge in astrophysics, but that it is done well for Hubble. Dr. Gaudi agreed, noting the heterogeneity and adding that Kepler is tasked to document their data products thoroughly. Dr. Holmes posited that the Explorer missions might not do this as well.

The fourth paper on data science methodologies found that NASA's science research community is not adequately connected with new methodologies in modern data science and software engineering; i.e. with the work of computer scientists, information technologists, applied mathematicians and statisticians. BDTF therefore recommends that SMD organize and fund professional development activities in statistics and informatics science for its own scientists and the wider Earth and space science communities. Such activities would include workshops, on-line training materials, methodology conferences; the use of expert consultants where suitable; and the use of data science SMEs in review panels for proposal selections.

Per this BDTF recommendation, Dr. Dahlburg posed that one could look at the agendas of some recent major data science and software engineering meetings and assess the areas in which NASA people already were presenting, and from this information then determine where professional development support would be most beneficial. Dr. Peterson posed whether organizing and funding workshops and training materials is the job of the universities, and that NASA should enable but not do this. Dr. Patterson suggested looking at groups such as the BlackSky or Planet and leveraging these industry capabilities. These groups are planning an extensive amount of data downloads and quick access for users, providing answers to questions rather than data, and using commercial resources to do so. Dr. Holmes agreed that bringing industry in is useful as that they have great techniques to apply.

Dr. Holmes brought forward additional findings and recommendations on the ability of NASA's data archives to meet future demands:

- The BDTF finds that SMD's data archive programs and projects are performing quite well and are properly taking steps to modernize and meet future challenges. Like all infrastructure projects they could use increased budgets and will put them to use wisely. Selective implementations of recommendations coming from peer reviews and the communities served are important to consider when augmenting what are generally steady-state funding profiles.

- The BDTF finds that the fraction of science papers, often from outside the original science team, that rely on archive data is increasing in all divisions, and is rivaling the fraction of papers based solely on new mission data and in many cases, exceeding 50%.

The BDTF therefore recommends that as a matter of policy, SMD should view the set of its data archives at the same level it regards its flight missions, because data archives and centers are integral to generating

new scientific results. This is particularly true as tools evolve to discover and extract new meaning from existing data sets.

Several members posed questions of whether higher use of the archives is a natural consequence of long-term missions, such as Hubble, and whether any datasets would be in jeopardy, for instance if Spitzer no longer operated. The Astrophysics Data Analysis Program (ADAP) for handling of the astrophysics archives was seen as an asset, but Dr. Holmes recommended more management attention to all the archives, given that these are contributing to about half of NASA's science output.

Dr. Holmes addressed a BDTF finding on NASA's Frontier Development Lab (FDL), an 8-week workshop for early-career scientists that is in its second year. FDL is led by the SETI Institute, is sponsored by both STMD and SMD, and uses modern data science methodologies to address complex problems such as space weather and the prediction of solar flares as well as the detection of Near-Earth Objects. The BDTF supported these types of workshops, as valuable to their specific domains and also because they often create collaborations that can last lifetimes as the young scientists enter into their professional careers.

Dr. Holmes introduced a BDTF recommendation on standing up a new Data Science and Computing (DS&C) Division under SMD. Such a division would manage NASA's High Performance Computing Program and would support the infusion of data science methodologies into SMD's data analysis programs. BDTF further recommends that the SC and its four thematic science committees should seat at least one expert who is a routine user of high-performance computers, is active in employing modern data science methodologies, and/or is deeply involved in the science operations of large, complex scientific data archives.

Dr. Holmes closed with the four prior recommendations BDTF had brought to the SC and asked that the Committee reconsider them:

- NASA should continue to participate in the Department of Energy's (DOE's) Exascale Computer Program
- NASA should become involved in the National Data Superhighway, also headed by the DOE.
- NASA should participate in a joint program with NSF's Big Data Innovation Regional Hubs and Spokes
- NASA should stand up an SMD Data Science Applications Program

Dr. Peterson noted that detailed discussion of the findings recommendations would continue on the following day.

Discussion

Members returned to discussion of the R&A charge. Dr. Peterson suggested looking at the proposals with high dispersion in the reviews. Dr. Flanagan suggested taking a year to look at what the review panels funded overall, how many high-risk proposals were funded out of the total amount, as there is risk aversion. Dr. Desai agreed, noting that direction would need to be given to the panel, or else it will not happen. Dr. Gaudi underscored having the support from the community, as there is pushback when structures change.

November 29, 2017

Dr. Peterson opened the meeting, noting that it was a first meeting for new SC member, Dr. Meenakshi (Mini) Wadhwa.

BDTF Follow-Up Discussion

Dr. Peterson re-opened the BDTF discussion and Dr. Holmes reviewed the first recommendation on data accessibility. Dr. Patterson asked about the quality of data calibration, and how this would be determined. Dr. Holmes said a common practice in the Planetary Data System (PDS) was to set up peer review panel to review the quality of data, while the Earth Science Division (ESD) has a formal process called Calibration/Validation. The Astrophysics Division (APD) and Heliophysics Division (HPD) have no similar process. Dr. Dahlburg noted that there are many published papers in heliophysics that include substantial good information about the quality of the observational data. Dr. Holmes agreed that was the case with open data, but it's an *ad hoc* process, without documentation or user's guides on metadata. The major issue BDTF found in the heliophysics archives was that either the metadata was not uniform or it was incomplete. Dr. Flanagan, being most familiar with the Great Observatories (GOs), thought the GO archives were well-documented and well-defined. Dr. Holmes said the user guide recommendation was more a recommendation for new missions. Dr. Peterson noted that the Explorer programs are cost-capped, and asked whether the recommended documentation would require resources. Dr. Holmes felt that additional resources would not be required if a user guide was written into the requirement, and that typically it takes about $30-35k to finish off documentation.

Dr. Holmes reviewed the finding behind the recommendation on Data Science Methodologies, commenting that Big Data doesn't mean just petabytes; there's also variety and velocity of data. Processing queues are having a hard time keeping up in some missions. Dr. Flanagan noted that astrophysics data volumes are not high, and posed whether there is a need to fix astrophysics archives that are already good enough. Dr. Holmes conceded that not all processes need it, but some do; he felt that SMD should still make the effort, as it takes leadership from the top to change things. He pointed to numerous examples cited in the accompanying white paper, and noted that BDTF found in its interviews that there are many people already working on prototyping solutions, and that the push towards implementation is what is really lacking. Dr. Dahlburg noted that most academic journals will not publish a paper that reports numerical simulation results if the simulation does not meet American Institute of Aeronautics and Astronautics (AIAA) editorial standards for numerical accuracy. Dr. Holmes didn't think

there were standards (yet) for data science, as these methodologies are just beginning to emerge from commercial efforts. Dr. Dahlburg asked if the best the SC could do at this time would be to encourage efforts. Dr. Holmes noted that there are already two active groups in NASA, one of which is the JPL and the other STScI, who have established senior leadership positions in data science, showing that these organizations recognize that NASA must start infusing these methodologies.

The second part of the Data Science Methodologies recommendation is that there also should be opportunities for data scientists to participate in writing specifications for NASA's AOs, and to sit on review panels when appropriate. Data pipelines should also be constructed using the modern processes, with data science professionals in the loop. Dr. Peterson commented that it seems NASA could sponsor workshops or support academic units in data science areas relevant to NASA goals; it would be important to define NASA's role. Dr. Holmes cited as one excellent example the Frontier Data Laboratory (FDL), noting that this educational group tapped into data science expertise that already exists in industry.

Dr. Holmes reviewed findings on Modeling Workflows, as well as the short finding on FDL. Dr. Flanagan, citing her familiarity with astrophysics, said that the devil was in the details, and asked whether Dr. Holmes had spoken with NASA individuals as to day-to-day impacts. Dr. Holmes said he would be briefing management on this subject on the following day. He said that in the centers, they're ready to go, they just need funding and leadership. He remarked on his experiences at Ames Research Center (ARC), JPL and Goddard Space Flight Center (GSFC), where many workshops already are available. BDTF member Dr. Eric Feigelson had also been to Institute of Electrical and Electronics Engineers (IEEE) workshops in this area. Dr. Peterson said that he and the SC would look to the BDTF white papers for good enlightening examples to support these findings, and noted discussion would continue later that morning.

<u>Earth Science Advisory Committee Update</u>

Dr. J. Marshall Shepherd, the incoming chair of the Earth Science Advisory Committee (ESAC), began his briefing by touching on the ESAC charter and task, which has evolved in the last few months. He noted that in its objectives and scope, the goal is to draw on expertise of the community to provide advice to the Earth Science Division (ESD) director. He reviewed current membership and the new FACA designation. ESAC has quite a few new members, and retained roughly half its membership from its prior incarnation, thus there is some continuity. GSFC held an event at the Smithsonian's Air and Space Museum, where some key successes and impacts of ESD were shared; the event is available on video. Much data and related visuals were displayed at the museum's IMAX theatre.

2017 Senior Review

ESD held its 2017 Senior Review, chaired by Dr. Doug Vandemark, in which missions were based on ratings of Excellent to Poor. The main conclusions of the review were that all 14 missions, including Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Orbiting Carbon Observatory (OCO-2), and Global Precipitation Mission (GPM) received high marks in the renewal of their extensions. The most significant missions in the portfolio continue to provide groundbreaking science and applications. ESD has a vigorous R&A program, for which all these missions are providing

excellent science data. Dr. Shepherd referred to Dr. Zurbuchen's slides of lights at night in post-hurricane Puerto Rico, wherein ESD's remote sensing assets had provided valuable data for disaster response agencies. Science merit was generally high across all missions, as indicated by consistent scores of Very Good to Excellent. The missions are highly valued in the science and applications realm. Some missions scored lower on data quality, largely for reasons of age. The Senior Review report was presented to the ESAC and approved during an October teleconference.

GPRAMA
ESAC held an annual performance review of the ESD, as required by the Government Performance Review Act Modernization Act (GPRAMA). It unanimously voted on October 30 to grade all performance indicators for ESD as Green. ESAC felt that science output was meeting and exceeding metrics in all cases.

The next Decadal Survey for Earth Science is expected to be publicly released in December of this year. Dr. Shepherd felt it was clear that NASA leadership values the Decadal Survey, and that the community is looking forward to having new guidance. ESAC has tentatively scheduled a mid-January teleconference to hear a debrief on the newly released Survey. A tentative date for ESAC's next full meeting is January 24-25, 2018. Dr. Shepherd noted that Dr. Jack Kaye would be at the meeting of the American Geophysical Union (AGU), where NASA will be marking 50 years of Earth Science in space; his session will be held on Wednesday at 4pm, and will feature invited talks.

Earth Science Societal Benefits
Dr. Lawrence Friedl, Associate Director for ESD's Applied Sciences program, presented an update. He started with a story about an instance of torrential rainfall in Louisiana, where 30 inches of rainfall accumulated in a week's timeframe. This data, provided by the GPM satellite, proved critical to a citizen named Ms. Ginger Heuvel, whose house was flooding precipitously. She contacted NASA, which enabled disaster agencies to understand the extent of the flooding at the ground level. Initially, the Federal Emergency Management Agency (FEMA) thought they had enough trailers to house the displaced in the area, but using data from a JAXA Synthetic Aperture Radar (SAR) satellite to see below the clouds, as well as NASA's airborne assets, FEMA was able to double the number of trailers they ordered. The story serves to demonstrate that NASA, the National Oceanic and Atmospheric Administration (NOAA), and other tax-supported agencies do this hard work every day, in a seamless and routine way, to provide societal benefit.

ESD has four main programs: Flight, R&A, Technology, and Applied Sciences. There are many benefits to society resulting from all 4 areas, aside from the funded applications. The three lines of business are capacity building, societal and economic applications, and applications in mission planning, the latter of which is concerned with assessing applications years before mission launch. The six applications areas are: Wildland Fires, Health and Air Quality, Water Resources, Ecological Forecasting, Disasters, and Agriculture/Food Security, which are facilitated by nine different types of earth observations: land temperature, sea temperature, vegetation, sea surface salinity, total rainfall, aerosols, fires and thermal anomalies, chlorophyll, and sea surface height.

The Applications program brings benefits in three ways: it can enhance an existing decision support tool with the partner organizations; support development of a new application and decision support tool with the partner organizations; or support development of information products, maps, and tools used by organizations the partners serve. In an example of enhancing an existing decision support tool, the U.S. Drought Monitor, managed by the U.S. Department of Agriculture (USDA) and NOAA, was recently aided by NASA in its data integration process. The U.S. Drought Monitor issues a drought map on a weekly basis. In 2012, there were extreme drought conditions. NASA examined how to use Gravity Recovery and Climate Experiment (GRACE) data to look at surface soil moisture, at the root level, and worked out ways to integrate this data into the existing tool to improve monitoring. Another related effort was to improve grid scales, going from a basin-wide approach to an assimilation approach; this is a first step toward seasonal forecasting. The GRACE-FO (follow-on) mission is due to launch in April 2018; in the interim, NASA has been working hard to continue its coordination with the U.S. Drought Monitor.

In another example, NASA has been working with the Nature Conservancy's BirdReturns program, which oversees the Pacific Flyway that is host to the migration of 300 bird species. Over several decades, the wetlands within the Flyway have diminished significantly. The Nature Conservancy has been looking to buy land to have available for migrating water birds for purposes of rest. Using NASA's citizen science and Earth observation data, NASA helped identify key places for respite, enabling the Nature Conservancy to pay farmers to rent out their flooded rice fields, outside the growing season, to help the water birds. The solution was an all-around success, as it saved money for the Conservancy, helped birds, and created extra revenue for farmers. The intervention resulted in an observably increased bird count and increased species diversity during the migration period. The Nature Conservancy estimated that it would have cost $150M to buy natural wetlands, vs. $1.5M to rent rice fields, for this purpose.

In a third example, Malaria Map Rooms are being served by NASA data (as well as a similar effort for vector-borne meningitis). The Rooms are developed by the International Research Institute for Climate and Society (IRI), and are based on three key climatological factors: relative humidity, precipitation, and temperature. These three can be measured from NASA satellites. The data help to create a map of Africa where "suitability" is high, and help to predict where to plan to distribute mosquito nets (or to vaccinate, in the case of meningitis) to prevent malaria outbreaks. Dr. Dahlburg commented that if any surprising factors had been found in the mapping process, such as an outbreak occurring in an unexpected area, it would be good for that data to be promulgated quickly, and also available for future reference.

Mr. Friedl described how active fire detection products had been enhanced with data from the Suomi National Polar-orbiting Partnership (Suomi NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) 375m band, and how the Soil Moisture Active Passive (SMAP) satellite has been able to improve correlations for the monthly World Agricultural Supply and Demand Estimates. Using the data from SMAP's radiometer to make these estimates is proving to be much less expensive than the survey work that is ordinarily done to make these estimates.

In a recent example at Gombe Park, the famed chimpanzee preserve, broader scale Landsat and higher-resolution imagery is being used to better manage the land. Images from 1999 had showed a dramatic decrease in forest cover (from 1972). The Jane Goodall Institute started to work with villagers to help them survive outside the park, equipping them and engaging them to help the forests recover. This effort reduces the need for locals to acquire resources from inside the park. Seeing the imagery has helped the locals psychologically engage with the preservation effort.

Data from NASA's Aura Ozone Monitoring Instrument (OMI) satellite are being used to help provide air quality managers with evidence that the Northeast ozone levels are becoming more nitrogen oxide (NOx)-limited. If the air quality managers can institute activities to reduce NOx, it will go a long way to help limit ozone.

In a joint collaboration with U.S. Agency for International Development (USAID) called SERVIR (from the Spanish verb: to serve), the NASA Earth Science applications program supports different hubs around the world. One example it has contributed to is frost mapping in East Africa, where tea and coffee production constitute a major part of the local economy. While the region employs sophisticated systems for farming, it is not as well prepared to predict frost conditions. Temperature data from the Moderate Resolution Imaging Spectroradiometer (MODIS) Land Surface Temperature (LST) instrument has improved predictions, and has provided a secondary benefit to the insurance community, enabling it to better verify damage claims.

NASA data played a role in preventing glacial lake outburst flood (GLOF), after the 2015 earthquake in the Himalayas and Nepal, which produced the condition of lakes filling up extensively due to dam fractures. One SERVIR researcher followed on with a group to look at what threats were coming and how to lower lake levels; different partners in the Nepalese government decided to lower lake levels to prevent outbursts, reducing the risk to 100,000 people.

In disaster response, NASA has the ability to support first responders, and has set up a tier system to first assess the hazards, determine severity, and help organizations to put strategic efforts in place. Data from GPM was used extensively during the most recent Atlantic hurricane season. The National Hurricane Center referenced GPM's microwave imager information and used it to measure Harvey's eyewall replacement rate. SMAP data was used to measure changes in soil moisture over time, yielding more information on how much soil was being saturated, and predicting the extent of flooding. FEMA flood maps also benefited from other assets, such as Sentinel-1. The Copernicus Emergency Management Service fed its data into their overall response activities. NASA also used an Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR) to map the Harvey floods, flying the asset for four days, where it helped to identify dry spots, flooding in oil refineries, and levee breaches. Suomi NPP, Landsat-8, Sentinel 2A and 2B and TerraSAR data are also being used to generate night-time light maps, getting information on lighting on a neighborhood level. Updates can be done daily. These same techniques were used to map Puerto Rico following Hurricane Maria, and to create damage proxy maps.

Mr. Friedl solicited ideas about how NASA might better communicate the impact of NASA's Earth Science program. Dr. Hoffman noted that these were incredible activities and asked if ESD had been putting together economic metrics on what NASA has contributed. Mr. Friedl said ESD had looked at the microscale level, but that the Europeans have done more macro-level studies on the Copernicus system. In the U.S., there hasn't been much appetite to do this. At present, NASA was looking at more program-level efforts. Dr. Peterson concurred that NASA and the science community need to learn how to disseminate the message.

Heliophysics Division Update

Ms. Peg Luce, Acting Director for the Heliophysics Division (HPD), presented a status update. The solar eclipse of August 2017 has brought welcome attention to HPD at a time when new launches are coming. The Division is currently interviewing candidates for a new Director. Former Acting Director Mr. Steve Clarke was detailed to the Office of Science and Technology Policy (OSTP) in July 2017. New faces have been filling in the team, most recently Dr. Elsayed Talaat as Chief Scientist, and Dr. Jeff Morrill as the new lead Living With a Star (LWS) scientist. HPD continues to align with the Decadal Survey and is completing the program with Space Environmental Testbed (SET), Ionospheric Connection Explorer (ICON), Global-scale Observations of the Limb and Disk (GOLD), Solar Orbiter Collaboration (SOC), and the Parker Solar Probe. The DRIVE (Diversify, Realize, Integrate, Venture, Educate) initiative is on track for completion. The HPD budget had been dwindling, but is now getting stronger, with a big emphasis on reviving R&A. This funding is being used to accelerate the Explorer program and add more Missions of Opportunity (MoOs). The Interstellar Mapping and Acceleration Probe (IMAP) mission AO was released as a PI-led mission with a LRD of 2024. HPD is set to have a midterm assessment next year; an RFI is out to solicit innovative ideas.

Over the next year, HPD will be launching a number of missions that will improve the ability to make multipoint observations, and add data to simulation and modeling to understand the Sun-Earth connection. ICON has been postponed from a December 2017 launch, to investigate issues with the separation system. It is being stored. GOLD will be the first NASA instrument to fly on a commercial satellite. The instrument has been through environmental testing, and is set for launch on January 23, 2017. The Solar Probe Cup instrument (the only unshielded instrument) had some temporary issues that have been mitigated or resolved, with some additional qualification runs to be completed. The Solar Orbiter Collaboration 2019 launch is likely to slip due to ESA contractor issues.

The HPD Senior Review committee met in October; its final report will be presented to the Heliophysics Advisory Committee (HPAC) shortly. Five missions were selected in the 2016 SMEX AO, including three MoOs, and one Category 3 MoO selected for technology development. The Geospace Dynamics Observatory (GDC) RFI responses are due on November 30, and the GDC Science and Technical Definition Team (STDT) is on track for formation in 2017. GDC has high international and interagency collaboration. ROSES selection rates are still very low. Budget increases have been submitted for the FY18 President's Budget Request (PBR), from $41M to $65M in additional funds to the Sounding Rocket and Guest Investigator programs; Ms. Luce was optimistic that the community will benefit from these requests.

Dr. Sarah Jones continued the briefing, focusing on the GOLD and ICON missions. These missions are complementary, measuring the same region in upper atmosphere (thermosphere) but from different vantage points. The upper atmosphere is Earth's shield against ionizing solar radiation, where it absorbs much ultraviolet (UV) radiation. Neutral gas and ionized gas (responding to electrical and magnetic fields) interact interdependently; the neutral gas is a little cooler, more dense, and slower. GOLD is a split spectrograph that images UV, and will be in a fixed orbit over the Western hemisphere, where it will obtain a full image of the hemisphere every 30 minutes (this is an improvement over daily refresh rates). ICON will give a localized view, and will obtain information on the dynamics of the region, from global scale down to meters. Research is still sorting out effects under different atmospheric conditions. There are oscillations over hours and days, referred to as tides, as well as longer-term, larger-scale effects. Solar winds also feed into the poles, where they affect the structuring of the ionized gases. Weather-like effects result in the lower atmosphere, much like fronts. Over the last decade, research has shown how terrestrial effects can affect the upper atmosphere; ICON will study this. GOLD is meant to tease out the solar effects. GOLD and ICON will help protect human exploration, satellite assets, and improve the accuracy of global positioning system (GPS) measurements and radiofrequency transmission.

ICON will ride on ISS into the atmosphere's "airglow." Measuring airglow can provide information about temperature, density, and composition, as well as image structure and dynamics. Together, ICON and GOLD will build a new picture of Earth's boundary with space. At night, UV sensors will give information about atmospheric oxygen, and during the day, they will get information about composition.

Heliophysics Science Highlights

Dr. Jeff Hayes stepped in and presented heliophysics science highlights for Ms. Luce who had to depart. He began with the re-naming of Solar Probe Plus to the Parker Solar Probe, in honor of Dr. Eugene Parker, which occurred when he received the NASA Distinguished Public Service Award on May 31. Voyager celebrated its 40th anniversary, upon which William Shatner sent an audio message to Voyager: "We offer friendship across the stars. You are not alone." The spacecraft's Radioisotopic Thermal Generator (RTG) is expected to totally degrade by 2020, whereupon NASA will probably start to turn off instruments annually. Voyager II is expected to cross the heliopause in roughly 18 months. It has a plasma instrument that Voyager I did not have. This year's total solar eclipse proved to be a great opportunity to teach the public about climate change, atmosphere, and the scale of the universe. It has been estimated that half of the American population traveled to see it. The U.S. Post Office issued a temperature-sensitive color-changing stamp to commemorate the event. Dr. Hayes displayed a spectacular eclipse image taken by polarization cameras that were used to view the corona through a 3850 angstrom filter.

Discussion

Dr. Peterson re-opened discussion on the SC charge to examine high-risk, high-reward R&A projects. Examination of the various strategies employed by each of SMD's science divisions will be a major topic for the committee in March. He asked for any relevant opinions. Dr. Dahlburg noted that PSD appears to have a screening method related to the concept of the "bimodal" review distribution (high-dispersion) that

seems to indicate the presence of a high-risk concept. Dr. Peterson felt he could recommend using this filter right now, but deferred deliberation to the other advisory committee chairs. He liked the idea of looking informally at the outliers as a means of determining promising proposals. Dr. Peterson felt that there were two remaining major issues that needed further examination, this one, and the other being the BDTF report, before the SC could act on findings and recommendations.

Dr. Desai asked for further clarification on NASA's internal funding model for its civil servant scientists. Dr. Dahlburg asked to include in this clarification how each of the Centers have decided to allocate these resources. Different divisions appear to have their scientists funded in different ways. For example, many internal scientists at centers in PSD are tied to missions at centers. This is not as true for the APD model. Dr. Peterson agreed that this was good topic for future deliberation.

The Committee turned back to the BDTF discussion, and Dr. Holmes addressed what the BDTF felt was the most important recommendation: the establishment of a data science and computing division in SMD. He also referred to a past, successful effort to connect universities and NASA science centers on the early Internet, and recommended that NASA become involved with the DOE/NSF high-speed science data network, and get the centers and universities hooked in. He noted that the Infrared Processing and Analysis Center (IPAC) at Caltech is already hooked into the National Science Data Super Highway. Dr. Dahlburg commented that in the years immediately following the passage of the High-Performance Computing Act of 1991, U.S. High Performance Computing (HPC) research and development efforts were well-coordinated among eight Federal science and technology research agencies including NASA, and that during this era NASA had been an outstanding key HPC research partner with NSF and the other coordinating agencies; she suggested that it may be useful to review the collaborative interagency roles from that time for possible ideas about how to move forward now. Dr. Holmes said the other top issue, in the BDTF's opinion, is to put some implementation money into server-side analytics and starting to streamline modeling systems, to make calculations more efficient.

Discussion with SMD Associate Administrator

Dr. Zurbuchen joined the SC for an outbrief. He began by thanking Dr. Holmes, the BDTF Chair, and said that it had been important to look at the big data problems from the bottom up. It will be important to align the pieces of the BDTF report, and take the really good recommendations and elevate them to the next level. His expectation is that SMD would carry out a further, deeper discussion with the BDTF Chair. In particular, Dr. Zurbuchen felt open models/open source was very important and a truly strategic idea, and thought APD was ahead of the game in that respect. He was not against connecting to the Science Data Super Highway, but felt more discussion was needed before doing so. He encouraged the SC to discuss the BDTF results thoroughly. Dr. Peterson noted that the BDTF was commissioned with a broad charter, and was deliberately vague. Dr. Dahlburg noted that the BDTF members were globally recognized HPC experts and that the four white papers are very valuable. Dr. Peterson said that the committee also would deliberate on the R&A program, adding that APD had done a thorough investigation on the topic, and hoped to have recommendations by next meeting.

Dr. Peterson described the Science Activation Showcase favorably and felt the program seemed to be reaching out effectively to the community it serves. Dr. Zurbuchen said he had attended their annual meeting and was excited about the passion teachers bring to the table. His concern was how SMD could fold it into the strategic view and keep it connected to the missions and the science. He cited his previous experience at the University of Michigan, and how it had helped to staff the Detroit Science Center. It has never been more important than right now to get this energy into education.

Dr. Zurbuchen asked SC members if they had heard anything surprising at the meeting. Dr. Hoffman mentioned that he had not known the extent of ESD's Applications program for societal benefits in areas such as agriculture and disasters, and noted that it would be good to widely publicize these impressive results. Dr. Peterson asked how the SC could help make these stories more visible. Dr. Zurbuchen related that upon his arrival at NASA SMD, he asked the divisions for two-minute synopses. Earth science always seems to be the easiest one, because there is a compelling anecdote every day, and the fundamental science is valuable. He suggested that perhaps the applications are not publicized enough. One problem is that the stories are so in-depth or scientifically complex, they can't be encapsulated in Twitter feeds or brief news item. One idea NASA has been kicking off is in finding ways to tell the "slower" stories of impact, perhaps in podcasts, which are being piloted right now. The Division Director is focusing on elevating these stories as well. This is also true of other divisions. He assured the SC that the problem is recognized. NASA must learn to talk to a variety of communities, including ones that use Snapchat and Twitter, maybe with one-minute interviews or otherwise. What are the modalities and what is the audience? There had been a NAS study on this subject, but much has happened in the last 5 years. Dr. Peterson felt that talking about Earth science as a system was also key to the publicity effort.

Dr. Peterson adjourned the meeting at 11:58 am.

Appendix A
Attendees

NAC Science Committee Members
Bradley Peterson, Ohio State University, ***Chair, Science Committee***
Jill Dahlburg, Naval Research Laboratory, Chair, Heliophysics Advisory Committee
Mihir Desai, Southwest Research Institute
Douglas Duncan, University of Colorado Boulder
Kathryn Flanagan, Space Telescope Science Institute
B. Scott Gaudi, Ohio State University, Chair, Astrophysics Advisory Committee
Tamara Jernigan, Lawrence Livermore National Laboratory *(via telecon/webex)*
Jeff Hoffman, Massachusetts Institute of Technology
Pat Patterson, Space Dynamics Laboratory
Walter Secada, University of Miami
J. Marshall Shepherd, University of Georgia, Chair, Earth Science Subcommittee *(via telecon/webex)*
Anne Verbiscer, University of Virginia
Meenakshi Wadhwa, Arizona State University *(via telecon/webex)*
Elaine Denning, NASA Headquarters, ***Executive Secretary, Science Committee***

NASA Attendees
Ralph Beaty, NASA HQ
Damara Belson, NASA
Dominic Benford, NASA HQ
Max Bernstein, NASA HQ
Sandra Cauffman, NASA HQ
Steve Cole, NASA OCOMM
Doris Daou, NASA HQ
Kristen Erickson, NASA HQ
T. Jens Feeley, NASA HQ
Lawrence Friedl, NASA HQ
John Gagosian, NASA HQ
Ellen Gertsen, NASA HQ
James Green, NASA HQ
Lika Guhathakurta, NASA HQ
Jeffrey Hayes, NASA HQ
Paul Hertz, NASA HQ
Sarah Jones, NASA GSFC
W. Vernon Jones, NASA HQ
John Karcz, NASA HQ
Jack Kaye, NASA HQ
Larry Kepko, NASA HQ
Bill Latter, NASA HQ
Peg Luce, NASA HQ
Roy Maizel, NASA HQ
Rebecca McCauley Rench, NASA HQ
Mamta Nagaraja, NASA HQ
Michael New, NASA HQ

Natasha Pinol, NASA HQ
Andrea Razzaghi, NASA HQ
Shannon Reed, NASA GSFC
Mary Sladek, NASA HQ
Eric Smith, NASA HQ
Gerald Smith, NASA HQ
Jim Spann, NASA HQ
Linda Sparke, NASA HQ
Todd Toth, NASA GSFC
Lucia Tsaoussi, NASA HQ
Kristen Weaver, NASA GSFC
Dan Woods, NASA HQ
Alex Young, NASA GSFC
Thomas Zurbuchen, SMD AA, NASA HQ

Non-NASA Attendees
Francesco Bordi, Aerospace
Rachel Connolly, WGBH/PBS LearningMedia
Anne Connor, Harris Corporation
Carter Emmart, AMNH
Orlando Figueroa, OLELLC/CTS
Jon Griffiths, GWU
David Gump, Deep Space Industries
Charles Holmes, NASA ret., BDTF
Grace Hu, OMB
Rosamond Kinzler, AMNH
Allison McGraw, NAS/LPL
Mark Mozenn, United Launch Alliance
Tim Rhaeti, STScI
Denise Smith, STScI
Nick White, USRA
Ana Wilson, Ingenicomm, Inc.
Paul Wloszek, Harris Corporation
Joan Zimmermann, Ingenicomm, Inc.

Telecon/Webex attendees
Gale Allen, NASA HQ
Jassim Al-Saadi, NASA
David Adler
Mike Beavin, U.S. House of Representatives
Sara Barber, U.S. House of Representatives
Louis M. Barbier, NASA
Robert Bauer, NASA
Anya Biferno, NASA JPL
Linda Billings
Lin Chambers, NASA
Kenneth Chang, New York Times
Alberto Conti, Northrop Grumman

Heather Doyle, NASA JPL
Kay Ferrari, NASA JPL
Jeff Foust, Space News
Martin Frederick, Northrop Grumman
Jessica Glover, NASA
Paige Graff, NASA
Sam Gunderson, Blue Origin
William Harwood, CBS News
Hashima Hasan, NASA HQ
Hussein Jirdeh, STScI
Tricia Johnson, NASA HQ
Ben Kallen, Lewis-Burke
Erin Kennedy, GAO
Irene Klotz, Aviation Week
Janet Kozyra, NASA HQ
Brandon Lawton, STScI
Amanda Leitz, Ball
Zigmond Leszczynski, Aerospace
Allen Li, U.S. House of Representatives
Sarah Lipscy, Ball
Michael Little, NASA
Amy Kaminski, NASA
Gilbert Kirkham, NASA
Emma Marcucci, STScI
Duane McMahon, NASA HQ
Tyler Micheletti, US House of Representatives
Doreen Neil, NASA
John O'Meara, smcvt.edu
Joel Parriott, AAS
Eliana Perlmutter, Lewis-Burke
Nick Perlongo, Aerospace
Jose Ramos, GAO
Christy L. Rivera, NASA
Ben Roberts, Moon Express
Richard Rogers, Stellar Solutions
John Rummel, SETI Institute
Susan Runco, NASA
Martin Ruzek, USRA
Nick Saab, Lewis-Burke
Amy Scott, AAU
J.P. Shankaran
Marcia Smith, Space Policy Online
Cassie Soeffing, Institute for Global Environmental Strategies
Micheline Tabache, European Space Agency
Sara Tucker, Ball
Erika Vick, NASA
Jeff Waksman, NASA
Paula Wamsley, Ball

Pamela Whitney, U.S. House of Representatives
Ashlee Wilkins, AAS
Steve Witkowski, Moog Inc.
Jenna Zink, AGU

Appendix B
NAC Science Committee Membership

Dr. Bradley Peterson (Chair)
Ohio State University

Dr. Susan K. Avery
Woods Hole Oceanographic Institution

Dr. Jill P. Dahlburg
Naval Research Laboratory

Dr. Mihir Desai
Southwest Research Institute

Dr. Douglas Duncan
University of Colorado at Boulder

Dr. Kathryn Flanagan
Space Telescope Science Institute

Dr. Bernard Scott Gaudi
The Ohio State University

Dr. Jeffrey Hoffman
Massachusetts Institute of Technology

Dr. Tamara E. Jernigan
Lawrence Livermore National Laboratory

Dr. Pat Patterson
Space Dynamics Laboratory

Dr. Walter G. Secada
University of Miami

Dr. J. Marshall Shepherd
University of Georgia

Dr. Anne Verbiscer
University of Virginia

Dr. Meenakshi Wadhwa
Arizona State University

Ms. Elaine Denning (Executive Secretary)
NASA Headquarters

Appendix C
Presentations

1. SMD Overview; *Thomas Zurbuchen*
2. Science Activation Showcase; *Kristen Erickson, Kristen Weaver, C. Alex Young, Denise Smith, Rachel Connolly, Rosamond Kinzler*
3. Astrophysics Division Update; *Paul Hertz*
4. Astrophysics Advisory Committee; *B. Scott Gaudi*
5. Planetary Science Division Update; *James Green*
6. Final Report of the Big Data Task Force; *Charles Holmes*
7. Earth Science Advisory Committee Report; *J. Marshall Shepherd*
8. Heliophysics Division Update; *Margaret Luce*
9. Flash Talk on ICON and GOLD; *Sarah Jones*
10. Heliophysics Science Highlights; *Jeffrey Hayes*

Appendix D
Agenda

Dial-In (audio) & WebEx (view presentations online) information is located on page 2.

NASA Advisory Council
Science Committee

November 28-29, 2017

NASA Headquarters
Room 5H41

Agenda
(Eastern Time)

Tuesday, November 28

9:30 – 9:45	Opening Remarks / Introduction of Members	Ms. Elaine Denning Dr. Bradley Peterson
9:45 – 10:15	Discussion with SMD AA	Dr. Thomas Zurbuchen
10:15 – 10:45	WIETR Discussion	Dr. Thomas Zurbuchen Dr. Paul Hertz
10:45 – 12:10	Science Activation Showcase	Ms. Kristen Erickson Ms. Kristen Weaver, NASA Goddard Space Flight Center Dr. C. Alex Young, NASA Goddard Space Flight Center Dr. Denise Smith, Space Telescope Science Institute Dr. Rachel Connolly, WGBH / PBS LearningMedia Dr. Rosamond Kinzler, American Museum of Natural History
12:10 – 1:10	*Lunch*	
1:10 – 1:30	R&A Charge Update	All
1:30 – 2:10	Astrophysics Division Update	Dr. Paul Hertz
2:10 – 2:30	Astrophysics Advisory Committee (APAC) Report	Dr. B. Scott Gaudi
2:30 – 2:45	*Break*	
2:45 – 2:50	Public Comments	

Dial-In (audio) & WebEx (view presentations online) information is located on page 2.

2:50 – 3:30	Planetary Science Division Update	Dr. James Green
3:30 – 4:45	Big Data Task Force (BDTF) Final Report	Dr. Charles Holmes Chair, BDTF
4:45 – 5:00	Discussion	

Wednesday, November 29

8:30 – 8:35	Re-open Meeting	Ms. Elaine Denning Dr. Bradley Peterson
8:35 – 9:00	BDTF Follow-up Discussion	All
9:00 – 9:20	Earth Science Advisory Committee (ESAC) Report	Dr. J. Marshall Shepherd
9:20 – 10:05	Earth Science Societal Benefits	Dr. Lawrence Friedl
10:05 – 10:45	Heliophysics Division Update Flash Talk: ICON and GOLD Heliophysics Science Highlights	Ms. Margaret Luce Dr. Sarah Jones Dr. Jeffrey Hayes
10:45 – 10:55	*Break*	
10:55 – 11:30	Discussion, Findings and Recommendations	
11:30 – 12:00	Outbrief for SMD AA	Dr. Thomas Zurbuchen
12:00	*Adjourn*	

Dial-In and WebEx Information

For entire meeting November 28-29, 2017

Dial-In (audio): Dial the USA toll free number 1-888-592-9603 or toll number 1-312-470-7407 and then enter the numeric participant passcode: 5588797. You must use a touch-tone phone to participate in this meeting.

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