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MEETING REPORT

Ellen Williams 7/27/2023

Ellen Williams, Chair

7/31/2023

Jason Callahan, Executive Secretary

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Welcome and Introduction

Mr. Jason Callahan, Designated Federal Officer (DFO) of the NAC Science Committee (SC) called the committee to order and detailed the Federal Advisory Committee Act (FACA) rules governing the meeting. Dr. Ellen Williams, SC Chair, led introductions of Committee members.

Goals of the Spring 2023 Meeting

Dr. Williams reviewed the agenda and enumerated goals for the meeting.

Earth System Observatory (ESO) Independent Review Board (IRB) Update

Mr. Geoff Yoder, co-chair of the Earth Science Observatory (ESO) Independent Review Board (IRB), briefed the SC on the IRB's final report, touching on key highlights. The IRB was chartered to review whether the ESO, a mission recommended by the most recent Earth Science Decadal Survey and designed to further the understanding of the changing Earth was technically robust and able to satisfy the mission's essential requirements. The IRB was also designed to incorporate Lessons Learned from previous large, strategic science missions.

Mr. Yoder co-chaired the ESO IRB with Dr. Waleed Abdalati, former NASA Chief Scientist. Dr. Abdalati attended to the science aspects of the mission and Mr. Yoder covered the programmatic aspects. The IRB had members of the Earth Science Decadal Survey team on board as well, which helped to clarify many items and provided connections that otherwise might have been missed. A subject matter expert (SME) in technology helped to identify alternative hardware, in some instances. Mr. Yoder noted that everyone on the IRB was completely open and cooperative, and a pleasure to work with. In particular, he said, representation for data and open science policy was really on the right track.

The IRB discussed in detail the significance of the ESO and its three major mission suites, as well as the role of open science in the missions and over the whole portfolio. Generally, the Board concluded that in the end the mission's relevance is reliant upon the data, and the major issue for ESO was whether it is something that's looked at the end, or upfront in the project's design. The IRB had specifically wanted to understand the role of the data and concluded that the team is on the right track, commendably so. The Board did make some recommendations on having more data integration up front.

In the areas of program mitigation and guidance, the Decadal Survey had deemed all things tradeable, save for cost, and recommended that any cost gaps be mitigated by first delaying large missions. The IRB found that this first mitigation had already been used. As to continuity, ESD has already experienced an 18-month gap with the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) situation. The Survey further recommended a reduction of the cadence of medium-size missions; the IRB notes that cadence is already down to three, from the original four. The Decadal Survey (DS) recommended that budgets should not be reduced more than five percent; the IRB noted that this has also been done, and even with these collective measures,

ESO is more than able to fit into the Decadal Survey cost box. The question becomes whether costs should be allowed to grow? Is it time to go to the Committee on Earth Science and Applications from Space (CESAS), a science advisory team of the National Academies? Mr. Yoder detailed the three main missions, derived from the Decadal Survey's Designated Observables (DOs): Mass Change is a single medium-class mission. Surface Biology and Geology (SBG) is an instrument for a hosted payload, currently in the study phase. The Atmosphere Observing System (AOS) is a large, two-satellite mission that observes clouds, convection, and precipitation, with an estimated cost of $1.8 billion. Mr. Yoder pointed out that the Decadal Survey's mid-term review will occur soon, presenting an opportunity for a re-assessment of EOS.

Top findings of the IRB

The IRB found that the major strengths of the ESO are:

- Missions as laid out follow the DS science recommendations and would result in significant science and applications advances
- Data Systems study is focused on the right areas
- The Applied Sciences Program personnel (Program Applications Leads) are actively engaged throughout mission planning

Aside from citing strengths, the IRB recommended that SMD look at the management structure, having raised some concern that the reporting structure is not clear as to the right integration point in the chain of command. Mr. Yoder said that the IRB did not prescribe a solution, and quoted Dr. Thomas Zurbuchen's approach: "Provide the shovel, don't dig the hole" Mr. Yoder also noted that both the Science Mission Directorate (SMD) and Earth Science Division (ESD) have already responded to all the IRB recommendations. The Board also made some findings on design-to-cost, noting that there were challenges here with some imbalances in mission approaches, hardware risks, and choices of de-scopes. The Mass Change approach, for instance, is a high-risk, single-string, 3-year design life concept with a 5-year mission requirement, that poses some risk to continuity. In addition, while Applied Sciences was perceived as going in the right direction, the IRB felt that closer synergy is needed to connect the needs of the science teams, DAACs, and the user community to make ESO data scientifically useful for interdisciplinary science. The IRB also recommended that ESO explore partnerships that go beyond the traditional and found that Lessons Learned (about 10 altogether) haven't been entirely incorporated.

Cross-cutting findings and recommendations include, in the context of science priorities, that the DS expected advanced capabilities to be realized through innovative technologies and programmatics that seem to have not materialized. In the area of data systems, the IRB found that the success of the ESO as an integrated observatory is heavily dependent on a data system that is not well-defined at the moment, but that ongoing work by the Earth Science Data Systems group to define the data system is innovative and very promising. Mr. Marc Weiser asked about the overall budget for the ESO runout to 2034. Mr. Yoder said that the total comes to $3.1 billion combined, and that the IRB estimates that over the run out to 2034, the ESO will overrun by $500 million.

The IRB found that ESD's Applied Sciences Program is on the right track, but also recommended that tighter synergy be attained. IRB findings on Data Systems are similar to those on Applied Sciences, and Mr. Yoder commented that these recommendations indicate the Board thinks this synergy is happening. In the area of Organizational Management, that IRB found that there needs to be more interfacing between the technology and data systems offices across the board and that there is no central ESD point of contact (POC) responsible across the ESD suite of missions and functions. Thus, IRB recommends that SMD perform an assessment to determine the best solution for integrating the missions into a coherent ESD observatory structure. SMD might consider POC(s), possibly a Program Scientist and Program Executive, or "Czar," looking across the entire ESD flight portfolio, and establishing a forum that includes Data Systems, Flight Programs, Research and Analysis, Applied Sciences (ESTO) and the two Program Office Managers to form a quarterly ESD Integration panel. Asked if ESD were looking at a James Webb Space Telescope-type structure, Dr. Karen St. Germain, ESD Division Director, commented that SMD is looking at some options, but she didn't think it made sense to pull management outside of ESD. ESD is trying to convey how integration is being accomplished within the ESO. NASA wouldn't want to separate ocean missions, for instance, as they are still in progress. Dr. St. Germain added that there is relevant history that predates her time at the Agency, and that while she recognizes the importance of the recommendations, the ESO needs both science and applications expertise, and this may require more than one person.

Mr. Yoder addressed the findings and recommendations regarding funding. The IRB found that ESO is set to overrun its costs by $31M by 2026, and roughly $500M by 2034. Recommended options to reduce funding requirements include:
• Potential contracting efficiencies between Atmosphere Observing System-I (AOS-I) and AOS-P
• Modifications to enable/enhance AOS s/c commonality
• Additional partnerships; larger international partner role
• Use descopes; however, these options appear very limited

Dr. Williams asked if there were risks in technologies or in executing programs, and if high-impact/high risk technology had been part of the discussion. Mr. Yoder said that yes, there are other technologies that are part of the Technology Maturation group, which is outside the ESO technology portfolio. The Laser Ranging Interferometer to measure intersatellite distance changes with unprecedented precision is one technology that is relatively mature and is ready for the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission. There are also lower Technology Readiness Level (TRL) accelerometers in development, but they will require more funding to mature. Mr. Yoder added that the Decadal Survey (DS) for Earth Science used costs estimated well before the impacts of COVID-19, the current inflation cycle, and ubiquitous workforce issues. Mr. Weiser if there were large technological leaps envisioned by the DS, on the order of "…and then a miracle occurred?" Mr. Yoder said the IRB had discussed those questions, but that the questions do not change the nature of the present cost prohibitions. Mr. Weiser asked about the impact of direct versus indirect costs. Mr. Yoder noted that the projects spent $200 million just dealing with COVID-19, but that there were other factors as well. The fact remains that the path forward as presented, without additional innovation, break the cost cap by $500 million. Dr. Sara Tucker asked if there were innovative technologies that had not come to fruition, or any programmatic issues. Mr. Yoder said that one technology that did not

materialize was W-band radar, and that programmatics were affected by the Valley of Death challenge in technology. In discussions with the DS Committee, it seemed that their expectation was to "come up with the solution." The IRB had many discussions about assumptions. The DS Committee believed they had the right number, based on reasonable assumptions about ongoing innovation paths. Mr. Yoder felt that there had been no hand-waving. In terms of programmatic expectations, Mr. Yoder felt that the DS Committee expected more innovative partnership approaches. Asked if a JAXA partnership had been considered, Mr. Yoder and Dr. Williams opted to move that discussion off-line.

Science Mission Directorate (SMD) Update

Dr. Nicola Fox, the newly appointed Associate Administrator for SMD, introduced herself and engaged the Committee in a general introduction and discussion. She said she had spent her three months on the job thus far working to tie missions together cross-divisionally. Mars Sample Return (MSR) is a big priority right now, particularly as there has been a big leap in mass spectrometry for assaying samples. SMD is getting a real start on ESO, looking at Earth as a system for the purpose of advancing climate science. SMD is also excited about the developing Habitable Worlds Observatory. Dr. Fox described her career as a heliophysicist, her involvement with the Parker Solar Probe, and her experience at the Applied Physics Laboratory and the Goddard Space Flight Center. SC members shared their backgrounds, and their individual concerns, with Dr. Fox.

Dr. Fox presented the graphic for SMD's 140+ missions, noting that the science in the intersection of cross-divisional collaboration makes the SMD footprint even larger. She reported having seen much interest in the Moon-to-Mars effort and has been encouraging the Lunar Exploration Analysis Group (LEAG) and the Commercial Lunar Payload Services (CLPS) representatives to brief to the Planetary Sciences Advisory Committee (PAC). Recent Earth Science launches include Tropospheric Emissions: Monitoring of Pollution (TEMPO), Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats (TROPICS), and Surface Water and Ocean Topography (SWOT). First light data from SWOT demonstrated a one-hundred-fold improvement in the resolution of measurements for the surface height of the ocean and small bodies of water (rivers wider than 300 feet). SWOT is providing a look at almost all the water storage on the planet. The Parker Solar Probe just completed orbit 15, during which it was 5.3 million miles from the Sun at its closest approach. The next Venus flyby will carry the probe to within 3.9 million miles (final distance) of the solar surface. "Jetlets" in the corona have already been observed by instruments, perhaps providing evidence of nanoflares. The Webb Telescope continues to produce detailed imagery of iconic structures such as the Pillars of Creation, the ring around Neptune, and the remnant of Cassiopeia A. For the recently created Biological and Physical Sciences Division (BPS) within SMD, the Orion 1 capsule carried Bioexperiment-1, which contained samples of yeast, fungi, algae, and seeds that were examined for their gene expression in response to the space environment. BPS currently has a partnership with the US Department of Agriculture and is conducting plant research at the Department's lab facilities at Disney's EPCOT.

The SMD Budget Request for FY24, at a top line of $8.26 billion, will allow NASA to support a great variety of platforms that allows NASA to choose the right science to do on the right

platform. The FY24 budget request is the largest ever for science. In ESD, the budget will help NASA focus on system missions. In PSD, there is a robust budget for MSR. NASA has just kicked off a second IRB for MSR, headed by Mr. Orlando Figueroa. Asked if NASA would be feeling any effects from debt ceiling negotiations, Dr. Fox said that any effects were to be determined. In the Astrophysics Division, there is robust funding for the Roman and Webb space telescopes, and technology development for the Habitable Worlds Observatory. The Heliophysics Division (HPD) has had to pause the Geospace Dynamics Constellation (GDC) mission and is awaiting further guidance. For BPS, the budget shows modest growth, while the division looks forward to its new DS. Dr. Serina Diniega asked if there was room to bring innovation and diversity through the missions. Dr. Fox said that that SMD has a robust budget for an ambitious program, and that she would also love to see technology innovation in the Explorer and Discovery programs. She noted that it is tougher with the Flagship missions, however. The Habitable Worlds Observatory is a good example of a program that will encourage innovative technologies. MSR already has highly developed technologies, with innovation having been already infused. The Principal Investigator-led, competitive missions will have more scope for innovation. In the area of Diversity, Equity, Inclusion, and Accessibility (DEIA), SMD is now requiring inclusion plans in science team formation, as well as for Science Definition Teams (SDTs), and has been encouraging early-career researchers to sign up for SDTs, to help infuse diversity and new technology ideas. There are also student experiments, and instruments on cubesats and sounding rockets, that provide an avenue for increased diversity. Dr. Vinton Cerf, citing a conversation he had on the subject of power supplies at a cis-lunar conference, asked how likely it would be for NASA to get permission to fly nuclear-powered generators to orbit, or to the Moon. Dr. Fox took an action to get a briefing on this subject. Mr. Weiser said there are wireless charging aspects to be considered as well for lunar power supplies. Dr. Cerf noted that the radionuclide-based devices currently under development (10- 40kW range) are designed to provide power for decades, and to run on low enrichment fuels. Asked about any further guidance on the SMD budget, Dr. Fox said that the Agency is waiting for appropriation/authorization language, which often contains instruction. She noted that the GDC mission will not be re-prioritized, as it is a mission that is already in the program of record.

ESO IRB Update (Continued)

Dr. Diniega asked if the ESO IRB found indications of workforce issues similar to those found by the Psyche IRB. Mr. Yoder said that it had, and had made similar recommendations, however in the case of the Surface Biology and Geology (SBG) mission, the workforce is deemed adequate. Dr. Diniega asked if any connections were seen with the Psyche COVID-19/competition issues. Mr. Yoder said there were, and that workforce number and retention issues were similar as well. Dr. Diniega noted that the PAC has been asking for other updates and analyses on workforce issues, and whether there were any new models for handling them. Mr. Yoder said that Center allocation was one example that was considered. Mr. Weiser asked if the IRB had explored partnerships beyond the traditional. Mr. Yoder said the IRB had considered synergies with ground systems, control systems, and not just buses, but that it did not specifically explore tech-based institutions that build low-cost components. The IRB did look at Lessons Learned across the board from Psyche, Webb, WFIRST, and other, smaller missions. Asked if the IRB considered efforts such as procuring a ride on a satellite, or buying data, Mr. Yoder said there were plenty of internal discussions of that nature that did not go into the report. Dr. Cerf

supported the idea of commercial partnerships, especially for sensors. Mr. Yoder noted that during the Constellation era, NASA had forecasted technologies for the industry to respond to. Dr. Tucker said she was worried about the workforce at NASA, in that there is a big industry workforce ready to build hardware and spacecraft. When NASA does internal technology development and then competes with industry, there needs to be a different way to think about "pre-funding" the missions through industry: the workforce is the workforce, period. Mr. Yoder noted that the Atmosphere Observing System (AOS) team did reach out to the high-volume manufacturers, who expressed no interest in producing very small batches of components.

Earth Science Division Update/Tropospheric Emissions-Monitoring of Pollution (TEMPO)

Dr. St. Germain introduced a briefing on the recently launched Tropospheric Emissions-Monitoring of Pollution (TEMPO) instrument, first displaying ESD's current 25-mission fleet with significant representation on the International Space Station (ISS), along with some free flyers. About half the missions in the fleet are well beyond their projected lifetimes, some by decades. The instruments are still making good observations, but decaying orbits affect their utility as continuity contributors. There are more than a dozen missions in development for ESD. Three current missions, the Joint Emissivity Database Initiative (JEDI), the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS), and the Orbiting Carbon Observatory-3 (OCO-3), will fly to the end-of-life on ISS.

ESO is an interconnected mission focused on five DS-predicated Directed Observables (DOs), designed to use the enormous power of synergy in making measurements in the same epoch. ESD combined these five areas into three missions to create the ESO. Dr. Cerf said a spreadsheet of these missions with planned timelines vs. actual timelines might help NASA think better about mission planning, adding measurements made at the same time can also lead to correlation. Dr. St. Germain cited a NOAA/Aerospace study on design life which showed that missions last at least 50 percent longer than planned, and that the shorter the design life, the more probable those missions don't make it past early days. It appears that the engineering required to achieve a 3-5 year life span often results in a lifespan of 10 years and beyond. Dr. St. Germain agreed that correlations can provide significant data about linkages.

For the competed aspect of EOS, ESD used seven variables for competition. The DS recommended competing three or four instruments during the decade. An Announcement of Opportunity (AO) is out now and ESD is looking at four proposals, planning to down-select to two, while committing to one proposal to cover greenhouse gas emissions.

The NASA Earth Action Strategy is using cyclical feedback from foundational Earth System observations to help inform applications and user products, which over time will help NASA to ask questions it didn't know it needed to ask. NASA is trying to establish bridges from the science to the tools for practitioners. A New Earth Information Center (EIC) will open at Headquarters in June 2023 as a multimedia education and exposure tool. NASA is also enabling climate-informed services across the government such as OpenET,an evaporation application and irrigation prediction tool. OpenET, with a resolution of about 30 meters, has received a lot of positive feedback. OpenET is a freely available website currently focused on the west, but is expanding eastward. Its best forecast is built on an ensemble of different models and is yielding

best-in-class answers. The new EIC will provide a "face" for some of the new products such as OpenET, with much of the effort happening in parallel. NASA has been meeting with the agricultural community to examine how farm equipment can be used as surface validation data, which will serve as important feedback for NASA.

Dr. Barry Lefer, TEMPO Program Manager, reported on the TEMPO instrument, launched in April 2023. TEMPO is a pathfinder instrument for detecting pollutants from space. The Environmental Protection Agency (EPA) has identified a number of air pollutants particularly concerning to human health, including ground-level ozone, particulate matter, carbon monoxide, lead, sulfur dioxide (SO^2), and nitrogen dioxide (NO^2). The TEMPO instrument will measure the spectra required to retrieve ozone (O^3), NO^2, sulfur dioxide (SO^2), formaldehyde, glyoxal ($C^2H^2O^2$), aerosols, cloud parameters, and UV-B radiation. TEMPO will also quantify the daytime temporal evolution of aerosol loading. NASA's Aura satellite currently provides data on ozone, NO^2, formaldehyde, and SO^2 as a daily global coverage of total column, but it cannot see through clouds. In terms of NO^2/SO^2 concentrations over urban areas, Aura data has shown that Asia has worsened over the decades, while the US and Europe have improved, demonstrating that regulations for air quality have been a massive success story. Aura also saw the temporal effects of COVID-19 and air quality improvements associated with the lockdown. US CO^2 emissions have been decreasing, but CO^2 in other countries is increasing. India is now the highest SO^2 emitter, and its population has now surpassed China.

TEMPO will provide hourly scans of North America from geostationary orbit and is expected to be a gamechanger. TEMPO is flying as a hosted payload and its data is scheduled to go public in January 2025. TEMPO is a hyperspectral instrument that has neighborhood-scale spatial resolution far superior to that of Aura's Ozone Monitoring Instrument (OMI). TEMPO will be able to detect such data as solar-induced fluorescence, demonstrating how drought affects photosynthesis. TEMPO now has a partnership with Applied Sciences and ESD Data Systems, which is in the process of determining stakeholder needs for TEMPO products. There are already over 400 early adopters of TEMPO data that will use Lessons Learned to enhance core applications, which will help to support an Atmospheric Composition Virtual Constellation.

While Ball Aerospace was building TEMPO, it was also building a Korean satellite, the Geostationary Environment Monitoring Spectrometer (GEMS), that can now work in concert with other instruments. ESA will launch Sentinel-4 in 2024. All three satellites are hourly, but there is still an observation gap in the Southern Hemisphere. Models can help fill in gaps, and there are other infrared (IR) sounders and instruments that can collect other pertinent data, including NOAA's Ozone Mapping and Profiler Suite (OMPS) instrument on the Joint Polar Satellite System (JPSS), and OCO-3 on ISS. Altogether, these instruments can serve as an integrated observing system for air quality. Dr. Cerf mentioned a related effort at Google, a Data Commons designed to deal with very large amounts of data, and offered to provide a contact. Sr. Lefer said that NASA has made air quality forecasts based on ESD data available on Google Earth/Engine. Dr. Tucker asked where low-cost in situ sensors for ozone and NO^2 might be headed. Dr. Lefer noted that while Europe and the US are well monitored, South America and Africa are not. However, there are 70 US embassies around the world that have sensors that can be used as on-site calibrators. There is also a nonprofit organization (Open AQ) that has been buying used air quality (AQ) monitors, refurbishing them, and getting them to users in Africa. In

addition, in the early 2030s, NOAA will be launching satellites that will help coverage of South America. There should also be upcoming opportunities to train people how to use the satellite data. Dr. St. Germain added that there is a discussion now at the NASA executive level on further measures to cover gaps, but there are no concrete plans at present. Dr. Godwin asked if there were any targeted areas for higher resolution. Dr. Lefer said that there is the ability to do 10-minute scans until the Sun is up in California, after which TEMPO can be redirected and stare at regions for a few hours. TEMPO operations are based at Harvard. NASA also has a protocol for disaster response that is used to direct assets.

Deep Space Network (DSN) Support for Science Missions

Ms. Sandra Cauffman, Deputy Director of APD, presented a status of the Deep Space Network (DSN), having stepped into the role of SMD liaison to the Space Communications and Navigation (SCaN) division previously held by the recently retired Dr. Jeff Newmark. DSN is aging and oversubscribed, and is presenting challenges to SMD in terms of availability and sufficient bandwidth for ongoing science missions. There have been 33-hour outages at the Goldstone facility, for example, and any equipment failure can result in immediate health, safety, and science return impacts at SMD. The issue of oversubscription is caused in part by increased data rates and data volume, simply adding more to the system. SMD has several events from 2024-26 that will require coverage. The lunar mission, Volatiles Investigating Polar Exploration Rover (VIPER), as just one example, will require constant coverage beginning in November 2024. Asked if there were any data that shows when SMD would no longer be able to satisfy its coverage needs, Ms. Cauffman said there was no such forecast at present.

There are several proposed solutions. SCaN began the "Road to Green" initiative in 2020 as part of a general update to the network, and both GSFC and JPL have completed network loading studies. SCaN is also working on capacity increases, including the Lunar Exploration Ground Segment (LEGS), the DSN Aperture Enhancement Project (DAEP) Ka-band upgrade, and Lunar Communications and Navigation Relay Services. In addition, a DSN Futures Study has begun an 18-month assessment of SCaN, with a final report to be presented to the Space Studies Board. Dr. Diniega asked when LEGS and DAEP would be completed. Ms. Cauffman said completion dates were to be determined. She agreed that some missions cannot be planned until these plans are defined, and that there will be some delays in Announcements of Opportunity (AOs), and Tracking and Data Relay Satellite (TDRS) planning as well. Currently there are plans to elevate this issue as an essential infrastructure problem, with the Office of Management and Budget (OMB) being briefed, as this is a resource issue.

DSN is also looking at commercial services in the near-space domain, where there is a potential for meeting NASA needs, and is actively engaging the commercial sector for lunar navigation/communications services. SCaN has also been working with international partners to drive some solutions. Ms. Cauffman said that she had not yet done a top-down assessment to determine all the immediate needs for DSN/SCaN, given her short time in the new position, but would be beginning the assessment at once. Dr. Williams commented that it seems that DoD, the Space Force, and other agencies are expanding capacity that perhaps NASA could leverage. Ms. Cauffman agreed. Mr. Weiser asked if the Artemis Accords (AAs) contained any language on the communication backbone. Mr. Callahan said the AAs are more about behaviors than

specifics but took an action to track the information down. Ms. Cauffman said that NASA is in the middle of a Fiscal Year budget exercise and will have real numbers by the end of June. Dr. Godwin said it seems like one of those things that will look cheap in hindsight. Mr. Weiser said it sounds like a recipe for failure. Dr. Cerf said he was surprised at the lack of information about the Delay/Disruption Tolerant Networking (DTN) effort on the ISS, along with SmallSats that are carrying DTN nodes. He recommended that Ms. Cauffman talk to Jay Wyatt at JPL, and David Israel at GSFC, who is involved in the LunaNet design. He also recommended contacting a speaker at the cis-lunar conference, who gave a detailed presentation on DTN.

Dr. Diniega asked if the SmallSats that need SCaN are being included in the needs assessment. Ms. Cauffman said yes, and that previous barriers to their funding were being ameliorated by new attention to the lunar aspect. The SmallSats are getting more attention, but not as fast as desired. There are also natural hazards affecting the networks; a major typhoon in Guam took out communication infrastructure in late May. Dr. Cerf commented that the mission-centric versus infrastructure view affects the thinking around infrastructure. The DTN effort is designed around the belief that there will one day be an interplanetary network, but it's difficult to get a mission or Project Manager to think about the bigger picture. The DSN needs to be much expanded in many different dimensions, and automated as well, to support ambitious space plans. NASA can't be confined to arm-wrestling matches as to whose mission is more important. Dr. Williams asked where data is being transmitted and stored, and who is paying for it. Dr. Cerf commented that the cost of storage has dropped exponentially and is not as much of a concern. Mr. Weiser noted the NASA- Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) mission is collecting as much data as all NASA missions combined. Mr. Callahan said there is also the matter of data upkeep; some data are so old that they are recorded in obsolete formats that are no longer usable and require painstaking translation. Dr. Cerf added that digital preservation is also critically important; it will be necessary to rewrite data in modern formats and maintain software over a longer period. This is not just a NASA problem, it is also a problem for expiring photo data formats. Dr. Diniega asked if there were any sense as to when/if an entirely new DSN needed to be built. Lunar exploration ground sites are sort of a new system. Dr. Cerf said thought had been given to networking multiple 34m antennae, but the project did not get funded or lost funding. One solution would be to find a way to build more flexible antenna fields to increase capacity and sensitivity. Asked if she would be staying in the position, Ms. Cauffman described her role as "duties as assigned," but did recognize that the position is too important to be part-time, as it has implications for an entire directorate. Dr. Diniega said the current issue goes back to the point to having someone who looks at the whole system, to acquire the time to build connections and history. Ms. Cauffman said she hoped to have a clear picture of what NASA needs from DSN, from the top down, by August.

Wrap-up/Discussion

The Committee discussed thoughts on the ESO IRB. Dr. Williams said that the IRB recommendation to apply the data plan systematically across all the parts, and getting a forum of managers together, was a good one for the SC to support. Mr. Weiser commented that the parallel structure of the MSR program reporting to the PSD Director, for example, has worked for other big missions like Webb. Dr. Matina Gkioulidou said NASA should not prioritize another management level at the expense of having more resources available and said this was an

inherent issue for such a recommendation. Mr. Weiser said lack of coordination drives up costs. Dr. Gkioulidou said it was not just a question of coordination, it's a question of who's going to do the work. Dr. Tucker felt the SC should be careful about how it frames its recommendations and to whom. Dr. Cerf said that while the IRB was well structured and necessary, pandemic costs obviously could not be foreseen. Treating the ESO as a whole will need a person who sees it as one mission. The SC can reinforce some IRB recommendations, but it's important that the parties must recognize that their missions are part of an aggregate. Systems Engineering (SE) should be involved. Dr. Williams suggested focusing on the simultaneity of observations issue. The two extreme solutions at present seem to be cutting back on science or increasing funding. Mr. Weiser noted that the IRB had been formed by Thomas Zurbuchen and SMD has already provided its response. He said the SC should look at the responses before issuing findings and recommendations on the subject. Dr. Tucker said there are things to think about in the partnering approach, and that one challenge with international partners is the sheer number of agencies levying requirements and needs onto the system. The other challenge is negotiating between other agencies and NASA Centers. The SC finding should be just to recognize that ESO is very hard to do, and to commend NASA for being willing to do this. Asked if there were a Program Scientist (PS) for ESO as a whole, Dr. Tucker said she would check. To further clarify the discussion, Mr. Callahan gave some background on the rapid decision to brief the SC on the recently released ESO IRB report, which will impact SMD across the board. Dr. Tucker suggested looking at what the Committee had previously recommended on the Psyche IRB. Mr. Weiser noted that the response on the appointment of an ESO PM is that NASA partially concurs with the recommendation, while adding that the ESO may in fact need to have a few people. Dr. Tucker said that any ESO managers must be able to manage across Centers, and that SMD has the ability to support ESD in this endeavor.

The Committee discussed the NASA posture on risk management in resource-scarce situations. Dr. Cerf noted that NASA certainly successfully tolerated much risk in missions such as the Webb Telescope, and in the balloon landings of the Mars Exploration Rovers. Dr. Diniega added that innovation and diversity must remain important. Dr. Williams couched risk in terms of service to innovation and diversity. Dr. Tucker noted that accepting risk can reduce cost.

The Committee discussed the SMD update and TEMPO. Dr. Cerf praised the briefing and was happy to see the budget. He suggested a finding welcoming the new SMD AA. Dr. Diniega said she liked the feedback pyramid idea for the Earth Action Strategy, and the TEMPO ties to the virtual atmosphere constellation. Dr. Williams noted that TEMPO will require much work to integrate all the data and the applications. Dr. Godwin suggested a thumbs-up for the TEMPO collaboration with commercial and international partners. Dr. Matina Gkioulidou applauded the use of simulated data. Mr. Weiser commented that a new resolution for AQI will change people's lives. Dr. Godwin felt NASA should promote this effort for its use to citizens. Dr. Diniega gave kudos to TEMPO for its upfront coordination efforts.

The Committee discussed DSN. Dr. Cerf felt the SC should reinforce the fact that DSN needs a huge amount of maintenance, and that the lack of resources has hindered innovation over the last decade. He said that the SC should recommend massing antennae for synthetic aperture functions. SCaN also seems to have omitted mention of 25 years of automated protocol development. SMD should make proposers aware of what the DSN situation can support. Dr.

Diniega said the SC should support Ms. Cauffman's effort to put together a comprehensive top-down inventory and budget. Dr. Cerf said he was struck by the large number of science missions and the additional burden of lunar missions. Future, highly ambitious Mars missions will need a better and more resilient communication system than NASA currently has. Dr. Diniega added that many SmallSats tend to create big spike events for communications. Dr. Godwin asked about lunar network sites and whether the Orion capsule will need DSN. She thought the SC needs to hear more about this. Dr. Cerf proposed that the SC get a briefing from planners of the expanding lunar communications network, and also that the SC recommend that SMD/SCaN brief mission proposers to help plan missions around the expected communication capacity. Dr. Tucker suggested that the SC review relevant SCaN notes from its previous meeting.

June 1, 2023

Opening

Mr. Callahan called the meeting to order and made administrative comments. Dr. Williams briefly summarized the previous day's proceedings.

Transformation to Open Science/Open Source Science Strategy

Dr. Kevin Murphy, SMD's Chief Science Data Officer, briefed the SC on NASA's Open Science initiative. He first defined Open Science, a policy developed with the Office of Science and Technology Policy (OSTP), underscoring that Open Science is a government-wide strategy. NASA has long operated as a leader in an open science environment through its data-sharing with space agencies around the world. In 2019, NASA released the SMD Strategy for Data Management and Computing for Groundbreaking Science, bolstered by the "[NASA Administrator Bill] Nelson Memo." Another driver is SPD-41a, the first directorate-wide policy document on Open Science. The Open Source Science Initiative has four components: policy and governance, core data and computing services, open science incentives, and community engagement. The effort is funded through the Chief Science Data Office at $20 million per year and receives guidance from the Open Source Science Initiative Council (OSSIC), the Science Management Council (SMaC), and Advisory Committee feedback.

The Original SPD-41 document was a consolidation of existing Federal and NASA policy on sharing scientific information. SPD-41a expanded and updated existing policy and has a strong similarity to the OSTP policy memo. NASA is the first to roll out this policy in the government. It's important to note that SPD-41a is not a reach-back policy, it applies to only new activities. NASA does encourage current missions to abide by SPD-41a, though it's not a requirement. SPD-41a applies to all the divisions, but each division can alter it to their needs (in that they can be more open), and each division has responded in their own ways.

NASA has made updates to NPR 2210.E, a document that governs the release of NASA software, and they are under review. SMD-related updates include language concerning ways in which to hold scientific workshops and meetings openly to enable broad participation, pre-registering research plans prior to conducting scientific activities, and providing project personnel with open science training or enablement (if not described elsewhere in a proposal). The NASA Plan for Access to Scientific Research is also being updated in response to the OSTP memo of August 2022. The draft plan is under review at OSTP, after which it will undergo an open comment period and be further altered. Mr. Weiser asked about the role of international partners. Dr. Murphy said that within SPD-41a, there is language relevant to international partnerships. In addition, each division can make data more open. This approach has been especially successful in ESD, which has seen a lot of support from international partners.

Dr. Murphy said the Core Data and Computing Services Program will provide a layered architecture on which SMD science Divisions can seamlessly and efficiently integrate their discipline-specific services, such as data archives. Efforts are underway to identify services that are already available in the divisions and scale them up. Asked if this service will this apply to grantees, Dr. Murphy said that each SMD division has its own approach to archiving data, but there has been much talk about moving mission data and mission data management tools to the Cloud. In terms of research data, that will have to be a core service that NASA either purchases or provides via collaboration. The Data and Computing Architecture Study concluded that NASA needs a coordinated Cloud/High End Computing (HEC) infrastructure to better support SMD's scientific data and computing needs. Asked if there were mechanisms to target outreach to underserved communities, Dr. Murphy said that in the Commercial Cloud environment, NASA already has many Space Act Agreements for public outreach, such as summer schools and participation in science team meetings. Access to HEC is a separate issue that requires training and secure access. Outreach efforts would have to provide access to HEC outside the secure space. NASA has already done this and is ensuring non-R1 institutions are a large part of the training process.

The Data and Computing Architecture Study will investigate how a coordinated cloud-High End Computing (HEC) infrastructure can meet the data and computing needs of SMD, enable efficiencies, and support SMD's transition to Open-Source Science. As part of this study, a Request for Information was released in January 2023. Since that time, NASA has held several workshops focused on best practices and capabilities for future architecture and computational requirements to meet NASA's Open-Source Science policies. These workshops are available on-line, on YouTube.

The infrastructure currently has core services that include a Science Discovery Engine, which is in beta phase right now. Dr. Murphy said it is basically a data catalogue and has about 80 percent of SMD science data. It also contains Science Explorer, a digital library portal. Members of the Core Data and Computing Services Program have been engaging the public and have gone to many science conferences. To support open-source sustainability, NASA has a dedicated program, funded at about $4-5 million per year, to competitively select open-source libraries. NASA selected 16 proposals this year, and is also funding topical workshops, symposia and hackathons.

NASA's Transform to Open Science (TOPS) is a five-year community engagement mission to accelerate the adoption of open science and has already achieved a great success in science discovery—detection of CO^2 on an exoplanet. TOPS team members are engaging the community and already have about 1700 people signed up to get "badges" to participate in Open Science 101, a community-developed introduction to Open Science with DEIA at the forefront. The TOPS program is also engaging participation through online discussions and monthly newsletters and is designed to provide researchers with core open science skills. Mr. Weiser suggested getting TOPS integrated into the existing science curriculum. Dr. Murphy said he was already talking with all the divisions on this. In working with ESD, the intention is to train trainers at Centers and divisions and have them go out and be champions for TOPS. Asked about accountability, Dr. Murphy said NASA is trying to incentivize the activity through earning badges. There are no incentives beyond badges at present, but maybe in the future participants will earn credits for computing time on a Cloud-based system. This would need to be an equitably distributed incentive, however. There are limits as to what can be funded with government money. Dr. Murphy said that TOPS has some ties with SMD's Bridge program for incorporating DEIA and is already working with Minority University Research and Education Project (MUREP). He welcomed more suggestions. Dr. Williams suggested ensuring that education modules will teach valuable skills that alumna can crow about.

Dr. Murphy reported that five modules, each 3-4 hours long, will be offered in July: Ethos of Open Science, Open Tools and Resources, Open Software, Open Data, and Open Results. Participants earn badges at each level. Ethos has already been taught to 350 people at in-person workshops, which have taken place at the annual Lunar and Planetary Science Conference (LPSC) and American Meteorological Society (AMS) conference, and at professional society meetings. There are plans to offer them at the American Astronomical Society (AAS) meeting. The goal is to reach about 13 professional society meetings per year. TOPS has not yet partnered with missions but is planning to do this.

NASA is working with other agencies to further identify incentives for participating in TOPS such as awards, certification, prizes and challenges, recognition, and support. Dr. Noel Bakhtian recommended talking to Jen Gustetic, Director of Early-Stage Innovations and Partnerships in NASA's Space Technology Mission Directorate (STMD), about recognition, and asked who the target audience was. Dr. Murphy said NASA started enrollment in January 2023. Of 4000 people on the mailing list, 1700 signed up, a pretty good conversion rate. Right now, TOPS is on track to train about 6000 people per year. Dr. Murphy said TOPS might be speaking in an echo chamber, but this is not known yet. Dr. Williams asked what would happen if the program received 20,000 enrollees from NIH? Dr. Murphy said that would be fine, but that NIH has actually expressed interest in coordinating with NASA. The modules are meant to be generic to the government. The NASA Open Science effort is coordinated with OSTP, as the White House announced 2023 to be A Year of Open Science. Dr. Diniega applauded the use of GitHub and the use of existing tools, as well as ease of use, which helps to tie into the community in a standardized way.

Division Advisory Committee reports

Astrophysics Advisory Committee (APAC)

Dr. Kelly Holley-Bockelmann, the new Chair of the APAC, provided an update. The APAC held its last meeting in March, during which the Committee was introduced to the Habitable Worlds Observatory (HWO), a powerhouse flagship mission that was a top recommendation from the Astronomy and Astrophysics 2020 Decadal Survey (DS). Schedule is a mission Level 1 requirement for HWO, and the DS calls for the mission to use fully mature technologies. The mission concept includes robust margins as well. The scale of the mission is a paradigm shift for NASA, thus the APAC's major concern about HWO is that the very large leap in precision required for the mission may require a high degree of technical development. Therefore, the Committee has recommended the mission be assigned a standing risk review board that would report periodically to APAC. The Committee's next major concern is Time Domain/Multimessenger Astronomy (TDAMM) itself, representing the launch of a brand-new field that requires a large investment to enable enormous discovery potential. Asked to define Multimessenger Astronomy (MMA), Dr. Holley-Bockelmann explained that the "messenger" of light gives information about density and other characteristics of celestial bodies, while gravity is the "messenger" of mass. MMA is the combination of these messages. To deal with NASA's TDAMM approach thus far, APAC has created a new cross-Program Analysis Group (PAG) Science Advisory Group (SAG) to deal with it, in addition to the APAC's three existing PAGs. The APAC recommended a summary of the TDAMM workshop report to be presented at a future meeting. It also recommended that every APAC presentation describe how IDEA is implemented in their mission and/or program. Examples may include team demographics, an inclusion plan, description of IDEA initiatives, and/or metrics. The APAC suggested that APD explore ways to magnify the impact of the SMD Bridge Program through institutional buy-in. There is some concern about models for US participation in international missions that are against the concept of DEIA (such as EUCLID and ULTRASAT). APAC will hold its next meeting in June.

Planetary Science Advisory Committee (PAC)

Dr. Diniega, PAC Chair, provided some science highlights to preface the briefing. OSIRIS-Rex will be returning samples in September, after which the mission will become known as the Apophis Explorer, a good example of succession planning. Mars Sample Return (MSR) is progressing, and the Perseverance rover continues to work well. A sample-prioritization workshop was held recently and seemed to be a good way to engage the community. The MSR IRB has just started, while MSR is due to reach its Preliminary Design Review (PDR) milestone in September. The ESA mission, Jupiter Icy Moons Explorer (JUICE), launched in April, will arrive at the Jovian system in July 2031. The delayed Psyche asteroid mission is now scheduled to launch in October 2023. The PAC will hear more about the Psyche IRB in September. The Dragonfly mission to the Saturnian moon, Titan, is also progressing well. Artemis science is also progressing well, keeping the Artemis III team engaged.

Current terms for PAC members have been extended to the end of the calendar year to be more accommodating to the hybrid/virtual meeting environment. The last PAC meeting was held in February, with the next meeting scheduled in late June. Dr. Diniega highlighted select findings, including PAC's continued concern about the VERITAS mission to Venus, as well as Psyche workforce issues at JPL and other institutions (PAC has requested continued briefings on this

item). PAC is concerned about MSR and other large projects that have the potential to impact other missions and has asked to be kept apprised of forecasted overruns or schedule delays. PAC issued a finding commending the Astrobiology research coordination networks (RCNs). PAC further recommended that PSD leadership converse more closely with the AGs on IDEA (as DEIA is also known within SMD). Finally, PAC issued a finding regarding its concern about end-of-operations planning for the Arecibo facility.

The PAC's upcoming meeting will address the Psyche IRB Interim report and will seek more clarity about the Mars Exploration Program. PAC will also receive a status report on inclusivity plans in PSD. PAC is moving to a rotating schedule of AG presentations, to accommodate its nine analysis groups, and has formed a new cross-AG Ocean Worlds Working Group. Dr. Diniega said that PAC wishes to reiterate a previous finding, that SMD establish a point of contact (POC) for IDEA, an outward-facing, paid position to help coordinate IDEA activities, perhaps based on the Planetary Data Ecosystem (PDE) model. Dr. Holley-Bockelmann supported the idea of rotating AGs. Dr. Diniega explained that each PAC meeting now hosts three AGs in depth, while the remaining AGs each get 10 minutes or so of presentation time.

Heliophysics Advisory Committee (HPAC)

Dr. Gkioulidou, substituting for HPAC Chair Dr. Therese Moretto-Jorgensen, reported that the Committee is going through a major re-organization. It officially has three members at present, and has 14 acceptances for new member positions. The last HPAC meeting hosted a "Space Weather 101" presentation, describing the effects of solar energy in geospace and beyond, and some updates from the Space Weather Council (SWC), a FACA subcommittee to HPAC. The HPAC heard responses from the SWC on four assigned tasks. Task 1 was to coordinate between Space Weather groups to achieve a common understanding of space weather. In response, the SWC had presentations from the Space Weather Advisory Group (SWAG) and the Space Weather Roundtable (SWR), run by the NOAA and the National Academies (NAS) respectively. As a result of this discussion, the chairs of the three groups had the first of a series of quarterly telecons earlier in September to further clarify roles and responsibilities. SWC also discussed how to communicate these roles to various audiences. Possibilities include short articles in select publications. Task 2 was to summarize a space weather gap analysis. The SWC found in this instance that most of the science gaps have been identified but that there is no clear path forward to implementation. Targeted analyses are also missing. SWC has proposed a gap analysis focused on the cis-lunar radiation environment, to take a comprehensive look at infrastructure, observation, and modeling gaps. Task 3 was to examine the status of Artemis and space biology. In response, the SWC met with NASA's Moon to Mars (M2M) office and the Space Radiation Analysis Group (SRAG) at the Johnson Space Center (JSC) to discuss how SWC might assist in deep-space exploration. The SWC found that current radiation exposure models are not sufficient, and that while current ARTEMIS plans offer an opportunity to test warning protocols for astronaut protection, the scenarios do not yet include Solar Energetic Particle (SEP) events.

Task 4 was an examination of coordination between agencies. SWC examined roles and responsibilities between National Science Foundation (NSF) and NASA and found that differing timeframes and grant sizes often make collaboration difficult, but that most scientists recognize the need to cooperate across agencies. Dr. Tucker asked about the state of coordination between NASA and NOAA, as there is much overlap between the agencies in terms of operations and

research in space weather. Dr. Gkioulidou said that HPAC hadn't yet reviewed the recommendations but said that the SWC did identify some problematic communication avenues between NASA and NOAA, which the Council felt needs to be resolved at a higher level. Dr. Tucker noted that it might be worth talking with Weather leads at NASA. Dr. Cerf suggested that NASA consider the problem of collision avoidance for satellites. As activity in space increases, it might be worthwhile to generate indications and warnings, and bring together mega/metadata to inform situational awareness. Dr. Gkioulidou said it was generally difficult to get data from industry on their anomalies, which is another issue to address. Dr. Cerf suggested a "Miss Utility" regulation for space, to prevent accidental disruptions of known orbits.

Earth Science Advisory Committee (ESAC)

Dr. Tucker reported on the August ESAC meeting that hosted Dr. David Saah, Chair of the Applied Sciences Advisory Committee (ASAC). The focus of the meeting was not on specific missions or science, but rather on the climate and culture of the ESD, and some objectives like IDEA, Open Science, and commercial data buys. Dr. Tucker quickly summarized some findings: ESAC commended ESD's focus on environmental events related to climate change and their unequal impact on communities, and appreciated ESD's commitment to DEIA. ESAC applauded new funding opportunities to help build institutional capacity, the establishment of inclusion plans in the Research Opportunities in Space and Earth Science (ROSES) application process, and improved review panel composition and accessibility. The Committee did note that female representation could be improved. ESAC agreed that Open Science faces cultural barriers and will need a shift in incentivization, but really appreciated the TOPS funding efforts. ESAC also found that ESD continues to make progress on missions critical for observing and dealing with climate change.

Key ESAC recommendations included helping Principal Investigators (PIs) deal with the additional requirements imposed by SPD-41a and DEIA by providing additional training, best practices, and templates. ESAC also recommended that NASA provide guideline documentation for proposing to the ESD Applications Program, and more PI Launchpads (more of them at MSIs and in underserved communities), as well as shorter workshops for younger PIs in how to apply for ROSES grants. ESAC recommended that ESD evaluate its pilot programs in underrepresented communities early and continue to support these communities in areas that are known to be working well, thus avoiding an erosion of trust.

In the context of diversity at the Center level, ESAC recommended that ESD promote the importance of diversity and provide a statistical breakdown of relevant metrics. The Committee also recommended that ESD review and reconcile the inflation numbers used in calculating effects to NASA programs. ESAC further recommended that ESD begin including Environmental Justice (EJ) among the categories used to determine whether to migrate specific data sets to the Cloud. ESAC recommended coordinating meetings with ASAC to allow discussion of overlapping topics. Dr. Diniega liked the point on EJ and suggested that the SC talk to Dr. Murphy about it. Dr. Holley-Bockelmann supported the idea of thematic meetings and noted that APD now requires each mission to brief their IDEA plans.

<u>Public comment period</u>

R. Mark Elowitz asked if NASA's Software Catalog website is considered part of the Open Software and Data initiative? He also asked if there are there any plans to make the process of obtaining software through the software catalog website easier, such as eliminating the need for a login account, signing non-disclosure agreements (NDAs), and reducing the number of steps needed to download the software. Dr. Murphy said the Software Catalog is a web-based set of tools, and those tools will be subject to the new regulations. Access to the site is constantly evaluated to balance user needs and NASA internet security protocols.

R. Mark Elowitz asked if NASA could file a formal complaint to Congress about underfunding, not allowing sufficient scientific missions to be carried out. He suggested NASA could state that if the proper amount of congressional funding is not provided, the US will lose its lead in planetary science. Mr. Callahan replied that it is illegal for NASA to lobby on its own behalf, the Agency can only request funds thru PBR process.

Dr. John Whitehead asked about the Mars Ascent Vehicle for Mars Sample Return flight testing at high altitude above Earth. He stated he felt the MSR budget and schedule have been unduly optimistic, largely because the MAV challenge has been widely underestimated. Mr. Callahan replied that NASA is currently working on MSR formulation. No decisions have been formally made yet, and there is awareness of the need to test the MAV. Dr. Cerf asked about testing the MAV on Moon. Mr. Callahan said he thought it has been discussed but one issue was the schedule and budget impacts of various testing methods. There is no infrastructure on Moon to allow NASA to conduct such testing, nor is there a budget. Dr. Cerf asked if the MAV might be useful as a moon ascent vehicle. Dr. Godwin mentioned that contracts for MAV are already awarded. Dr. Whitehead stated that there’s not enough atmosphere on the Moon, and too much gravity for MAV testing.

Gene Mikulka said the DSN maintenance issue reminded him of the situation with the Arecibo Telescope. He said he thought the DSN was a national treasure, not only for space exploration but for the US to reflect "soft power" to its allies by assisting those nations in their space efforts as well. He thought the public needed to let their lawmakers know about the situation and that the DSN needs attention now.

R. Mark Elowitz asked if completion of the Mars 2020 and ESA's Franklin rover missions would mark the end of unmanned exploration of Mars as there appear to be no further Mars exploration rovers on the planning chart. Dr. Diniega replied that MEP has a draft Strategic Plan that does show NASA is looking at more rovers. She said there would be an update at the next PAC. She highlighted that the fleet of Mars orbiters are aging as well.

Discussion

The SC discussed findings and recommendations and finalized some language on a resolution of welcome to Dr. Nicola Fox, and recognition of a healthy FY24 SMD budget request.

The SC discussed findings on the ESO IRB. Dr. Cerf asked if the potential partnerships recommended by the IRB were intended to be broad, and what the actual partnership status was, at present. Dr. Tucker noted that the ESO cost cap tends to constrain NASA to stick to traditional

approaches. She didn't feel that it was valuable to issue a finding stating that management of the program was a challenge. Dr. Gkioulidou asked if the complexity lay in the coordination and questioned whether a partnership approach would reduce cost. Dr. Cerf commented that while a classic response to the situation would be to appoint a "czar," ESO is a collaborative effort and the collaborators need to be coordinated. Mr. Weiser suggested throwing SC's weight behind the language in the NASA's partial concurrence with the IRB recommendations.

In considering a finding on TEMPO, Dr. Williams suggested adding a statement that NASA Earth Action Strategy is excellent. Dr. Diniega noted that TEMPO would need significant support for gathering data. Dr. Tucker suggested adding language about NASA efforts in atmospheric composition data and how they can lead toward future operations for NOAA. Dr. Williams said the Centers for Disease Control would be a suitable partner with NASA in the Environmental Justice realm.

The SC discussed the status of the DSN. Dr. Cerf commented that if NASA fails to do the maintenance, many missions are at risk. Drs. Tucker and Williams recommended that NASA increase the priority of addressing DSN issues. Dr. Cerf added that DTN is meant to bolster the efficiency of DSN so that NASA can support more missions, and suggested SC recommend that NASA assign more support and attention for Ms. Cauffman's top-down budget inventory of DSN needs to elevate the sense of urgency. He added that additional ground stations would make a big difference, and can also serve LEO, Near-Earth, and Deep Space requirements. Dr. Williams suggested a finding or recommendation for NASA to also evaluate Space Force/DoD capabilities.

The SC discussed the Transform to Open Science initiative. Dr. Tucker suggested making Environmental Justice one of the criteria for Cloud migration, as well as a recommendation for SMD to set up a coordination process with the community to minimize duplication of effort in DEIA/IDEA. Dr. Williams applauded the progress of open data sharing. Dr. Diniega appreciated that TOPS is using standard community methods, and she solicited ideas for other incentives. Dr. Williams said that the concepts are so far ahead of implementation that it creates tension and requires resolution. The TOPS badges can be useful to managers for encouraging employees, however. Dr. Tucker said that the badges are not sufficient, the recognition has to be turned into action. Drs. Gkioulidou and Diniega suggested tracking the demographics of individuals signing up for TOPS badges, as well as such characteristics as stage in career and institutional origin. Dr. Diniega noted the clear parallels between TOPS and DEIA, in that they are beneficial to both sides, inviting closer coordination. Dr. Tucker suggested using one of the TOPS modules for DEIA training. Dr. Diniega suggested NASA put out templates for archiving software.

Debrief to DAA Research for SMD

Dr. Williams debriefed Dr. Michael New, SMD Deputy Associate Administrator for Research. on findings and recommendations.

In response to SC comments on DSN and SMD, Dr. New noted that DSN is not operated by SMD, but by the Space Operations Mission Directorate (SOMD). Dr. Williams said that the Committee feels that SMD should push for its interests in terms of continuing support for science

missions and reiterated the strong sense of urgency in the community. She noted that the problem is not a job for just one Program Executive or Manager. Dr. Cerf added that while SMD is not responsible for DSN, it is a key consumer of its communications services, and future science demand is overwhelming. The ideal outcome of a DSN refurbishment is a real interplanetary network with an expanded ground-based component. Dr. Cerf said SMD should communicate the importance of its missions as well as inform its PIs as to the status of DSN. Dr. New said he would consult with both SOMD and the Human Exploration program on the issue, adding that he was aware of the impacts of Artemis, and that APD may lose priority channels with the loss of TDRS. Dr. Cerf noted that there are intersatellite links that can support space missions, and that NASA will need much more than the DSN to make progress. Dr. New agreed.

In response to a recommendation that SMD set up a coordination process for DEIA with the science community to minimize duplication of effort, Dr. New asked for clarification on what kind of coordination. Dr. Williams explained that the SC envisioned coordination both between SMD and the community, and inter-divisionally. Dr. Diniega added that the PSD model was one approach to consider. Dr. New said that SMD had certainly been coordinating across divisions with limited success, but that DEIA is a bigger issue with the community. He said he would bring these thoughts back to the SMD AA and added that Centers are very much bound by the IDEA Executive Order.

In discussing the TOPS initiatives, Dr. New said he would take a clarification of the Environmental Justice idea back to SMD, and further commented that Open Source starts with copyrights. Scientists often confuse archiving software with perpetual maintenance. NASA just requires that the software works when you upload it. In collecting demographics for people signing up for TOPS badges, Dr. New said that the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) is able to collect the basic categories (gender, race), and noted that new R1 institutions are a priority at NASA. The number of proposals from every other institution is much smaller. He said there is a solicitation out targeting non-R1s to start a research program, and NASA is also providing seed funding to existing programs to expand them. There is also a big push to translate articles into Spanish.

In response to a recommendation that NASA hold a workshop on “How to be a ROSES PI,” Dr. New said that NASA is currently fund proposal writing workshops across the country and is also actively researching the “How to be a PI” idea.

Dr. Williams adjourned the meeting at 4:08pm.

Appendix A
Attendees

NAC Science Committee members

Dr. Ellen Williams, Chair	Dr. Willie May
Dr. Noël Bakhtian	Dr. Matina Gkioulidou, Acting
Dr. Vinton G. Cerf	Dr. Sara Tucker
Dr. Linda Godwin	Mr. Marc Weiser
Dr. Kelly Holley-Bockelmann	Mr. Jason Callahan, Designated Federal Officer

Day 1

Alexandra Antoine	Griffin Reinecke	Lin Chambers
Amy Reis	Irma Rodriguez	Linda Karanian
Ann Zulkosky	Jack Kaye	Maria Triandos
Anna Shelby	Jake Leachman	Marshal Pennock
Ben Phillips	Jamie Foster	Mayra Montrose
Carter Yungwirth	Jeff Foust	Nathan Boll
Chris Caisse	Jeff Herring	Nick Saab
Christine Bognar	Jennifer Kearns	Patrick Taylor
Conor Brown	Jim Green	Paul Voosen
Cynthia Dinwiddie	Jim Lochner	Peter Bender
David Millman	Joan Zimmermann	R. Mark Elowitz
Dennis Feerick	John Dyster	Ralph Beaty
Dylan Pitts	Jonny Pellish	Sid Boukabara
Elizabeth Goldemen	Joy Burkey	Stanley Sander
Francesco Bordi	Julie Castillo	Stephen Clark
Gene Mikulka	Julie Robinson	Steve Krueger
Gilbert Kirkham	Kinsey Flanders	Tonya Woodbury

Tonya Woodbury
Will Thomas Ext
William Faulkner
Yaswant Devarakonda
Zach Jacobs
Danny Lentz
Etienne Dauvergne
Lin Chambers
Tammy Dickinson

Day 2

Amy Reis
Ben Kim
Caroline Coward
Carter Yungwirth
Chris Caisse
Christine Bognar
Cynthia Dinwiddie
David Millman
Dylan Pitts
Elizabeth Goldemen
Gene Mikulka
Griffin Reinecke
Hashima Hasan
Jeff Herring
Jennifer Kearns
Jim Lochner
Joan Zimmermann
John Whitehead
Kaveh Pahlevan
Kinsey Flanders
Leslie Tamppari
Linda Karanian
Marcella Yant
Maria Triandos
Nathan Boll
Nick Saab
Peter Bender
R. Mark Elowitz
Richard Rogers
Steve Krueger
Etienne Dauvergne

Appendix B

NAC Science Committee Membership

Dr. Ellen Williams,
Chair, University of Maryland

Dr. Noël Bakhtian
Bezos Earth Fun

Dr. Vinton G. Cerf
Google

Dr. Linda Godwin
University of Missouri

Dr. Kelly Holley-Bockelmann
Vanderbilt University

Dr. Willie May
Morgan State University

Dr. Therese Moretto-Jorgensen
NASA Ames Research Center

Dr. Sara Tucker
Ball Aerospace

Mr. Marc Weiser
RPM Ventures

Mr. Jason Callahan
Designated Federal Officer, NASA HQ

Appendix C
Presentations

1. Earth System Observatory (ESO) Independent Review Board (IRB) Final Report Summary; *Geoffrey Yoder*
2. Inspired Science: Powered by NASA; *Nicola Fox*
3. Tropospheric Emissions; Monitoring of Pollution; *Barry Lefer*
4. Open-Source Science Strategy; *Kevin Murphy*
5. Deep Space Network Support for Science Missions; *Sandra Cauffman*
6. Astrophysics Advisory Committee Update; *Kelly Holley-Bockelmann*
7. Heliophysics Advisory Committee Update; *Matina Gkioulidou*
8. Earth Science Advisory Committee Update; *Sara Tucker*
9. ESA's JUICE mission, NASA, and the exploration of the Jupiter System*; Curt Niebur*

Appendix D

Agenda

Agenda
(Eastern Time)

Wednesday, May 31, 2023

10:00 – 10:10	Opening Remarks Introduction of Members	Mr. Jason Callahan Dr. Ellen Williams
10:10 – 11:10	Earth System Observatory IRB	Mr. Geoffrey Yoder
11:10 – 12:00	SMD Update	Dr. Nicola Fox
12:00 – 1:00	Lunch	
1:00 – 2:00	Tropospheric Emissions: Monitoring of Pollution	Dr. Karen St. Germain
2:00 – 2:15	Break	
2:15 – 3:15	Transform to Open Science Update	Dr. Kevin Murphy
3:15 – 4:00	Wrap-up Discussion	All

Thursday, June 1, 2023

10:00 – 10:10	Re-open Meeting	Mr. Jason Callahan Dr. Ellen Williams
10:10 – 11:10	Deep Space Network and SMD Needs	Dr. Sandra Cauffman
11:10 – 12:10	Division Advisory Committee (DAC) Chair Reports:	
	Astrophysics Advisory Committee	Dr. Kelly Holley-Bockelman
	Planetary Science Advisory Committee	Dr. Serina Diniega
	Heliophysics Advisory Committee	Dr. Matina Gkioulidou
	Earth Science Advisory Committee	Dr. Sara Tucker
12:10 – 1:40	Lunch and Learn: NASA Contributions to JUpiter ICy moons Explorer	Dr. Curt Niebur

1:40 – 1:55	Public Comments	
1:55 – 2:10	Break	
2:10 – 3:00	Discussion, Recommendations, and Findings	All
3:00 – 3:30	Outbrief to SMD AA	Dr. Ellen Williams Ms. Sandra Connelly
4:00	Adjourn	