**Minutes of the Meeting of the**

**Astronomy and Astrophysics Advisory Committee (AAAC)**

**18–19 September 2023**

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| **Members attending:** |  |  |
|  | Darcy BarronAlyson BrooksWenda CaoSarah HörstNikole LewisBritt Lundgren | Raffaella MarguttiMichael McCarthy (Chair)Willie RockwardHee-Jong SeoAbigail ViereggAnn Zabludoff |
| **Agency personnel:** |
|  | Carrie BlackDan FabryckyDaniel LyonsValerie MaizelSean JonesCarrie KolarCraig McClureR. Chris SmithJames NeffTanner AbrahamMatthew ViauHans KrimmLuca RizziSarah Marie BrunoAndreas BerlindJohn ChapinChristopher DavisHarshal GuptaJacqueline KeaneZoran NinkovElizabeth PentecostJoseph PesceAndrea PrestwichJoshua RedingMartin StillAshley VanderLeyJean Cottam AllenAmy Rodgers | NSF-ASTNSF-ASTNSF (Assoc.)NSF-ASTNSF-MPSNSF (Assoc.)NSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-ASTNSF-PHYNSF (Assoc.) | Mark ClampinHashima HasanBrian HumenskyRoopesh OjhaValerie ConnaughtonKathy TurnerBryan FieldChris JacksonTheodore LavineHelmut MarsiskeRegina Rameika | NASANASANASANASANASADOEDOEDOEDOEDOEDOE |
| **Others:** |
|  | Alexandra WitzeBob BlumBrittany McClintonConnie WalkerDennis FeerickPatrick McCarthyFederica BiancoGrant TremblayGriffin ReineckeMichelle McCrackinMitch AmbroseJames StraitJeff FoustJennifer AndrewsLamont Di Biasi Linda Karanian | Lucas Macri, NOIRLabMarcia SmithMargaret SheridanNicholas WhiteNick SaabPhil PuxleyRichard GreenRichard RogersSara BarberSolomon MorganTupper HydeVeronika FuhrmannWendy SwartzYaswant Devarakonda |
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**MEETING CONVENED AT 9AM ON SEPTEMBER 18, 2023.**

# Day 1

## Introduction and Agenda

Carrie Black of the NSF Division of Astronomical Sciences (AST) introduces herself, then new members introduce themselves, going around the room and including members on Zoom.

Carrie Black opens the meeting, welcoming all attendees and new members. She reviews the Federal Advisory Committee Act (FACA) and the role of advisory agencies, then explains why the AAAC is a traditional committee with an important role.

Black next reviews conflicts of interest and the appearance of conflicts of interest, regulations on gifts, and who members of the committee cannot accept gifts from, as well as the Hatch Act, Anti-Lobbying Act, and requirements for AAAC members.

Finally, Black turns the meeting over to Chris Smith (NSF). Smith introduces Sean Jones (NSF), the Assistant Director of Mathematical and Physical Sciences (MPS), who welcomes the committee and expresses his appreciation of the work they do, emphasizing the importance of committee recommendations to NSF, NASA, and the Department of Energy (DOE).

### AAAC Orientation

While MPS/AST often includes the orientation in its welcome message, this time the division decided it was important to discuss the orientation for the committee. Smith reviews the AAAC’s establishment and history, including its founding by Congress in 2002 to enhance coordination between NSF and NASA, and its expansion in 2004 to include DOE.

The AAAC’s congressional charge is to assess and make recommendations regarding the coordination of the astronomy and astrophysics programs of NSF, NASA, and DOE; to assess and make recommendations regarding the status of the activities of NSF, NASA, and DOE as they relate to the recommendations in the Decadal Survey and similar reports; and to deliver an annual report to the NSF Director, NASA Administrator, and the Secretary of Energy. The report also goes to three Congressional committees that want to see the AAAC’s assessments and recommendations.

Smith emphasizes that this portion of the charge specifically talks about areas of cooperation and the Decadal surveys. He reminds the committee that there are multiple advisory committees, Decadal surveys, studies, and so forth that focus on specific areas and what the three agencies are doing in those areas. The AAAC is unique because it looks at the cooperation across agencies, assessing the existence of cooperation and looking for patterns and areas of overlap.

Smith reminds the committee that while its recommendations are important to NSF, NASA, and DOE, they also go directly to agency heads and members of Congress. Thus, committee findings and recommendations will be most impactful if they are concise, relevant, and practical. He advises members that findings are sometimes more impactful than recommendations. For example, it may be more effective to find an area critical than to recommend a funding increase.

Smith also notes the most impactful recommendations and findings come from what committee members obtain from the community, and he recommends members not limit their information to committee-provided materials. Members should look at previous reports and consult the AAAC webpage for community-provided resources. He emphasizes that the organizers want committee meetings to give members the information needed to write an impactful report. On that note, he introduces a proposed schedule change for the committee. The committee leadership wants to move presentations earlier in the year, allowing time for the committee to develop and discuss a report, rather than crunching everything into the final month.

A committee member asks about the Office of Science and Technology Policy (OSTP) role in this process. Smith replies that, first and foremost, OSTP and the Office of Management and Budget (OMB) guide science policy at the highest level, so they tend to be focused at that level. Feedback and comments intended for OSTP should not be narrowly focused on astronomy. The committee should gauge its feedback with the realization that OSTP’s tools are agency-wide, not astronomy specific.

Another committee member asks about the factors driving the schedule starting in June 2024. Smith refers this question to Martin Still, who replies that, in general, the committee feels it is waiting too long to start the report. Still notes this question will be covered in his comments.

## Chair Remarks

Committee Chair Mike McCarthy reviews the AAAC’s charge, reminding the committee its job is not to revise or reinterpret the Decadal. McCarthy states the annual report is the most important outcome of the committee’s work. He underscores the need to receive as much input as possible from committee members, because that input will improve the quality of the report.

McCarthy reviews committee member expectations and the new timeline. There has been a rush at the end of the year to write the report, so committee leadership wants to start the process earlier. The goal is that, by the end of January, the committee will have covered major topics, made assignments, and begun writing the report in earnest. It will circulate the report to agencies for review in late February and send it off on March 15. May and June will be spent doing wrap-ups and assessments. The chair wants to nail down dates soon and will send a spreadsheet so members can provide areas of interest and other information.

A committee member notes a discrepancy between proposed dates. Smith replies that members are seeing a bridge timeline between the current and proposed schedules. Black notes they are ahead of schedule and will be sending out Doodle polls to lock in dates for the committee.

## NSF Update

AST Interim Division Director Chris Smith delivers the NSF update. Director Smith describes NSF staffing changes, explaining that he was named interim division director when former AST Division Director Debra Fischer was rotated out in July. He thanks Fischer for her visionary leadership, acknowledging he is stepping into a tough role. Smith explains he is “interim” director because there was a need for stability, as MPS head Sean Jones is also leaving the agency for Argon National Labs. Denise Caldwell, currently head of Physics, will be stepping in as acting Assistant Director of MPS, and Saul Gonzalez was named Acting MPS Senior Advisor for Facilities.

Director Smith emphasizes the importance of AAAC members understanding where AST sits in the structure of NSF. He reviews the structure of MPS, where resources live in the directorate, and where MPS sits in NSF as a whole. To provide context for the committee, Smith locates MPS in the agency’s budget and organizational chart. He next reviews the NSF director’s current “pillars and priorities,” which include “strengthening established NSF, inspiring mission millions, and accelerating technology and innovation.” Smith notes the last two are very important to the NSF director, the current administration, and Congress. He also reviews cross-cutting themes in NSF, including “advancing emerging industries, building a resilient planet, creating opportunities, and strengthening research infrastructure.”

Within the structure of NSF, AST supports forefront research in astronomy, facilities and development of new instrumentation, and broadening appreciation and understanding of astronomy. Smith emphasizes the importance of tying AST’s functions to the priorities mentioned above, explaining AST supports research in all areas of astronomy and astrophysics based upon two criteria: intellectual merit and broader impact.

Director Smith gives an overview of AST’s division programs, highlighting several new developments.

* **Astronomy and Astrophysics Research Grants (AAG) –** The catch-all program for individual investigator grants, these highly competitive awards are funded at approximately the $50M level. In conjunction with new facilities, AAG is the cornerstone of the AST program. Developments include establishing a relationship with Charles Simonyi to support early career astronomers whose research supports the Vera T. Rubin Observatory or who do related science, doubling the impact of AST funds.
* **Artificial Intelligence for Astronomical Sciences** – A new approach for AST is supporting centers for artificial intelligence. NSF is creating a new artificial intelligence program with AST and the Directorate for Computer and Information Science and Engineering (CISE). The preliminary proposal deadline is October 31, 2023; full proposals are due February 16, 2024. Two centers may be awarded, with each award being between $16–20M for 4–5 years of funding. This will be a significant investment in AI specifically for astronomical sciences, co-created with the Simonyi Foundation (Charles and Lisa Simonyi Fund for Arts and Sciences), which is co-sponsoring both centers.
* **Workforce Development –** NSF, MPS, and AST each have a portfolio of programs for workforce development. Programs start at the undergraduate level and move to graduate, post-doctoral programs, and then supporting early career faculty with the Career Program and the Leap Program, which are intended to incentivize and broaden participation. AST’s Partnerships in Astronomy & Astrophysics Research and Education (PAARE) is designed to increase participation, as is a new, NSF-wide program called Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED) which will support institutions that may not have the infrastructure to support a grant or grant process. The expanded PAARE program has finished two rounds of awards. AST encourages new partnerships between established and less-established research institutions with two tracks: long-term, fully-fledged partnerships and shorter-term associations.
* **Tools, Technology, and Instrumentation**: AST’s portfolio of buildings, tools, and instrumentation includes tools from the sub-million-dollar level up to the $100M level. Funding for large facilities is NSF-wide and therefore highly competitive; the astronomical community must compete in levels 1–2 of the MidScale Infrastructure Research, because that’s where much of NSF’s resources are going. AST is trying to understand the future of astronomical instrumentation. The AST team (led by Fischer) was planning on holding a workshop to determine what next-generation instrumentation will look like and how AST can support that instrumentation. The committee might compare AST’s program with other programs and provide feedback. AST understands instrumentation for large telescopes has become expensive, but there may be innovations that fit into smaller instruments (i.e., “precision measurements”). AST must consider what can be accomplished at a smaller scale as opposed to requiring a larger scale, using existing versus desired resources. The committee should consider these questions separately.

### Major Research Facilities

AST has been moving to a consolidated model of federally funded research development centers (FFRDCs) that incorporate individual facilities. AST’s portfolio of technology and innovation mechanisms includes the following FFRDCs:

* **National Solar Observatories (NSO):** Daniel K. Inouye Solar Telescope (DKIST), NSO's Integrated Synoptic Program (NISP), and the Global Oscillation Network Group (GONG).
* **National Optical-Infrared Astronomy Research Laboratory (NOIRLab) Observatories:** Gemini-N(orth), Gemini-S(outh), Mayall, and Wisconsin-Indiana-Yale-NOIRLab (WIYN). This FFRDC also includes component telescopes at Kitt Peak, Blanco, Southern Astrophysical Research (SOAR), the Small and Moderate Aperture Research Telescope System (SMARTS), Cerro Tololo Inter-American Observatory (CTIO), and the Rubin Observatory.
* **National Radio Astronomy Observatory:** Very Large Array (VLA), Very Long Baseline Array (VLBA), Atacama Large Millimeter/submillimeter Array (ALMA)
* **Green Bank Observatory**

Various programs bring together a holistic view of different areas of astronomy (solar, nighttime astronomy, radio). AST considers these facilities to be a cornerstone of their efforts to broaden participation, because they *must* give public access to any astronomer with a strong proposal. AST is looking at how to ensure astronomers at small institutions have access to these facilities.

### Results from Several Facilities

Smith shared recent scientific developments from several FFRDCs:

* DKIST was turned on and is producing beautiful images of the sun that are reaching a broad range of the public—helping with public outreach and engagement. DKIST is also resulting in very exciting science, and Smith references a paper published.
* GONG has exceeded its initial promise of looking at the interior of the sun and is now a cornerstone to NSF’s research support as well as to the National Oceanic and Atmospheric Administration (NOAA). NOAA supports operational modeling looking at the data coming from NSF instruments to model space weather. This cornerstone of the United States’ space weather program is aging infrastructure, having operated for three decades.
* In radio astronomy, AST supports the VLA, VLBA, and Central Development Laboratory (CDL). VLA continues its important work looking at both individual objects as well as the sky survey. The VLBA not only supports high-precision imaging and studies of distance objects but also serves a role as important national infrastructure supporting the Global Positioning System (GPS).
* Another NRAO component is ALMA, which is an international collaboration. Models of international collaboration are fundamental to the field, as facilities are becoming incredibly expensive to build and operate. The facility is continuing to break records in terms of proposals and time requested.

**Miscellaneous Updates**

Smith provides updates on a variety of other issues:

* **ALMA Cyberattack:** The ALMA cyberattack has been mostly resolved. They still have lessons to be learned but have moved on without any significant data or operations being compromised.
* **Green Bank:** Green Bank continues to do excellent science. It’s now considered a middle-aged telescope, so AST is looking and significant infrastructure costs to keep it going. AST replaced the damaged wheel and are looking at more replacements.
* **Gemini Observatory:** The Gemini Observatory is the current flagship pair of large optical telescopes. It has detected signatures of a planet being evaporated as it skimmed the surface of its star, which helps us understand the future of our solar system.
* **Older Telescopes:** The Victor M. Blanco telescope is one of the most productive ground-based optical telescopes operational today, mostly because of the cooperation with DOE.
* **Rubin Observatory**: The collaboration is continuing to move forward toward operations. It is still suffering some impacts from Covid and supply-chain issues, so the team is looking at completion in early 2025. The telescope itself, which is the NSF part of the collaboration with DOE, is moving into the testing phase.
* **Supplemental Funding for Gemini-N and Kitt Peak:** The team is closing out the Gemini-N mirror saga; they got it online with a repaired mirror after repairing and recoating it. Kitt Peak National Observatory has mostly recovered from the damage from the Contreras Fire. Both were helped along by supplement funding from AST so that the impacts of these events were covered by special funds.
* **Current Events:** Smith acknowledges the Maui fires impacted the Maui community, including the DKIST staff, their families, friends, and neighbors. NSF did what they could, which was allow staff time to deal with everything; they closed the telescope, and everyone was given leave. DKIST staff were amazingly dedicated and brought DKIST back online back online much sooner than expected.
* **Cyberattack at NOIRLab:** AST’s second cyberattack in recent history targeted NOIRLab (Gemini-N and Gemini-S). NSF shut down access to multiple facilities out of an abundance of caution. It took two months to bring ALMA back online, and NOIRLab is slowly coming back online after the Gemini attacks. It appears these attacks were a sign of the times rather than a consequence of open doors, and a broad examination of NSF facilities is underway.
* **Sustainability:** Sustainability efforts in NSF facilities were a goal in the 2020 Decadal Survey in Astronomy and Astrophysics (Astro2020). They have been adding photo-voltaic cells at Cerro Pachon, with the goal of making Gemini-South carbon neutral. They are extending this effort to the Rubin Observatory, which is a challenge because it’s very power-hungry machine. They are looking at how to fund Rubin with green energy.

### Major Facility Recommendations

Smith also covers several updates and facility recommendations:

* **US-ELT:** The US Extremely Large Telescope (US-ELT) program was put into the Major Facility Design Phase in 2022, which requires the director’s approval. NSF executed a preliminary design review and got a positive result on the technical evaluation. AST developed the final design plan, which was reviewed by a blue-ribbon panel.
* **Maunakea:** NSF is making progress on Maunakea with the Stewardship and Oversight Authority. NSF is committed to working closely and respectfully with the Hawaiian community, which takes time. The agency will work on their timescale. They are meeting with them, talking with them, and working to understand their needs. They want to work with the Authority on both existing and potential facilities.
* **Next Generation Very Large Array (ngVLA):** ngVLA has been moved into the design stage. This facility is at the beginning of the design process.
* **Cosmic Microwave Background-Stage 4 (CMB-S4):** NSF is moving toward submitting CMB-S4 to the Conceptual Design phase. The CMB-S4 team is working on designs to meet the footprint requirements, though these requirements are evolving on the ground.

Smith reviews the Major Facilities Design Phase and what that means for each project at each stage. He emphasizes that these are prioritizations across MPS, not just in AST. MPS is looking across disciplines, not just within astronomy. Entry does not imply approval for construction.

Smith skips several process slides that he says will be in the committee's notes.

### AST Budget

Smith reviews the AST budget. AST is closing out the 2023 fiscal year, waiting for FY 2024, and developing FY 2025. Smith recommends keeping that in mind when looking at the plans, which are mostly relevant for 2025 and 2026. AST is currently developing the FY 2025 budget. In NSF, budget allocations are year to year. AST has a base, but those budget increases vary by year. NSF does a year-to-year planning process based on the priorities of the director, the administration, and Congress. The more recommendations resonate with those priorities, the more likely those recommendations are to be heard.

Smith notes the reality of FY 2024 is still in question. He outlines NSF’s numbers relative to the President’s request, the Senate numbers, and the House numbers.

The lifecycle costs of Major Facilities present challenges to AST. These costs include immediate needs (design), future needs (construction), and long-term needs (maintenance costs).

They are doing aspirational planning, looking at the needs described in Astro2020, while preparing to make the tough decisions that financial realities may require.

Smith notes that he hasn’t covered some sections of AST because they’ll be covered in later sessions.

Smith concludes the NSF presentation.

## Q&A on the NSF Presentation

Abigail Vieregg notes that it’s great that the ngVLAs and ELTs are moving forward and says that’s great progress. Vieregg asks about CMB-S4, and Director Smith responds the South Pole has some thorny issues that are outside the realm of the people in the room.

Ann Zabludoff says Smith mentioned international partnerships and asks if he thinks there are additional avenues to grow these partnerships and what the drawbacks may be longer-term. Smith replies there are certainly opportunities to grow these public-private and interagency and international partnerships. In the public-private there are elements of opportunity, but those don’t come free. They require human resources, investments of time and energy by the team to grow those relationships and find those partnerships, which is always a challenge. There’s a self-regulating factor there that there may or may not be out-of-the-box solutions for. Additionally, when you do these things, you have to assume that only one out of ten may grow into something significant. Smith passes the question to Jim Neff, who notes there is tremendous potential for public-private partnerships, and AST has been very successful over the years. Neff notes government-private foundation partnerships require a lot of attention to detail and work best when the money doesn’t get commingled. Partnerships are viewed as a source of income, but the other party wants something too. It’s not just a source of funding; it’s a true partnership.

Willie Rockward asks how the leadership change will affect partnership relationship-building. Smith responds that it does affect continuity, but that most partnerships are developed by the AST team/staff. He’s expecting to rely on the staff who have been building these relationships to keep them running and grow them if possible.

Wenda Cao asks if NSF is working with the community to develop a plan to support NASA to do a solar space mission. Carrie Black responds that NSF is working on the Parker Solar orbiter memorandum of understanding (MOU) with DKIST, and that coordination between space- and ground-based observation is a much broader issue in astronomy. It’s a fine balance between going through the proposal process and making sure nothing is missed. Cao and Black discuss how Cao’s organization is handling this balance, and Black suggests they discuss it further over lunch. Smith adds that, at the MPS and Geo levels, there is interest in bringing those conversations together—of bringing the AST and the Division of Atmospheric and Geospace Sciences (AGS) together—to better integrate NSF’s interest in solar and space physics. There certainly is attention there that is slowly spinning up. DKIST is spinning up, and NSF is starting to look at the next investments.

Britt Lundgren mentions that Smith said the AAG is very competitive. Lundgren asks if the latter has statistics on how competitive they are right now. Jim Neff responds that they don’t release success rates on a year-by-year basis anymore, but it bottomed out at one in seven back in about 2014. It has been steadily climbing back up, and they are holding between one in four and one in five these days. They are doing everything they can to ensure the success rate doesn’t drop below one in five. As a follow-up question, Lundgren asks that whether they can comment on the amount of funding per grant allocated, given NSF maintains this one-in-four to one-in-five level, and whether that level of funding can support the kinds of groups people have been used to in the past 15 years or so. Neff responds that detailed questions like that fall under the purview of the Committee of Visitors, and they’re working now on a report that comes out after the Mathematical and Physical Science Advisory Committee (MPSAC) meeting in November. But overall, NSF tries to send a signal that the proposal budgets should be justified. The cost per award has been creeping up, so to sustain the success rate, they have benefitted a lot from funding from other programs. Additionally, while costs are going up all around, the average award amount is also going up. Finally, Neff notes they are not arbitrarily cutting budgets or signaling that people should inflate their budgets. Incidental funding that comes in, such as when a student gets a fellowship, happens more often than one might think—which allows for NSF to keep the award amount the same.

Mike McCarthy asks if NSF can work the committee through the disconnect between what the Decadal wants us to fund and larger fiscal realities. Smith responds that it comes back to having an aspirational budget but a realistic plan. There is recognition within the AST team that people do the science, and facilities are the tools people use, so that is guiding their planning. A lot of the aspirational part is built on potential help from outside the AST budget. AST is also benefiting from actual deferred maintenance supplements from outside the AST budget. Smith hasn’t had time to vet being able to show those numbers, but there are significant flows from MPS. The directorate’s money goes towards the facility costs so they can protect the grants. So, part of AST’s aspirational costs is that those flows continue. They are looking outside the directorate and outside the agency for help with the most aspirational aspects while they keep their eye on the health of the grants program.

Ann Zabludoff asks if Smith could talk a little bit more about interagency support initiatives and if it’s possible to give a number of how much money is involved. Smith gives a rundown of the initiatives, saying that for CMB-S4 the baseline going in is a 50-50 split if that were to go forward; for ngVLA, they’re looking at how it can be leveraged for interagency and international partnerships (e.g., GPS, wavelengths, other major facilities). Smith doesn’t have a number for the ngVLA, but for international support and partnerships for ELTs, they are looking at possibly 50-50 percent split. AST is aiming for the 25 percent specified in the Decadal, but the reality is looking more like 50-50 partnership, which is still pretty good. Smith doesn’t have many numbers, but the initiatives are there. He notes that AST is also looking for synergies and potential coordination in data management, not just in facilities, and that the committee will hear about that later today or tomorrow. There are also possible collaborations on instrumentation with NASA, as well as putting together specific programs, and workshops, and other issues.

## DOE Update

The Department of Energy (DOE) presentation is given by Kathy Turner from the DOE Department of High-Energy Physics, Brian Field, and Christopher Jackson.

Turner gives an initial introduction to DOE’s High Energy Physics department. DOE and its Office of Science have a mandate to advance science and develop new tools and technologies. The “crown jewels” in the Office of Science are its 17 laboratories. Turner’s office is tasked with reviewing the labs, their jobs, and where they are located in the United States.

### Office of Science Update

Turner gives a quick update on the Office of Science as of 2022. Within the Office of Science is the office of High Energy Physics (HEP), which has a mission to “discover the elementary constituents of matter and energy, probe the interactions between them, and explore the basic nature of space and time.” Primary tools are accelerator-based, but the various fields are intertwined.

Turner presents the “Office of High-Energy Physics at Glance.” HEP is the largest supporter of particle physics in the United States. Its budget for FY2023 was $1.166B, and the FY 2024 request is $1.226B.

Turner reviews the HEP program, which is primarily accelerator-based, but notes that Cosmic Frontier, which uses naturally occurring data to study matter, energy, space, and time, is becoming increasingly important. In fact, in the last decade it has become an “integral and priority” part of the HEP program. HEP also has a theory program, so if someone has a theoretical scientific study, even if it’s in cosmology, they would apply to that program. It includes high-performance computing, computational HEP, growing artificial intelligence and machine learning (AI/ML) efforts, detector research and development (R&D), and quantum information science.

In carrying out the mission, HEP develops and supports a specific portfolio of projects, and emphasis is placed on building facilities, operating experiments, supporting research, supporting future R&D, and publishing the results. Turner notes that this means that even if there are other facilities and programs in the U.S. that are doing similar research, DOE has to focus on supporting their own. HEP also forms partnerships with agencies like NASA, NSF, and international partners, as well as working with labs and universities to achieve their goals.

### Science Collaboration Model

HEP’s strength is its Science Collaboration Model. Scientists participate in all phases of a project, from design and fabrication to commissioning, experimental operations, science planning, and data analysis. Turner emphasizes this involvement in all stages of a project gets the best results, including for training students and postdocs to have experience in the entire project lifecycle—not just coming in at the end to do data analysis. This way, they get training on how to build and run a project too.

Turner notes that as a mission-driven agency, DOE supports research that is directly in line with the roles, responsibilities, and science goals on that project. She gives an overview of the structure of the Office of High Energy Physics and where the various projects live.

Regarding program guidance and planning, FACA panels provide guidance to the government, and DOE has several panels to provide guidance on various topics. The HEP Advisory Panel is the primary FACA panel within HEP and advises DOE and NSF on high-energy and particle physics. It has several sub-panels, of which she mentions three: the 2009 Particle Astrophysics Science Advisory Group (PASAG), which developed the prioritization criteria for when, how much, and what they should contribute to a project; the 2014 P5 developed the 10-year strategic plan which HEP is currently carrying out, and there is another P5 panel currently developing the next 10-year plan (to be released at the end of 2023).

Another FACA Panel that HEP is involved in is the AAAC (the current meeting).

HEP also gets advice from the National Academy of Sciences (NAS) when the agencies charge NAS to do certain studies, like the Decadal surveys. Not only is there Astro2010 and Astro2020, but there is also a Decadal Survey of Elementary Particle Physics (EPP2024) that is ongoing. EPP2024 is a charge by DOE and NSF. HEP guidance is also provided by the Board on Physics and Astronomy and the Committee on Astronomy and Astrophysics that observes HEP activities.

Turner reminds advisory panels that they are providing high-level advice about how the office is furthering its mission, rather than prescriptive details the agencies must resolve when they get their budgets and other inputs. She advises the committee to look at the big picture of how the agencies are performing according to the committee’s charge, including how they are working together, planning together, and executing on the Decadal.

Turner reviews the prioritization criteria developed by PASAG and how they are used to develop and select projects. These criteria include that the scale of the project should align with the office’s science goals, HEP must be able to make a major contribution to the project beyond writing a check, and the HEP community of experts (particle physicists) need to be involved.

### Cosmic Frontier Program

Turner reviews how different sub-panels were used to develop their current programming for the Cosmic Frontier. She talks about how HEP carries out the Cosmic Frontier program and aligns it with current science drivers. She also explains how the DOE/NSF strategic plan was developed and carried out. Within the program, the research frontiers identified are being executed with the following projects:

* **Dark Energy:** Large Synoptic Survey Telescope (LSST) at the Rubin Observatory and the Dark Energy Spectroscopic Instrument (DESI).
* **Cosmic Microwave Background:** Plays a role in the CMB-S4 multi-agency project.
* **Dark Matter:** A suite of “generation 2” direct detection experiments to detect dark matter (DM) particles.
* **Neutrino Mass:** Survey experiments to provide information on neutrino properties.

HEP is executing on Astro2020 through the DOE/NSF partnership on CMB-S4, as well as by working on the DEI and demographics/data with NASA and NSF as required by the Decadal.

Snowmass 2022 brought the community together to lay out science interests and potential directions for the future, and the Particle Physics Projects Prioritization Panel (P5) takes that input together with Astro2020 and the P5 plan that recommends certain projects. The National Academy has a study going as well.

Cosmic Frontier program objectives include carrying out select, high-impact experiments and projects that make significant leaps in science, carrying out the roles and responsibilities that make significant contributions, achieve the earliest, best, and most cost-effective results for U.S. science by virtue of HEP’s involvement, and work in partnerships as needed and appropriate.

Turner provided the following additional updates on the Cosmic Frontier program:

* **Cosmic Acceleration:** The Extended Baryon Oscillation Spectroscopic Survey (eBOSS) was completed in 2020; DESI is operating; the LSST camera is completed, and they’re now commissioning it for the Rubin Observatory; and the Dark Energy Science Collaboration (DESC), which is the collaboration supporting the science goals on Rubin Observatory, is in planning.
* **CMB:** The program built the focal plane for the third-generation South Pole Telescope-(SPT-3G), which is operating, and have concept planning for some of the CMB experiments, including Background Imaging of Cosmic Extragalactic Polarization (BICEP) and Polar Bear. They are in conceptual design for CMB-S4 for direct detection of weakly interacting massive particles (WIMPs) and axion types of dark matter. Other experiments did indirect searches for dark matter, along with many other topics; these included Veritas and Hawk, for which the program’s support has ended.
* **Small Projects:** Small projects include searching for the Dark Ages signal using the Lunar Surface Electromagnetics Experiment-Night (LUSEE-Night) pathfinder mission, which is a partnership with NASA that is currently in fabrication.

### HEP Budget Overview

Turner reviews the budget for HEP, including how it works and HEP’s budget process for a specific fiscal year. First there’s internal planning, OMB and OSTP input, OMB review, and then pass-back. Then the budget is released; Congress considers the proposals; each side does a markup on the budget; both sides eventually agree; they pass a budget resolution; Congress appropriates the budget; and the President signs the budget. Finally, in the execution stage, HEP starts spending the money.

Turner then goes into more detail regarding the entire process for how the federal agencies formulate the budget. She emphasizes that when people say, “Oh, well just ask for more money,” that’s not how it works in the federal government. There is a complex process the agencies must undergo, coming down from the executive branch, and there’s a lot of detailed back and forth before everything goes into the President’s budget request.

Turner then turns from general FY appropriations to where we are now, in 2023, including ending FY 2023, planning the FY 2025 budget, and waiting to hear about FY 2024. She reviews the HEP budget history from 2013 to the present, showing the President’s requested budget, the actual appropriated funding, and the House and Senate marks for the HEP budget. FY2014 started at approximately $700M, but the budget has increased. The strategic planning process was very successful. Starting in 2018, the president’s request was very low, but the Congressional marks were much higher, and HEP got much more money. Turner shows the percentages of research, operations, and projects in the HEP budget, and she notes that the research budget funds the scientists, not the research itself (unlike NSF). In 2022, the budget got a big spike (approximately $303M) from the Inflation Reduction Act.

Turner mentions the community has concerns about the research budget not going up as high as people would like. She says the research budget is going up, but that’s mostly due to the new initiatives like AI/ML.

Turner reviews this year’s Presidential budget and discusses the research initiatives being included: Reaching a New Energy Sciences Workforce (RENEW), which targets efforts to increase participation from underrepresented groups; Funding for Accelerated, Inclusive Research (FAIR), which improves facilities at historically black colleges and universities (HBCUs); AI/ML; microelectronics; quantum information science and the quantum information center; and emerging technologies.

Turner also reviews the Cosmic Frontier budget for FY23, which includes:

* ~$53M for research (including university and lab research, future R&D, and AI/ML research);
* ~$58.8M for experimental operations; and
* Funding for projects that are previously funded or winding down, including the Lunar Surface Electromagnetic Experiment (LuSEE)-Night, CBM, etc.

Turner notes Cosmic Frontier is not itself a line-item on the budget, so they have to compete for the project within the office of HEP, which likewise competes within the entire Office of Science for the projects at DOE.

Finally, Turner reviews the Cosmic Frontier budget history slide. She provides an overview of the entire Cosmic Frontier program and gives a status update on the joint efforts with NASA and NSF, as well as DOE’s involvement and contributions to those joint efforts, including the following projects: Dark Energy Survey (DES), DESI, Rubin, LSST, the Dark Energy Science Collaboration (DESC), CMB-S4, the Super Cryogenic Dark Matter Search (SuperCDMS), SPT-3G, Fermi Gamma-ray Space Telescope / Large Area Telescope (FGST/LAT), the Alpha-Magnetic Spectrometer (AMS), and LuSEE-Night. Her slide covers who Cosmic Frontier is in partnership with, the project, DOE operations, oversight, and project status.

Turner provides the following additional project updates.

* **DESI:** DESI is the world’s first stage-IV dark energy project. It started operations in 2021 but was down for three months because of the Contreras fire. The project just restarted taking data in August after a summer shutdown for recoating the mirror. DESI has seen results, and investigators have published their first cosmology papers in recent months. An upgrade is proposed to DESI 2 operations.
* **Rubin Observatory:** NSF and DOE have a partnership at the Rubin Observatory. DOE built the camera. Hardware was completed Sept. 2021, and now the project is commissioning. They are doing tests, planning shipment, etc. Facility operations is a 50-50 split. Project completion is forecasted in mid-2025. The project is putting together the US Data Facility that will carry out the data facility efforts and deliver data to all collaborators; it’s not just for DOE scientists.
* **CMB-S4:** DOE has had decades of involvement in CMB research and experiments, not usually funded directly by HEP but using facilities, scientists, and so forth. Astro2020 recommended this approach to CMB-S4, and it is being considered by the current P5 survey. In December 2022, the project reported an alternative design that will address the South Pole infrastructure and logistics issues while still meeting all the science goals.
* **LuSEE-Night:** This project is a DOE/NASA partnership that aims to discover radio signals from the cosmic Dark Ages using the most sensitive constraints to date. Launch is planned for 2025, and the project completed decision-three review, meaning they are ready to start fabrication.

The committee is invited write down its questions and ask them later in the afternoon, since time is running out.

## NASA Astrophysics Update

Astrophysics Division Director Dr. Mark Clampin (NASA) delivers the NASA Astrophysics Update.

Director Clampin notes the committee has already seen two presentations about how the budget works, so he’s going to give an overview of the programs rather than going into the budget.

Clampin shows organizational charts of NASA and its Science Mission Directorate (SMD), reviewing who is who within the leadership and directorate. He reviews a chart showing an overview of the Science Mission Directorate. The chart shows that, across the divisions, the directorate runs 134 missions, including 24 operating missions and 23 upcoming missions.

Clampin lists members of the directorate and their positions. He mentions Nikki Fox, the Associate Administrator for Science, who is a key player in the SMD. The chart gives an overview of the mission directorate, which addresses a community of around 10,000 US scientists with 3,000 collective awards and about $600M awarded annually.

The directorate is currently working on 57 different science missions, many of which also envelop technology demonstrations—as do the Sounding Rockets and Balloons programs. The Balloons program is run out of the Astrophysics Division, and the Sounding Rockets program is the Heliophysics Division.

Clampin discusses budget allocations. He reviews the org chart and the various leads, missions, and programs. He goes into detail regarding the dollar amounts of the projects and various budgets.

Clampin presentsthe Science Mission Directorate swoosh chart of the Astrophysics Fleet Pre-Formulation. The chart is color-coded with small icons representing various traditional and small missions. He mentions Euclid and the X-Ray Imaging and Spectroscopy Mission (XRISM), which are missions recently launched, as well as the Atmospheric Remote-sensing Infrared Exoplanet Large-Survey (ARIEL) and Medium-Class Explorers (MIDEX) missions.

XRISM is a partnership with Japanese partners and the German Space Agency. Euclid is a partnership with the European Space Agency. At the end of the year, the Balloons program is due to fly the Galactic/Extragalactic ULDB Spectroscopic Terahertz Observatory (GUSTO). GUSTO is a mission of opportunity that will fly as a balloon payload from Antarctica. Clampin goes into depth about three launches: Euclid, XRISM, and GUSTO.

Clampin also mentions other work the division is doing, such as launching balloons and the Gamma Ray Polarimetry Experiment (GRAPE). He compares a prototype gamma ray, telescope for a future mission, and an infrared spectrum polarimeter for Earth observation.

### Decadal Survey Recommendations

Clampin gives a summary of where the division is with the Decadal survey recommendations. These were the key recommendations of the Astro2020 program. The Decadal Survey’s major recommendations included:

* Development of a near-infrared optical telescope that would provide high contrast imaging capability. This telescope is intended to have a six-meter aperture and coronagraphic imaging capability, allowing for the direct imaging of exoplanets and other high-contrast observations.
* A Great Observatories program mission and a technology maturation program, called the Great Observatory Maturation Program (GOMAP), which would mature the technology for future astrophysics missions. The basic science is to survey nearby stars for habitable planets and characterize them.
* A space-based science program for time-domain and multi-messenger astrophysics (TDAMM), which would put infrastructure in place to support rapid alerts across the portfolio of admissions. From the perspective of this committee, this program is a very important part of integrating our work and the network with the Rubin telescope program, the Laser Interferometer Gravitational-Wave Observatory (LIGO), and the IceCube Neutrino Observatory, creating an integrated alert system for TDAMM science.
* A survey to look for habitable planets that might be harboring life. This final recommendation requires NASA to survey sunlight from nearby stars to identify habitable planets and search for evidence of life. The Decadal also recommended that the division study the lifecycles of galaxies with a large-aperture space telescope, which will essentially be a segmented mirror telescope to get proper contrast levels.

### Conduct a Transformational Astrophysics Program

Clampin continues to explain that both program offices are conducting technology and road-mapping studies. The planning program office is conducting technology robots for deformable mirrors, coronagraphs, and integrated modeling.

Additionally, they have embarked on a series of programmer workshops, the first of which was just held. The offices are working on a large space telescope, an ultra-stable observatory, and a mapping of the technologies.

Clampin notes they have just started putting in place a Science, Technology, and Architecture (STA) review team. This group will look at the science priorities for this observatory, both on the exoplanet side and on the transformational astrophysics side, where we really need to do some prioritization of some of the science opportunities that the Decadal identified. Clampin mentions that astrophysics probes have a billion-dollar cost.

Clampin explains this principal investigator (PI)-led mission was recommended by the Decadal, which was very specific in the recommendation, saying it should either be a far-infrared imaging or spectroscopy mission; or, alternatively, an X-ray imaging and/or spectroscopy mission. The announcement of opportunity (AO) for this probe was issued in July. This AO is a two-step program. They will review the proposals when they come in and then select two science missions for competitive phase studies that will last about 12 months. There are no predetermined selection criteria here; instead, the focus is on science excellence as the primary requirement, combined with technical feasibility.

NASA is trying to put together support and alert networks to tie into gravitational wave neutrino and the Rubin space telescope survey program. There are many opportunities as Roman matures, and the effort is also generating many new NASA missions, such as the Compton Spectrometer and Imager (COSI), through the Upper and Small Explorers (SMEX) programs.

Clampin discusses the Roman telescope and some of the achievements it made possible.

He summarizes programs currently in development, including SPHEREx, COSI, and Ariel, which are missions of opportunity. There are also smaller, mid-class explorers:

* Imaging X-ray Polarimetry Explorer (IXPE)
* Transitioning Exoplanet Survey Satellite (TESS)
* Compton Spectrometer and Imager (COSI)

Clampin discusses the ongoing and planned Inclusion, Diversity, Equity, and Accessibility (IDEA) initiative in the Astrophysics Division (APD). APD is focused on inclusion plans for Research Opportunities in Space and Earth Science (ROSES) and is looking to expand that to other programs moving forward. They are also putting on community days, which include virtual visits to universities and underserved institutions. IDEA benefits from the telescope allocation committee and the benefits of dual-blind and dual-anonymous testing methods. Clampin provides an overview of Research and Analysis (R&A) funding and current strategic technology projects and selection rates. He recommends attendees review slides for more info. Finally, he discusses science data policy and a year of open science.

Clampin concludes the presentation.

## Q&A on the NASA Presentation

Anne Zabludoff asks about cross-agency and inter-agency collaboration with NSF and DOE: What are the challenges with those collaborations? Clampin replies that most collaboration has been with Debra about the time-domain capabilities and how to tie the alert system NASA is creating into their own alert system. DOE is on Fermilab (FNAL), and the pipeline analysts for the Roman Space Telescope. Joint funding gets tricky.

Zabludoff follows up with a question about TDAMM science and NASA and asks Clampin to elaborate on why cross-agency funding is difficult. Clampin replies they haven’t really pursued any cross-agency funding because the opportunity hasn’t presented itself. NSF may have a different perspective. The collaboration is on the grass roots level.

Martin Still mentions an upcoming joint-agency workshop in Tucson, focused on existing and new methods of coordination across the communities and across the facilities and emissions. Part of that may turn out to be recommendations from the Time Domain Multi-Messenger community about how the agencies can work closer together and potentially pull resources to get some of these recommendations implemented. Clampin mentions a white paper written about TDAMM science and goals. He says its contents are about collaboration.

Zabludoff asks about the alert system, collaboration, and the meeting agenda. She wants to understand how the agencies are working together and what the goals of the meeting are in terms of fostering collaboration. Clampin expects the results of the meeting will help identify problems and ways to solve them together.

Clampin mentions work to develop, upgrade, and build tools for out-of-date alert networks. He says that work can lead to collaboration with LIGO, Rubin, and NSF-funded entities.

An online questioner asks about the status of the pioneer selections. Clampin says selections may have to be deferred due to budgetary issues.

Mike McCarthy asks a question about NASA on laboratory astrophysics. There was no update on this matter.

There is a follow-up question about government funding and how it would impact the timeline of the Habitable Worlds mission, specifically the launch of the Roman Space Telescope. Could this be the end of the launch window for the mission?

Clampin explains the budget for future years is still being determined, and there are ongoing budget cycle deliberations. It is currently a late year for the budget cycle, and definitive statements will be difficult to make at this point. McCarthy emphasizes there is still a lot going on, and they need to wait and see where they end up with the budget.

Britt Lundgren is happy to hear about the large fraction of junior investigators that were successfully awarded time on the James Webb Space Telescope (JWST), stating that the performance of the instrument is obviously impressive and great news for the community. Lundgren asks if Clampin could talk about the budget for funding the science in those GEO programs. Lundgren’s understating is that it’s hard to complete the scientific analysis with the budget that’s being provided. She wonders if there was open conversation with the other agencies about making the dividing lines in individual investigator awards less restrictive in terms of what you can be awarded if you're using NASA resources. Clampin replies that, before he started, there was concern about the budget. In his first year the number has been restored to what was recommended, and they are not intending to reduce that number. The budget is at a level now that can support the science communities’ programs. He believes they're adequately funding the Roman program and the JWST science program.

Clampin reiterates that Observatory is the primary Decadal recommendation in astrophysics, and they are moving forward within the budgetary constraints. APAC (Astronomy and Astrophysics Advisory Committee) is his primary advisory committee. They will be meeting in October.

Clampin ends the presentation.

## Committee Discussion

The committee discussion is an opportunity for the committee to bring up whatever they want about what they’ve heard so far.

Mike McCarthy asks about the previous year’s report and when they might be scheduled. Darcy Barron replies there has not been a line-by-line reply to last year’s questions about recommendations. Chris Smith says there is a summary of the main topics (those for which there was a section or subsection) in the FY23 report. Topics include ELTs in this case, ground-based laboratory astrophysics, next generation VLAs, and CMBs. Protecting dark and quiet skies is important for TDAMM. Other priorities include astrophysics data, data archiving, and more data; the state of the profession, including demographics; and climate change.

### Focus of Subsequent Discussions

The committee considers focal points for a subsequent meeting.

Zabludoff says the presenters asked for a lot of things—in general, to make the committee’s job easier. She agrees with Smith’s clear description of their two charges and report responsibility, stating she found the presentations informative. She suggests the presentations should laser-focus on the committee’s charge and uses Kathy’s table as an example. The committee had asked for that table, and it describes all the programs, missions, and projects that are shared among two or three of the relevant agencies. Zabludoff finds this table useful, because it shows which agencies are coordinating where. She suggests the committee could go into depth on those projects, instruments, facilities, and missions, because that really should be where its focus is. Zabludoff also suggests another table that has the Decadal recommendations, as well as which agency is responding to which cases where more than one agency is responding to the same Decadal recommendation. She suggests having those tables in advance of the meeting.

Questions for the committee to consider include: How do we fund all these fun projects? How do we collaborate and find funding sources? How can we get creative in response to the Decadal recommendations to find more money? What are the drawbacks and benefits?

Chris Smith says Mike mentioned several of the talking points. The meeting was held around data, TDAMM, and whether the committee can dedicate a whole session on the day-to-day session work. With back-to-back presentations, the collection of activities will present a look at the bigger picture. That’s why the sessions are planned that way.

The committee discusses the content of the next day’s presentations and how they relate to the topics that have been prioritized. There are three main recommendations that overlap with NASA: data, TDAMM, and demographics.

Mark mentions it’s sometimes hard to decide what to present. It’s also difficult when the agreements aren’t in place to describe certain activities.

Smith asks if National Security Presidential Memorandum (NSPM) 33 is affecting collaborations. The memorandum establishes national security and policy for securing US-supported research data against foreign interference and misappropriation, among other threats. Martin Still replies, “yes, it does affect us.”

### Demographic Data Collection

Lundgren asks about demographic collection. Still says they are waiting for federal guidance once the reports are completed. It seems OSTP should provide guidance to agencies in this regard. Carrie Black mentions the Decadal survey sent these questions to the highest level and then to OSTP.

McCarthy says OSTP should provide a consistent format. He is surprised that it’s still an open question. Still says they’re waiting for a broad set of directions. Lundgren asks about the minimum amount of data they can collect and analyze in a systematic fashion; she states the committee does not know about the non-R1 institutions and PIs who are underrepresented, among other data, despite the inference that such data are collected.

Lundgren asks what the agencies are allowed to do. McCarthy replies the different organizations have different demographic info, and policies are implemented on different levels. Solutions must be agency wide. He says the Office of the Director is sending draft documents and plans, but agencies need clarity on the information or categories included within that subset of demographics. Lundgren asks for a general summary, and McCarthy suggests a tiered or phased approach. Black explains NSF makes some demographic information available but not at the division level, and it requires extensive clearance to make that data available. There is information available at the MPS level.

There is further discussion about how to better get demographic data. It seems OSTP wants a standard procedure and policy, but it has been difficult to implement or wait for those policies. If agencies take the lead on making that data public, it could help pressure other institutions, but some agencies don’t have the same rules, and there are anonymity concerns. There are different regulations around this data, so it is not easy. Identifying cases where they can release data for more transparency is something the government should prioritize. The NASA Space Telescope Science Institute (STSCI) has released a lot of demographic info.

Zabludoff asks about the difference between possibility and prioritization, citing the STSCI as an example of someone who has published demographic data without concerns that applicants will be identified. Still says it’s really difficult because there are legal obligations; STSCI is not a government organization, so they’re not bound by the same laws and regulations. People want to make progress on this. It seems easier than putting a camera on the moon. Zabludoff invites participants to apply for IPA positions to look at the data themselves.

Zabludoff asks if the data have been captured but can’t be released, or has it not been captured? Data is not collected uniformly. They know what data NSF collects but not whether that is complete, nor whether all categories exist that they would like to examine. Possibly the answer is no. Zabludoff is not convinced it’s a fair process due to a lack of transparency. She has not seen a clear understanding about the process and is not reassured these decisions are fair. She asks whether someone is evaluating how fair this process is, stating that if it’s hidden it won’t be fair. She notes this has been a problem for years and asks if the NSF Director would speak on this.

Black responds that the Head of the Office of Equity and Civil Rights spoke in January. Things like the Committee of Visitors are supposed to look at the details. Regarding whether their office is making reasonable decisions, she says, they assess funding decisions that have been made, and demographics data is something that they look at. If the question is whether AST is making appropriate award decisions, she’s not sure the AAAC is the right venue for that. She believes there are other sources of data outside the agencies.

Zabludoff says there are other reasons for the trip than to look at demographics data; for example, it's part of the Decadal survey. If you're looking at the health of the community, there are other sources of demographics data that are outside the agencies. She asks whether there are other sources of demographics data outside of the agencies that assess the astronomy community as a whole.

McCarthy says the AAS is doing this. There must be other ways of taking the temperature of the community. He says they are working on this because they are as frustrated about the speed of change. But they knew two years ago when this first came up that this committee is not the only pressure point. Federal government-wide, there is pressure coming OSTP, committees like the AAAC, and the broader government. The office is moving forward internally, waiting for direction to present data at open meetings.

There is further discussion about demographics and how they need to gather data in a fair and transparent way. McCarthy tries to pivot to foundational activities in the Decadal such as diversity, training, and harassment. He asks where agencies are in workforce development. It’s important to get people interested and excited about science and supporting them as they move through their career.

Sarah Horst asks what AAAC can do to move the demographic discussion forward. More discussion about data and demographics and how to merge the data from different places and types of collection. Black responds that the committee won’t see a lot of motion until decisions are made. Still adds that the committee should continue addressing these issues in its report. NSF accepts proposals at any time from anybody, Black adds.

Zabludoff asks whether social scientists are involved with the agency's process. Still responds that they are still focused on gaining access to the data. Zabludoff concludes there is data, technical information, and data fusion. It may not be that large a data set, but there’s a technical problem, and an interpretive problem because there aren’t social scientists in the mix. She asks whether the committee can get more information on how the data is being used, independent of the legal ramifications. Still responds that they have the information from the proposal surveys. They are collating the data but not interpreting it. Black calls out the need for a metric, for example the gender baseline against which to compare their raw numbers. Zabludoff suggests they start by looking at the success rates. Black says that they did that exercise but questions the significance of the finding. Still notes the distinction between information and interpretation.

Kathy Turner said she has some notes on the Astro2020 responses. EOs have come down starting in January 2021 that gave directives on DEI, demographics, and scientific integrity. There are cross-agency working groups involved with OSTP. DOE collects demographic info from grant applicants, but there are complications with postdocs/students who are added after a grant. Statistics are small. She says the physics community is pushing for more demographic data. They need to work with the Office of Science to upgrade data collection in the grants process. For data from various communities to get released, there will have to be a consistent way of doing it.

Turner adds that DOE does collect demographics when someone applies for a grant and if they get it. So, this is what makes it hard, and a lot of people don’t want to give it. So, then the PI requests it, and doesn’t get named until after the grant is awarded, and for Cosmic Frontier, the statistics are very small. For the data analysis, the worry is that people will know who is applying, so we have to work with all offices to get the right data.

Some applicants list a grant officer’s name as the senior person on the grant, which can skew the demographic picture. DOE has hired a data scientist who will hopefully get this going much better. We’re getting it from all communities, and things are happening at a high level, but we have to keep the pressure on.

McCarthy advises the group not to let perfect be the enemy of good.

## Workshop Report: Future of Astronomical Data Infrastructure

Luca Rizzi shares data in a presentation titled “Report on the workshop: The Future of Astronomical Data Infrastructure and Future plans.”

Rizzi summarizes attempts to meet data management and software pipeline recommendations from Astro2020. The two main findings of Astro2020 were: (1) Software development is an essential part of every sub-field but is not adequately funded or supported; (2) Progress will come from an end-to-end approach that considers the entire flow of data from the instrument to the archive.

Rizzi emphasizes the end-to-end and hand-to-hand approach to share data. Putting data into a science platform is determined by the archive and other factors, stemming from the proposal.The National Science Foundation and stakeholders should develop a plan to address how to design, build, deploy, and sustain pipelines for producing science-run data across all general-purpose ground-based observatories (not a small demand), both federally and privately funded, providing funding in exchange for ensuring that all pipeline observations are archived in a standard format for eventual public use.

Rizzi says there was a working group followed by a workshop, which was held to discuss how carry out the recommendation. NSF, NASA, and the Center for Computational Astrophysics of the Flatiron Institute worked together to identify technical solutions, implementation options, a long-term vision, and the tentative roadmap to achieving these things. The report has been written and will be released soon.

Results of the conference include:

* It’s most important to build an end-to-end ecosystem.
* Individual stakeholders are building individual pieces often with a lot of duplication. No one is tasked with building shared, end-to-end solutions.
* There is a desire and a sense of urgency in the community—they want to work together.
* Structural issues of the profession and funding models prevent effective collaboration.
* The community supports the creation of a coordination structure, but the actual implementation needs more work.

Possible models include:

* Coordinating committee to identify and prioritize critical software infrastructure for the benefit of the astronomical community;
* Inter-agency program office to oversee policy and funding;
* A new organization to support the development of tools; and
* Multi-site federated organization that serves as a layer on top of the existing facilities.

Rizzi says there is an end-to-end ecosystem comprising software tools and standards. Single-mission and joint-infrastructure funding are inadequate models. There is community support for a coordinating structure, perhaps with core engineering pool with distributed network. There could also be a multisite federated organization.

Next steps are:

* **Phase 0:** Discussion and engagement to achieve buy-in; this is what they are currently doing with AAAC.
* **Phase 1:** Drafting a report (nearly finished), engagement, discussion, and presentation to achieve buy-in from funding agencies.
* **Phase 2:** NSF and NASA should empower and fund a small steering committee with requirements (governance, use cases, etc.). Phase 2 agencies prepare for the implementation of plan delivered in Phase 1.

## Q&A on the Astronomical Data Infrastructure Workshop Report

McCarthy asks about the role of private partnership. Everyone is dealing with data, so how do you balance agency players with companies that want data? Rizzi responds that they believe private partnerships are fundamental, that it’s an effort from everyone. There’s no reason to limit participation from certain players. There are foundations that are eager to help, and they have the means and interest.

Lundgren asked about tech companies such as Amazon, Google, Meta, and Nvidia. Was there a decision not to involve them, and is the agency talking to people at those companies with parallel interests? Rizzi responds that it requires a level of maturity that the program doesn’t have yet. On the technical side it’s fine, but we need to develop the vision first.

Black pivots to the next presentation.

## NASA Presentation on Data Science, Data Management, and Infrastructure

Roopesh Ojha (NASA) presents slide with title: “Explore Solar System and Beyond: Data to Science—Data management and Infrastructure.”

Ojha says open science is the principle and practice of making research products and processes available to all while respecting diverse cultures, maintaining security and privacy, and fostering collaborations reproducibility and equity.

The goal is for everybody who is interested and wants to do this to be involved from the beginning. It’s not a top-down process. There is a ground swell from the community to pursue these goals.

Open-source science is NASA’s method of practicing open science. This method aims to:

* open the entirety of the scientific process from start to finish;
* broaden community involvement;
* increase accessibility of data, software, and publications; and
* facilitate inclusion, transparency, and reproductivity.

Four pillars of open science include:

* Policy and governance
* Core data and computing services
* Open Science initiatives
* Community engagement

NASA community engagement goals include:

* Support 20K researchers to earn NASA’s open science badge.
* Double the participation of historically excluded groups across NASA science.
* Enable five major scientific discoveries through open science principles.

### NPR 2210 Case Study

Ojha presents a slide that reads, “NPR 2210 approved: Release of NASA software.” He mentions this is a success story for civil servants who want to create software.

Highlights of updates related to Science Mission Directorate (SMD) include:

* Software developed solely for scientific publications will be treated as other science and technical information, and NPR 2210 is not applicable.
* When appropriate, projects can go through the software release process at the start and then be fully developed in the open.
* Additional licenses than NOSA can be used—consult with OGC on appropriate issues.
* NASA personnel can contribute to work-related open-source projects with approval from their manager.

### Scientific Information Policy

Ojha explains SMD’s updated scientific information policy is SMD Policy Document (SPD) 41a. It is forward-looking (it will apply to all future SMD-funded projects), and it consolidates other existing policies. SPD-41a includes the following major policy updates:

* Peer-reviewed publications are made openly available with no embargo period.
* Research data and software are shared at the time of publication or the end of the funding award.
* Mission data are released as soon as possible and unrestricted mission software is developed openly.
* Science workshops and meetings are held openly to enable broad participation.

Ojha discusses slide titled “Open-Source Guidance,”which contains the following information**:**

* Narrative guidance on how to comply with SPD-41a, including options and examples.
* High-level for relevance across SMD divisions.
* Adopts guidance published by other agencies.
* Living document to be developed over time.
* Contains:
	+ Background and motivation
	+ Open science and data management plan
	+ Sharing publications
	+ Data management and sharing
	+ Sharing materials for science events
	+ Glossary of open-source science terms

Ojha presents a slide titled “Astrophysics Scientific Information Management Policy.” He clarifies details of the implementation of SPD-41a to the scientific information produced by astrophysics division-funded activities and provides guidance through the information lifecycle, from measurements to curation and sustainment.

Ojha says the approach should couple with SPD-41a and avoid repeating material covered there. Minimalist approach avoids being too prescriptive. They are building on recommendations from the SMD strategy for data management and computing for groundbreaking science 2019-2024, government directives, NASA policy, community best practices, studies by academies, and community-led studies. There should be minimal compliance burden; work must add value.

### Data Analysis Landscape in 2030

Ojha says large datasets are on the way, so the astrophysics archive capabilities must improve. Data volumes in astrophysics archives double roughly every two years. Sets are on the way from Euclid, Roman, Rubin Observatory, etc. We're only beginning to get big, multi-wavelength data. Astronomy requires analyzing data sets jointly. Science often requires analyzing data along with simulations. Archives, for historical reasons, are generally differentiated by the wavelength that they observe in the era of multi-messenger astronomy. Advanced data science tools will also be necessary, such as AI and machine learning.

Astrophysics Science Platform has three components:

1. Cloud-based interface and supporting system rooted in open-source software, providing compute resources proximate to the data (low-latency access)
2. A rich collection of notebooks and pre-configured software containers for multi-wavelength and big-data science
3. Advanced data services that enable fast, location agnostic services for data held on the platform, in NASA Astrophysics archives, and beyond.

There is also an interest in talking more with community users. These are scientists needing server-side analysis for large amounts of data, those needing computational facilities for big data analytics, and machine learning collaborators at different institutions wishing to share a computational environment with scientists who cannot easily build the software they want to use. These are some of the constituencies NASA will be serving.

### SMD Core Services

Ojha says core services include existing and new capabilities that are reusable by all divisions. Core services include:

* ROSES SPD-41 Compliance
	+ Research data and software archives
	+ Independent FAIR assessments
* Hybrid cloud computing environments
	+ Cyber security
	+ Baseline capabilities such as egress optimization, deep archival user self-registration and usage metrices, data transfer services
	+ Account management, billing, cost management (CM), and notifications
* Discount (egress, storage, and processing)
* Publicly available collaboration tools (GitHub, Jira, Slack)
* Scientific information/knowledge management
* Open-source science training

### Scientific Data and Computing Architecture

Ojha presents a slide titled, “SMD RFI: Scientific Data & Computing Architecture to Support Open Science-I.” Lessons from the slide include:

* Request produced 75 usable responses from a range of players.
* They addressed NASA scientific data and computing architecture, cloud infrastructure, high performance, computing open science, software tools and training, and user support.
* Broadly suggested we should enable authorized users to easily collaborate access and share information. Both data and software accommodate users with a range of expertise levels.
* Cloud computing requirements include:
	+ Efficient cloud data services,
	+ Ability to quickly and easily share data and software, and
	+ Easy access to tools and libraries for authorized users.

Ojha continues to discuss a slide titled “SMD RFI: Scientific Data & Computing Architecture to Support Open Science-II.” Highlights from his presentation include:

* Cloud onboarding and training:
	+ It is critical for NASA to use cloud computing services.
	+ Resources should be comprehensive and targeted towards a range of users.
* Astrophysics Community responses emphasized:
	+ Data sharing
	+ Developing open science data and computing infrastructure that will continue to support existing activities of astrophysics data archives that are critical to collaboration and discovery.
	+ Increasing accessibility of computing services

Ojha ends his presentation and invites questions from the committee.

## Q&A on Data Science, Data Management, and Infrastructure

Mike McCarthy asks about new data policy: Is it unique to the astrophysics director, or is that something across NASA overall? Ojha says the SPD-41a is across everybody, but each division has its own guidance. They have different communities to serve. He explains that he was referring to his division’s policy, but each of these policies is consistent with the stated guidance.

McCarthy asks a follow up question about how Ojha will collaborate with colleagues at NASA and NSF. Ojha responds that he and Luca organized the workshop he just presented on, and the TDAMM conference in Tucson. The two of them are going to conferences and are trying to make sure that they can create uniform standards, having the right metadata. The hooks are there so that different things come together. Ojha shares an anecdote about two big federal agencies who couldn't compare fingerprints because they had completely different formats. This is the kind of silly situation they're trying to avoid when they respond to how best to do software.

Lundgren asks about use cases: Are you starting with a few relatively simple use cases and then scale them up? How will this process evolve here in your mind strategically? Ojha responds that there are very clever and forward-looking people in the different archives. Before they get dumped together, there have been different degrees of work on different sets of use cases by the archives, which they are fully exploiting right now. Some of them have taken a step-by-step approach, and they are in the process of putting it all together. There is a family of use cases, some of which probably need to be tested. There are already people testing things, seeing how they're working. Internally, there are people setting up a process. There will be an architecture review.

McCarthy suggests everywhere could use this kind of help. He says the need is scale independent of the institution. He addresses representation, as it is important not to miss out on work by researchers from different backgrounds.

## DOE Presentation: Data Management, Archiving, Standards, & Accessibility

Next there is presentation is on work performed by Bryan Field, Kathy Turner, and Christopher Jackson from the DOE, titled “DATA to Science: Data Management: archiving, standards, and accessibility.”

Bryan Field begins his presentation by stating HEP is considered a case study for large data. In 2018, the Large Hadron Collider (LHC) collected more than 115 petabytes (PB) of data in total. Data was recorded to tape, peaking at 15.8 PB total in November of 2018. That's a huge amount of data volume split out amongst tiered data centers. The European Council for Nuclear Research (CERN) is Tier 0. Tier 1 includes computing centers and seven locations. Data then flows on to Tier 2 institutions, and so forth, as it's processed beyond the volume of data.

Field next references plots on graphs on the slide that show the vast amounts of data recorded on tape by CERN month-to-month. This data must be considered in terms of volume, the rate at which it's produced, and where things are computed. Data volumes are so great they aren’t moved around we just use the resources to compute them where they’re residing.

### DOE Optimized Supercomputing Facilities.

Field discusses optimizing the use of supercomputing facilities. These facilities create, analyze, archive, and serve some of the largest data sets. His plan is to go through some of the data sets they are working with.

High-Energy Physics Center for Computational Excellence (HEP-CCE) is a DOE HEP collaboration of four national labs, six HEP experiments, and 4 HPC centers. HEP-CCE addresses the development and implementation of HEP scientific applications on next-generation computing, storage, and networking systems. Its current focus is to develop common strategies to efficiently run HEP software applications on a pre-exascale and exascale high-performance computing systems that will shortly be deployed by at Advanced Scientific Computing Research (ASCR) computing facilities.

Field adds DOE has a long history of funding projects that have successfully created, analyzed, archived, and served some of the largest scientific datasets ever created. They have a small part in the Alpha Magnetic Spectrometer (AMS). This is a large international collaboration which includes DOE and NASA. AMS is a small instrument on the space station that collects cosmic rays.

Field describes a slide showing a picture of the inside of a small particle detector. The Fiducia volume is a little bit smaller than that, and it was launched in 2011. It has been sitting on the space station ever since and is planned to sit there until 2028 or whenever they stop servicing the space station.

Members of the collaboration have unrestricted access to this data, Field explains; otherwise, data are read out every 23 minutes as the station orbits Earth. This thing collects about 700 K events that are then beamed down to the earth several times a day. Data are transmitted down through White Sands, then shuttled over to the Marshall Space Flight Center in Alabama. Then some of the data is left at NASA for archiving, and some of it is sent off to CERN for processing.

Field says AMS collects data at about ten megabytes per second (Mbps), and that comes up to about forty terabytes (TB) worth of data per year, and they have so far collected about twenty, 2.5 PB of total data. This experiment started in 2011; R & D started nine years before that. This experiment predates modern data management policies. Right now, they make public all the data that they need to make their graphs, but the raw data will not be released until one year after the termination of the experiment.

McCarthy asked about the maximum downlink speed. Field says the question may get answered later in the presentation. AMS has collected about 225B cosmic rays so far and they are reconstructed inside of a particle detector.

### FERMI Gamma ray Space Telescope/LAT (Large area telescope.)

Christopher Jackson continues the DOE presentation, stating NASA is responsible for the Fermi Gamma-ray Space Telescope (FGST) mission. DOE led the fabrication (managed by SLAC) of the LAT, the primary instrument on Fermi, in partnership with NASA and with contributions from international partners. The LAT detects gamma rays of energies from 20 MeV to over 300 GeV. After launch, DOE led the LAT Instrument Science Operations Center at SLAC. In the last few years, the ISOC has been carrying out critical roles at SLAC.

Jackson says DOE basically runs the operation center at SLAC; holds on to the data; and handles the data processing, hosting, and archiving. The LAT collects data continuously like the space station does. And there it is stored temporarily on the spacecraft, and then it uses the high-speed downlink previously discussed. That happens about fifteen times a day.

Data analysis tools are provided with data to members of the LAT Collaboration and to the public. Those tools can be installed on computers and data can be downloaded from servers for local analysis. LAT Collaboration members can also use installed tools and data on SLAC computers.

All photon data are made public as quickly as possible after collection on the LAT, generally within a few hours of being taken. The LAT collaboration has access to all LAT data including and beyond the photon data. Other data products made public are measurements of detected celestial transient sources, light curves of known bright variable sources and detected source catalogs. Public data releases are continuous, released as quickly as possible after processing or publication for source catalogs.

### LuSEE-Night Collaboration

Jackson next describes a DOE-NASA collaboration led by DOE’s Brookhaven National Lab (BNL) and the Space Science Laboratory (SSL) at UC Berkeley. BNL is a DOE-led institution. SSL is the overall leading institution.

DOE is responsible for the main instrument and sponsors some equipment. NASA is responsible for integration, thermals, and overall systems engineering.

LuSEE-Night will be delivered to the far side of the Moon on a future commercial lunar payload services (CLPS) flight. The vendor is Firefly Aerospace, and the launch is currently scheduled for late 2025.

Data is limited by the available download volumes from the Moon and are modest by modern standards.

Raw data will be ~6–10 GB per lunar cycle, so over 18 months, the total dataset will still be under 200 GB (smaller than two video games). Collaboration will be about 20 people when data collection is complete. They will mostly use their own computer resources, and there is no plan for a dedicated allocation given the modest data volumes.

NASA requires data to be public 6 months after data collection. The collaboration plans regular 6-month data releases. Initially these will be limited to basic data products; at end of the mission, the collaboration will release everything, including simulations.

During the probationary period, data will be otherwise limited to Science Collaboration members. The modest data volume will be served via the web. Data will be available on the website for the foreseeable future.

### CMB-S4 Draft Plans

CMB-S4 is a proposed next-generation experiment to study cosmic microwave background radiation. This joint DOE/NSF project aims to provide high-resolution maps of the CMB, which can help us understand the early universe, the formation of structures, and the nature of dark matter and dark energy.

Draft plans for the CMB-S4 project include the following key elements:

* Deploy multiple observatories at different locations, including the South Pole, Chile, and possible other sites. These observatories will house large arrays of telescopes and detectors to capture the CMB signals.

Develop advanced detectors and focal planes to improve the sensitivity and resolution of the observations. These instruments will be designed to operate at extremely low temperatures to minimize noise and maximize signal detection.

* Establish a robust data processing and analysis pipeline to handle the large volumes of data generated by the observatories. This will involve developing sophisticated algorithms and computational tools to extract meaningful scientific information from the CMB data. It is expected to use resources at NERSC and individual members own computing resources.
* Foster collaboration among scientists, institutions, and international partners. It will provide opportunities for researchers from different backgrounds to contribute to the project and share their expertise.

The primary science goals of the CMB-S4 project include studying the inflationary epoch, measuring the properties of dark matter and dark energy, and investigating the nature of neutrinos. The project also aims to explore the potential for detecting primordial gravitational waves, which can provide insights into the early universe.

DOE and NSF are building challenge data sets and simulations, the first of which is expected to be released sometime during the next calendar year.

### Dark Energy Survey (DES)

DES is a collaborative effort, led by NSF and DOE, involving scientists from over 25 institutions worldwide. The collaboration includes astronomers, physicists, and other researchers who work together to analyze the data and interpret the results.

DOE funded the Dark Energy Camera (DECam), which were led by FNAL. NSF funded the telescope upgrades, which were led by the Cerro Tololo Inter-American Observatory (CTIO), as well as the data management systems. The collaboration is in the middle of final data processing and key project analysis.

The primary objective of DES is to understand the nature of dark energy, which is believed to be responsible for the accelerated expansion of the universe. By studying the distribution and properties of galaxies, supernovae, and other cosmic structures, DES hopes to learn more about the underlying physics of dark energy.

DES covers a wide area of the southern sky, spanning about 5,000 square degrees. This large survey area allows for the study of a significant number of galaxies and the measurement of their properties.

DES uses DECam, which is a powerful digital camera mounted on the Blanco 4-meter telescope at CTIO in Chile. DECam is designed to capture high-resolution images of the night sky, enabling detailed studies of galaxies and other celestial objects.

The data was processed at the National Center for Supercomputing Applications (NCSA) and the University of Illinois at Urbana-Champaign (UIUC) computer cluster. The data processing involved using the Fermilab pipelines, which are specialized software tools designed for analyzing astronomical data. Fermilab has plans to handle the responsibility.

The NCSA and UIUC computer cluster provided the computational resources needed to handle the large volumes of data generated by the DES. These resources allowed for the processing and analysis of the data, including the application of various algorithms and techniques to extract meaningful scientific information.

The pipelines used in the data processing were specifically developed for the DES project and tailored to unique requirements. The data was approximately 80 terabytes in size. This release represented about 2% of the full data set available at that time, which was estimated to be around 4 PB.

### Rubin Observatory

The Rubin Observatory is a partnership between NSF/DOE. Rubin is the observatory, and LSST is the data set. Different groups work with that data set. The LSST data set is expected to be vast, and it will be utilized by various research groups for different scientific investigations.

The observatory is expected to produce about 20 TB of data per night, or about 30 PB per year after processing. After 10 years of up to about 300 PB, that’s LHC-style data. This will all be piped through the US data facility at SLAC. They're supposedly going to be public alerts within 60 second of transient events for people to come in on, and because of that, they're using LHC tools for data workflow.

The LSST is projected to produce around 20 TB of data per night, resulting in approximately 30 PB of data per year after processing. Over a span of 10 years, this could accumulate to about 300 PB of data. The LSST data will be processed and managed using advanced data management platforms such as Panda and Rouscio.

The LSST data will be hosted and served through the US Data Facility, primarily via cloud resources. The plan is to host between 5,000 and 10,000 science users via Google Cloud, while the rest of the data will be served through the US Data Facility via the Rubin Science Platform. Additionally, there will be 12 independent data access centers located in the US and Chile, providing immediate data access to researchers with data rights.

The LSST data will be made available to the public at least two years after its collection. After a proprietary period, the data will be released in manageable subsets, allowing for easier access and analysis. External data centers, such as NOIRLab, may also serve as repositories for the LSST data.

### Legacy Survey of Space and Time/Dark Energy Science Collaboration (LSST/DESC)

Within the LSST survey, there is a specific group called the Dark Energy Science Collaboration (DESC). DESC is a collaboration of scientists and researchers who focus on studying dark energy, which is one of the key science drivers of the LSST project. Dark energy is a mysterious force that is believed to be responsible for the accelerated expansion of the universe.

The DESC collaboration works with the LSST dataset to conduct research and analysis related to dark energy. Images and catalogs have been released for Data Challenge 2 (a simulation of the LSST survey). Photometric LSST Astronomical Time series Classification Challenge (PLAsTiCC) and Extended LSST Astronomical Time-series Classification Challenge (ELAsTiCC) Simulated time domain data are also currently available.

DESC serves its public data via its National Energy Research Scientific Computing Center (NERSC) data portal and Community File System (CFS). NERSC serves as the primary data storage and archive facility. Long-term archiving is planned to be done via NERSC HPSS tape storage.

Alyson Brooks mentions theDOE has a history and strategy of releasing big data sets publicly. She asks about individual investigators and the policies DOE has in place for them.

Field responds that while there are individuals involved in Cosmic Frontier, he can't think of anybody that his agency is funding who isn't part of a collaboration.

End of Day 1 Meeting.

# Day 2

## Introduction and Agenda

Mitch Ambrose, (Director of Science Policy, News, and Analysis at the American Institute of Physics) introduces himself and discusses the agenda for his budget presentation. His presentation is on the macro budget outlook for FY 2024 and the trends affecting the overall federal budget. He mentions the publication called FYI which focused on the mechanics of the federal budget process as it applies to science agencies. He encourages the audience to explore the resources on their website.

Ambrose discusses the key people for science funding, including NSF, NASA, and DOE. He talks about the specific science budget proposals on the table for FY 2024 and the historical data that can provide insights into future funding. He mentions the FYI website, which provides resources and a budget tracker web page for the community. He highlights the importance of staying informed about the budget process and advocating for science funding priorities.

### FY 2024 Budgets

Ambrose discusses funding sources and the budget outlook. Congress has approved large amounts of money for applied research and technology development through several bills. DOE and NOAA were the main beneficiaries of these funds. The CHIPS and Science Act provided $54B for semiconductor initiatives. There are also ambitious targets for increasing the NSF budget over five years.

Ambrose references concerns about federal deficits and debt, particularly in relation to funding for astronomy and astrophysics. The reconciliation process enabled certain laws to be passed, but there are disagreements between House Republicans and Democrats regarding funding cuts. The Senate has advanced several spending bills, exceeding the cap that was set.

There is uncertainty about the path forward, with fears of a potential government shutdown. Ambrose mentions the possibility of a short-term extension. He discusses the CHIPS and Science Act and addresses questions about whether automatic increases or decreases would occur if no budget is passed. The defense budget is also mentioned as an area that people would not want to cut. He says Chuck Schumer is interested in following up on how CHIPS could apply to other technology areas.

The US and China are increasing research budgets, particularly in strategic technology areas. Ambrose says the CHIPS and Science Act is a key factor in funding priorities, but astronomy is not explicitly included. There are concerns about the budget deficit and the likelihood of Congress meeting the Science budget targets set in the CHIPS and Science Act.

Ambrose notes potential interest in technology competition and a proposed AI research initiative. The budget outlook for three agencies involved in astronomy funding is discussed. The Office of Science has a relatively favorable budget outlook. The House proposed flat funding for the Office of Science, and the Senate proposed a 4% increase. NSF and the NASA Science Mission Directorate both face funding challenges. The House proposed a 2% cut and the Senate a 4% cut to NSF. Likewise, the House proposed a 5% cut and the Senate a 6% cut to the NASA Science Mission Directorate.

Ambrose relays concerns that the Mars sample return mission may be cancelled due to cost overrun. Money has been diverted from other science divisions to keep the mission on track.

Ambrose presents slides with the key Congressional leaders for science agencies such as NSF and NASA. He notes that Chuck Fleischman was appointed Chair of the House Subcommittee for Energy and Water Development, and Related Agencies. This may have helped the DOE Office of Science.

Ambrose presents the [NSF Budget Tracker](http://ww2.aip.org/fyi/fy2024-national-science-foundation) and discusses the proposed budgets for FY 2024. NSF requested for a significant increase in funding, he says, and House and Senate proposals aren’t coming close to meeting this request. The Major Research Equipment and Facilities Construction (MREFC) account is highlighted as important for funding major projects. NSF’s astronomy budget is flat, but the final numbers could be significantly different.

He presents a chart from the website that lets users toggle between fiscal years and shows more of a breakdown of the budget details.He relates concern about proposed cuts in funding for astronomy and astrophysics. The difficulty of moving past proposed cuts and the flat cap that has been set are mentioned. There is a mid-scale research infrastructure that has been funded for a few years and the committee's belief that there may be a request for an increase in funding for it.

Ambrose addresses a question about the Decadal recommendations and how they relate to the budget. The money would have to be requested by NSF, or Congress could award them funding.

The high luminosity LHC upgrade is nearing its end, while the Antarctic program is facing turmoil due to COVID restrictions and unspent funds. The budget outlook for the Antarctic program is uncertain, which may be influencing the Senate's decision to allocate lower funding.

### Funding Mechanisms

Ambrose highlights the importance of the Research and Related Activities and the MREFC accounts, respectively, for building new telescopes in the context of the Decadal Survey.

Ambrose explains the funding process for scientific research in the United States, specifically in the fields of astronomy and astrophysics. Requests for funding typically go through the MREFC account, and they have a high likelihood of being funded by Congress. The trade-offs between the science program and the human exploration program in NASA are also mentioned. Senate support for the facility operations transition program includes support for Decadal planning of up to $30M for design and development.

* MREFC Requests $305M.
* Senate proposes flat funding of $187M.
* House proposes increase to $254M.

### Allocation of Funds for Different Divisions

Ambrose discusses the allocation of funds for different divisions, specifically focusing on the Astronomy and Astrophysics Advisory Committee and the Office of Science. The lack of a dedicated construction account for the DOE is mentioned, as well as the budget projections provided by NSF for the Antarctica project and the mid-scale infrastructure program.

Funding and budget outlooks for astronomy and astrophysics facilities are discussed. The Senate is aware of the high operations costs and provides support for Decadal planning. The NSF has allocated funds for the design and development of facilities in Astra. NASA fully funds the technology maturation program and suggests separate budgeting for it in the future. The DOE provides little direction for high energy physics but mentions specific projects.

## Q&A on the FY 2024 Budget

Carrie Black asks if the current name of the agency is the Office Multidisciplinary Activities or the Office of Strategic Initiatives. Ambrose explains that the Office of Strategic Initiatives is the new name.

Zoran Ninkov (NSF) asks how interested Congress is in the success of Technology, Innovation and Partnerships (TIP). Ambrose replies that he is unsure. There was a big fight between the House and Senate over the TIP Directorate, and they reached a compromise. The Senate proposal was much more technology focused and used this new directorate to derive forward ten specific technology areas. The House (specifically the Science Committee) didn't like the idea of putting that type of focus within NSF, and it fought for more broadly increasing the agency budget and not having TIP be so focused on technology. They built in other focus areas to get broader buy-in. It's hard to know how much the appropriators themselves are deeply invested.

Ambrose responds to a question about NSF’s MREFC appropriations history and major equipment funding. Ambrose does not have a definitive answer, but he explains the graph is mostly to fund the leadership class facility to push the top line of funding higher than it’s been in years, which makes it hard to fund other things.

Ambrose addresses concerns about proposed cuts to education and engagement programs at NSF and NASA. He expresses concern about the projected cuts and wonders about the conversation surrounding those cuts. He mentions the potential impact on STEM education and engagement initiatives and expresses a concern that diverting funds from education to other areas could have negative consequences. He says he’d be shocked if a large cut went through.

Carrie Black asks about 2019 at the MREFC when there was a significant difference between the requested and appropriated funds for the MREFC. The requested amount was low, and the actual appropriation was higher, with a spike in funding. The specific reasons for this difference are not mentioned in the text.

McCarthy expresses surprise at the lack of a long-term timeline for government agencies, such as NASA and the Smithsonian, to communicate and announce their plans for construction. These agencies typically have a well-defined timeline for their projects, with NASA and the Smithsonian cited as examples. There’s not a wedge for new initiatives. There is some back and forth about this. There is confusion about who makes the different requests when the size and scope of projects are unknown.

Chris Davis says NSF has a very strict process to get something onto the MREFC that hasn’t passed through the stage yet it needs to pass through, to be put on to the queue.

There is a question about NASA funding requests.

Another member states that when they give presentations, they say they have a process where they show out years, and it's a plan to request. But each agency just does this slightly differently.

Valerie Connaughton explains that they have a five-year run-out, but the five-year run-out can change year by year because they get an appropriation every year. There is a planning budget, and an execution budget, and there are guidance numbers every year that may revise the out years. They must fit all the all the projects; all the missions have budgets.

McCarthy asks about the out-year budget. Ambrose replies that NSF is planning to 2029. The agency doesn’t have everything it needs to see what the budget shortfalls will be.

Chris Smith addresses questions about budget projections. There are also projects that they can’t divulge the contents of, so there is tension between showing folks the challenges faced. He also discusses the CHIPS Act. There is back and forth about challenges facing NSF projects and quantifiable and qualitative info. Large projects create three main challenges: they impact construction costs, design development, and operations.

In response to a question about why the Senate and the House seem to not be enthusiastic about NASA’s budget, Ambrose provides two theories: (1) the Artemis initiative has a huge budget, which could be forcing a tradeoff; and (2) the Mars sample return dynamic might have affected the top-line budget, because they are not providing as much funding for MSR.

Ambrose ends the presentation.

## Physics of the Cosmos Program (PhysCOS) Office Overview

Brian Humensky (NASA) presents the agency’s progress and updates in the field of TDAMM astronomy. He mentions the Astronomy 2020 Decadal Survey identified time-domain and multi-messenger astronomy as the highest priority sustaining activity in space. He discusses the importance of infrastructure development, funding for theoretical studies, and coordination between NASA, NSF, and international agencies.

Humensky highlights the findings from the white paper on TDAMM astronomy, which emphasized the need for real-time cyber infrastructure, theoretical funding, training for a diverse workforce, coordination between NASA and NSF, and continuity of capabilities across the electromagnetic spectrum.

Humensky also discusses the ongoing Physics of the Cosmos Program Analysis Group's work on TDAMM astrophysics, including the formation of a new TDAMM Science Interest Group (SIG) and several Science Analysis Groups (SAGs) to gather community input. Humensky mentions the upcoming special issue of the journal *Frontiers of Astronomy* and *Space Sciences*, which will include the revised white paper as a review article.

### NASA TDAMM Workshop White Paper

Humensky says the white paper addresses a wide range of science questions. These questions include probing dark energy and dark matter, studying explosive transient events driven by white dwarfs, neutron stars and black holes, mapping the Milky Way and the local volume, and using phenomena as tools to probe fundamental physics, cosmology, and dense forms of matter.

Humensky emphasizes there is an enormous amount of science opportunity in time-domain and multi-messenger observations, and that these observations can help answer important questions about various astrophysical phenomena. The white paper recognizes the need for theoretical funding to support studies that focus on new phenomena and provide direction for observational efforts. It also highlights the importance of coordination between observatories and agencies to optimize observing schedules and share data.

### PHysCOS TDAMM Study & Astrophysics Cross-Observatory Science Support (ACROSS)

Humensky explains the PhysCOS TDAMM study aims to investigate ways to streamline the implementation and coordination of NASA space-based missions. The study is divided into three phases, with the first phase focused on investigating options for a general observer facility and the subsequent phases examining coordination between NASA missions and ground-based facilities in the United States, as well as international facilities. This study led to the creation of the ACROSS pilot initiative.

Humensky mentions the ACROSS pilot initiative is starting up in the fall, and it aims to facilitate the planning and execution of time-domain science cases across the entire NASA fleet. The emphasis in the pilot program is on developing tools and infrastructure to streamline coordination between observatory science teams and observers, with the goal of prioritizing science cases and providing funding for observers to analyze their objects.

### Physics of the Cosmos Program Analysis Group (PhysPAG) Initiative

PhysPAG is a community analysis group that focuses on high-energy astrophysics, cosmology, and multi-messenger astrophysics. A new time-domain and multi-messenger astrophysics (TDAMM) Science Interest Group (SIG) has recently been formed. Humensky explained that PhysPAG is one of three program analysis groups (PAGs) that provide a platform for community-led discussions and interactions with NASA, along with those focused on cosmic origins (COPAG) and exoplanet exploration (ExoPAG).

Humensky highlights that PhysPAG serves several objectives, including establishing and disseminating best practices for conducting pre-time-domain astronomy, addressing issues related to sharing and citing data, and providing analyses and reports to NASA headquarters on specific topics. PhysPAG also plays a role in coordinating with other analysis groups and providing input for future missions and programs.

### Gamma-ray Transient Network, Science Analysis Group (SAG)

SAG, chaired by Eric Burns and Michael Coughlin, studies the science topics enabled by studies of gamma-ray phenomena, particularly those related to magnetars, compact mergers, and cosmic collapses across electromagnetic, gravitational wave, and neutrino spectra.

The SAG's objective is to identify the instrumental capabilities required to study these science topics and to propose actions to improve the science return. They have delivered a 70-page report to NASA headquarters, which analyzes the multi-disciplinary science questions and explores the instrumental capabilities needed to achieve the desired scientific outcomes.

The SAG also focuses on maximizing the use of the Interplanetary Network (IPN) for scientific purposes and explores ways to enhance its capabilities for time-domain and multi-messenger astronomy. The group is actively working on developing their terms of reference and planning a kickoff session at the upcoming meeting.

### TDAMM Space Communications Analysis Group

This group is focused on studying the requirements imposed by time-domain and multi-messenger astrophysics on commercial communication systems, particularly those that will replace the current Tracking and Data Relay Satellite System (TDRSS) satellites starting in 2030.

The group is examining a wide range of issues related to these requirements, including different orbits, bandwidth requirements, latency, coverage, and availability. Their objective is to deliver a report to NASA April 2024, which will provide recommendations and insights on how to optimize the communication systems for time-domain and multi-messenger astronomy.

### Future Innovations in Gamma Rays (FIG) SAG

Humensky makes several points about the Drivers of Future Gamma-ray Astrophysics:

* This project is focused on identifying the science drivers for future gamma-ray missions at all size scales, ranging from pioneers to probes and flagships, over the next five to twenty years.
* The objective is to study the science topics enabled by gamma-ray astrophysics and to explore the instrumental capabilities required to achieve the desired scientific outcomes. This includes studying the science questions related to gamma-ray phenomena and understanding the instrumental requirements to address these questions.
* The SAG is currently in the process of developing their terms of reference and planning a kickoff session at an upcoming meeting. Their work will contribute to shaping the future of gamma-ray astrophysics and guiding the development of future missions in this field.
* The group’s kickoff session will be held at the 243rd American Astronomical Science (AAS) meeting in January 2024.

### NASA attendance at Gravitational-Wave Agencies Correspondents (GWAC)

Humensky mentions NASA's participation in the Gravitational-Wave Agencies Correspondents (GWAC) committee in his presentation. Valerie Connaughton, the NASA TDAMM lead, has begun attending the GWAC telecoms to stay updated on the developments with gravitational wave observatories. The GWAC committee focuses on discussing the schedules, configurations, sensitivities, and other relevant aspects of gravitational wave observatories.

NASA's participation in the GWAC committee is expected to be very helpful in terms of staying informed about the progress and advancements in gravitational wave research. This information is crucial for NASA's mission planning, as it allows them to align their observatories' capabilities and wavelength coverage to maximize their ability to respond to gravitational wave events and conduct follow-up observations.

Humensky ends the presentation and invites question.

## Q&A on the PhysCOS Presentation

Humensky responds to a question about specific interaction with NSF: There's a number of activities, but in his flow chart there were twenty-six. Are Phase 2 TDAMM follow-up capabilities starting in about a year? Humensky says the study period where they try to initiate discussions with NSF and observatory facilities to try to understand areas they could streamline would start this fall. They’re attending a workshop at NOIRLab in October. The idea is to start exploring those opportunities over the next year. By next summer or next fall, they hope to start developing a study phase over the next year, then go into a development phase of whatever capabilities need to be developed beginning in FY 2025. Capabilities would become available in 2026 and 2027.

In response to a question about funding sources and what agencies are working together, Humensky explains the role of SLAC and DOE in funding LSST. He clarifies that when he said that NSF was funding it he wasn’t speaking broadly enough. Valorie says the following speakers will address this topic.

Britt Lundgren requests clarification on community workshops and joint proposal opportunities.

Valerie Connaughton responds that it was a wish list from the community, not an actuality. They recognize that TDAMM is an area of science that crosses funding agencies, and that crosses the boundaries between space and ground. Part of the interest in the workshop that their lab is holding next month is to see how it might work and how communities are working together, whether agencies support them, and to look at ways to follow up on that finding in the paper. There are currently no joint funding opportunities. They might find solutions other than joint funding to support joint communities.

## Vera C. Rubin Observatory: Ushering a New Era of TDA

Federica Bianco (Deputy Project Scientist, Rubin Observatory) provides an overview of the observatory's goals and structure. Her first slide is titled, “Vera C. Rubin Observatory and the legacy of space and time.” She says she will discuss Rubin’s contribution to time domain astronomy in general.

Bianco explains the observatory is designed to be explicitly transformational in four areas of science: probing dark energy and dark matter, taking an inventory of the solar system, mapping the Milky Way and the local volume, and exploring the transient and variable universe. She mentions the construction and operation of the observatory, the role of science collaborations within the ecosystem, and the data policy that aims to provide open access to data for the scientific community.

### Structure of the Rubin Community

Bianco highlights the various components and teams within the organization, including the construction project team and the operations team. She also mentions the science collaborations that are part of the Rubin ecosystem and their role in contributing to the scientific goals of the observatory. Bianco emphasizes that the Rubin Observatory does not have its own science team, but rather delivers data to the US and international communities through in-kind contributions. She also mentions the importance of coordination and collaboration among stakeholders to protect dark and quiet skies and to ensure the dissemination of information and resources.

The Rubin LSST (Large Synoptic Survey Telescope) collaboration works with various organizations and institutions. Some of the key collaborators include:

* Dark Energy Science Collaboration (DESC) studies dark energy and dark matter using LSST data.
* Solar System Science Collaboration (SSSC) studies objects within our solar system, such as asteroids, comets, and planets.
* Transients and Variable Stars Science Collaboration (TVS) studies transient and variable astronomical phenomena, such as supernovae, variable stars, and active galactic nuclei.
* Galaxy Science Collaboration (GSC) studies the properties and evolution of galaxies using LSST data.
* Strong Lensing Science Collaboration (SLSC) studies the gravitational lensing effect and its applications in cosmology and astrophysics.

Bianco says the Dark Energy Science Collaboration is the only science collaboration that receives funding for delivering science from the DOE. Many of the other science collaborations within the Rubin ecosystem do not have a single official funding source. Instead, they rely on a combination of grants, donations, and in-kind contributions from various organizations and agencies. Bianco reiterates the importance of supporting the community and providing resources for training a diverse workforce, enabling access to data, and supporting preparatory work to maximize the potential of the Rubin Observatory.

### Science Collaborations and Science Teams

Bianco states there are eight teams across five continents within the Rubin Observatory ecosystem. Each collaboration focuses on a specific area of research, such as dark energy, solar system science, transients and variable stars, galaxy science, and strong lensing.

While the exact number of members collaborating with the Rubin LSST project may vary, the science collaborations have a significant number of members. There are over 1,800 members and more than 2,000 affiliations within the science collaborations. These members come from various institutions and countries, forming a large and diverse community of scientists working together to analyze LSST data and contribute to scientific discoveries.

Bianco emphasizes the importance of science collaborations and science teams within the Rubin Observatory ecosystem. She explains that these collaborations and teams are essential for optimizing the scientific output of the observatory and advancing research in various areas.

The science collaborations within the Rubin ecosystem are organized based on scientific expertise and interests. These collaborations focus on specific areas of research, such as dark energy, solar system science, transients and variable stars, galaxy science, and strong lensing. They consist of members from different institutions and countries who work together to analyze LSST data, conduct research, and contribute to scientific discoveries.

The science teams within the observatory are responsible for self-organizing and working on specific scientific projects. They consist of members with expertise and interest in particular areas of research, contributing to the optimization of the observatory's scientific goals.

### Transformational Science Pillars

The Rubin Observatory is designed to be explicitly transformational in four areas of science, which Bianco refers to as "science pillars." These pillars are:

1. Probing Dark Energy and Dark Matter—studies dark energy and dark matter, which are believed to make up a significant portion of the universe.
2. Taking an Inventory of the Solar System—involves mapping and studying objects within our own solar system, such as asteroids, comets, and planets. The goal is to gain a comprehensive understanding of the solar system's composition, dynamics, and history.
3. Mapping the Milky Way and the Local Volume—studies the structure, composition, and dynamics of our own galaxy, the Milky Way, as well as nearby galaxies. The goal is to create a detailed map of the Milky Way and its neighboring galaxies, providing insights into their formation and evolution.
4. Exploring the Transient and Variable Universe—studies transient and variable astronomical phenomena, such as supernovae, variable stars, and active galactic nuclei. The goal is to understand the physical processes behind these phenomena and how they evolve over time. This pillar also includes the study of time-domain astronomy, which involves observing and analyzing changes in astronomical objects over different timescales.

### Project Timeline

The points on the timeline for the Rubin Observatory project, as discussed by Bianco, are as follows:

1. First photon—The anticipated date when the observatory will capture its first light, which is expected to occur in July 2024.
2. System first light—Approximately 18 weeks after the First Photon, when the entire system of the observatory is expected to be fully operational and producing scientific data.
3. Start of survey—The beginning of the survey phase, which is estimated to commence approximately 6 weeks after System First Light. During this phase, the observatory will systematically observe the sky and collect data for scientific analysis.

### Time-Domain Data

Bianco discusses time-domain data products of the LSST, including:

* Prompt data products—Real-time alerts that are generated when LSST detects any significant change or transient event in the night sky. These alerts are sent out within 60 seconds of the detection and provide information such as the location, brightness, and other relevant details of the event.
* Data releases—LSST will periodically release catalogs that contain comprehensive information about the observed objects in the sky. These catalogs will include measurements of various properties such as position, brightness, color, and variability for millions of stars, galaxies, and other celestial objects.
* Templates—Reference images of the sky that are used for image subtraction and the detection of transient events. LSST will gradually build up a library of templates to improve the accuracy and efficiency of detecting and characterizing transient phenomena.

### Data Policy and Access

Bianco discusses data policy and access issues related to the Rubin Observatory project, such as:

* Public access—The data policy is designed to be public and accessible to all users in the United States. The goal is to make the data available to the entire scientific community and enable broad participation in the scientific discovery process.
* Data products—Collection includes prompt data products, catalogs, and alerts. However, not all data products will be available for immediate download due to the enormous size of the collection. Efforts are being made to design a human science platform that allows users to access and analyze the data efficiently.
* International collaboration—This includes communities that have acquired data rights through in-kind contributions. These collaborations involve discussions about data access and rights, as well as the sharing of software and resources.
* Survey commissioning data—ongoing discussions and document production regarding data access, rights, and policies for the survey commissioning data. This data is separate from the regular survey data and has its own considerations and complexities.

LSST data will increase enormously. Bianco estimates the Discovery engine will produce ten million alerts a night in the astronomy discovery chain. These alerts include ten thousand super luminous supernova, fifty thousand tidal disruption events, one million quasars, and a thousand supernova that will be present in the data every night. The observatory is expected to detect and observe around 10,000 supernovae during its survey, it will study approximately 50,000 Tidal Disruption Events (TDEs). The observatory will also be able to detect and study a significant number of kilonovae.

### Scientific Advancements

Bianco discusses the advancements in photometric classification of transients, which refers to the process of classifying transient events based on their light curves and photometric properties, without the need for spectroscopic observations. This approach has had a profound impact on time-domain astronomy, as it allows for the classification of transients without relying on spectroscopic data.

Bianco mentions the Dark Energy Science Collaboration's PLAsTiCC Challenge, which aimed to advance photometric classification techniques. This challenge led to significant advancements in the field, enabling the classification of transients to a high degree of accuracy using light curve analysis. Bianco presents a confusion matrix for a classifier that won the PLAsTiCC Challenge. The confusion matrix shows the classification performance, with numbers around the diagonal indicating successful classification. This demonstrates the effectiveness of photometric classification in accurately identifying different classes of transients. Photometric classification techniques have been applied not only to supernovae but also to other types of transients, such as variable stars and gravitational wave counterparts. The ability to classify transients based on photometric data alone has expanded the scope of time-domain astronomy and enabled the study of a wide range of phenomena.

### LSST Survey Design

Bianco notes there was significant involvement of the community in the optimization of the survey design for the Large Synoptic Survey Telescope (LSST). The LSST survey design was developed in close collaboration with the scientific community. The community has been actively involved in providing input, feedback, and recommendations throughout the process. The LSST Science Collaborations, which consist of various research groups, have played a crucial role in the optimization of the survey. They have provided valuable insights, simulations, and recommendations to ensure that the survey design meets the scientific goals and priorities of the community. LSST Science Collaborations have also organized workshops to discuss and address specific aspects of survey optimization. These workshops have provided a platform for the community to come together, share ideas, and contribute to the refinement of the survey design.

The community involvement in survey optimization includes experts from various fields, including astronomers, data scientists, statisticians, and software developers. This diverse expertise has been instrumental in addressing complex challenges. Survey optimization is an iterative process, and the involvement of the community ensures that the survey design is continuously refined and improved based on scientific priorities and technological advancements.

Bianco notes the LSST survey design was funded through a combination of government funding from agencies like the NSF and DOE, private donations, and international partnerships.

Given the resource-intensive nature of time-domain astronomy there are several key development needs for Time Domain Astronomy (TDA).

### Workforce Development

Bianco emphasizes the need for support in training a diverse workforce in TDA. This includes providing opportunities for individuals from various backgrounds to participate in the scientific discovery process and contribute to TDA research. She states it is important to ensure the workforce is equipped with the necessary skills and knowledge to effectively analyze and interpret time-domain data.

Bianco also highlights the importance of recognizing the technical contributions of individuals involved in TDA research. This includes data scientists, software developers, and managers who play critical roles in processing and analyzing time-domain data. Finding ways to credit and acknowledge their contributions is essential for their career advancement and the overall success of TDA projects.

Coordination and collaboration between different agencies, observatories, and international partners is important, she says. This includes optimizing observing schedules, sharing data and alerts between observatories, and maintaining continuity of capabilities across the electromagnetic spectrum. Improved coordination can enhance the efficiency and effectiveness of TDA research.

The resource-intensive nature of TDA research creates a need for robust infrastructure and data management systems. This includes developing software tools, data repositories, and communication systems to facilitate data sharing, analysis, and collaboration among researchers.

Laboratory data should complement and enhance observational data in TDA research. Bianco suggested convening a panel of experts to identify the needs for laboratory data and explore new approaches and programs for building the requisite databases.

## Q&A on the Rubin Observatory

Ann Zabludoff asks about the challenges in the intra-agency collaboration era: when will the templates be available for imaging? Bianco says they will build the templates as they go and deliver alerts. After year one they’ll have two templates and five images, and they’ll select the best images to make the best templates. Rubin may run the first year with a modified template; after year one, alerts will be released as templates are developed and become available.

Mike McCarthy asks about the error bar on ten million alerts that are expected every night. He wants to know how confident Bianco is in her estimate. Bianco replies that the number comes from scaling from the cursive survey. There are assumptions, and she does not feel comfortable providing the error bar. However, she does not believe the error would be an order of magnitude. It’s a rule of thumb, but they don’t know exactly.

There is a follow-up question about whether artifacts will include known variable stars. Bianco replies that it will, though there is some discussion about how rapidly variable stars drop. The questioner notes there are many surveys, and Bianco notes the different surveys.

Wenda Cao asks about teams and data and collaborations. Bianco references the data policy that was mentioned earlier in her report. She reiterated the data rights to the Rubin data project collection, including international data rights. The data are enormous, and Rubin is designing a platform for easier usage.

Bianco ends the presentation.

## Multi-Messenger Astronomy (MMA) Coordination Workshop

Jennifer Andrews (Gemini Observatory, Hilo) delivers a presentation titled “Windows on the Universe: MMA Coordination Workshop.”

Andrews notes there will be a new era of multi-messenger astronomy encompassing neutrinos, gravitational waves, and cosmic rays.

Andrews mentions the Windows on the Universe workshop, which focuses on MMA coordination. She discusses the importance of effective coordination and collaboration among different observatories and agencies to optimize the use of resources as they come online. The workshop addressed the challenges and lessons learned from previous multi-messenger astronomy campaigns and the need for training a diverse workforce in this field. There is also an upcoming workshop and its goals in terms of infrastructure development, data analysis, and coordination among different observatories.

Andrews states that the 2017 detection of gravitational waves was a significant event in the field of multi-messenger astronomy, as it was the first detection of a gravitational wave counterpart. This was very exciting, and interest was generated by this detection and the subsequent follow-up observations. Data from this event was used in writing papers and contributed to scientific advancements in the field. Since then, there have been additional LIGO runs.

Andrews says her team faced challenges due to the lack of coordination and communication among different groups involved in the follow-up observations. Resources could have been used more effectively. She presents a localization map of lessons learned:

* The localization of events was challenging due to the lack of coordination and communication among different groups involved in the observations. This led to delays and limitations in accurately pinpointing the location of the events.
* There were fewer events than expected, which impacted the ability to gather sufficient data for analysis and scientific advancements.
* There is a need for collaboration and coordination among different observatories and research groups. Andrews emphasizes the significance of sharing data, resources, and expertise to improve the accuracy and efficiency of localization efforts.
* A robust infrastructure is needed to support current and future challenges in multi-messenger astronomy. This includes the development of software tools, data repositories, and communication networks to facilitate collaboration and data sharing.

### Motivation: New Challenges

Andrews mentions the importance of coordination and prioritization of science goals in the context of multi-messenger astronomy. She acknowledges that there are challenges in determining the most interesting and scientifically valuable targets for follow-up observations, as different people may have different opinions on what is interesting. She also highlights the need to coordinate follow-up observations to avoid redundancy and optimize the use of resources. Additionally, she mentions the importance of fostering collaboration within the multi-messenger astronomy community and ensuring that the field reaches its full potential over the next decade.

There are challenges in characterizing multi-messenger astronomy (MMA) events. Andrews highlights the need for comprehensive and coordinated observations across different wavelengths and messengers to gather sufficient data for characterization. She emphasizes the importance of sharing data and resources among observatories and research groups to improve the accuracy and completeness of characterizations.

Andrews also mentions the importance of real-time data analysis and prompt dissemination of information to facilitate follow-up observations and maximize the scientific potential of MMA events. She acknowledges that characterizing MMA events requires a combination of observational data, theoretical modeling, and collaborative efforts from the scientific community.

Andrews highlights the importance of developing standardized methods and protocols for data analysis and interpretation to ensure consistency and comparability across different observations and studies.

### Results from TDAMM Meeting 2022

Andrews says there was high community involvement and an unexpected interest in infrastructure discussion and coordination among ground and space, multi-messenger and electromagnetic, and NASA, NSF, and the community.

### MMA Workshop Details

The Windows on the Universe workshop will be in Tucson in October. This workshop will discuss infrastructure solutions and the future of all-messenger astronomy. It will involve panel discussions, breakout sessions, and active conversations among participants to address current challenges and strategize for the future.

The three-day-long workshop is in collaboration with NASA and aims to review the current state of follow-up resources, report on existing collaborations and partnerships, and identify potential obstacles to success in MMA campaigns.

Organizers hope to establish a roadmap to solve the identified obstacles with FY 2024 funding. The workshop will produce a community-driven white paper that will be made available for comments and then submitted to NSF and NASA for the FY 2024 planning.

Andrews shared key questions for the upcoming workshop:

* What are the challenges and obstacles to successfully perform MMA campaigns and maximize their scientific potential; how can the community overcome those obstacles through strategic planning and infrastructure development?
* How should we coordinate follow-up efforts to reduce operational redundancy across the network of ground and space observatories, ensuring efficient use of resources and avoiding duplication of observations?
* How can we foster collaboration in the MMA community, promoting effective communication, data sharing, and coordination among different observatories and research groups?
* How do we ensure the MMA field reaches its full potential over the next decade, identifying strategies and initiatives to advance the scientific goals and maximize the scientific return of MMA campaigns?

Andrews goes over the agenda for the conference. It will be very infrastructure driven, focusing on the discovery of the objects. Invited speakers and panelists will include junior and tenured professors from small and large institutions, so that there's a good representation of the community working on MMA. There will be about one hundred in-person participants. They wanted to keep it small so they could have more effective conversations. There are a few virtual attendees registered, but the virtual registration is open for another week or two, so there will probably be more.

There will be a lot of international attendees from Canada, UK, Australia, and all over the world. Many are remote. All attendees will contribute to a community-driven white paper, which isa key product that will be generated from the MMA conference. The white paper will serve as a guide for future NOIRLab planning and will be made available to the community for comments. It will then be submitted to NSF and NASA, and ultimately included in the AAAC report. The white paper will address challenges, potential obstacles, and recommendations for the MMA field, with the aim of maximizing its scientific potential over the next decade.

Andrews highlighted the importance of gathering input and feedback from the community to inform decision-making and prioritize science goals. She mentions the use of questionnaires and surveys to collect information from the community and the efforts to streamline the feedback received into actionable recommendations.

There are limitations in terms of resources and funding, and prioritization is necessary. There is a need to discuss and determine how to best allocate resources to maximize the scientific potential of multi-messenger astronomy. She also highlights the importance of considering the needs of different projects and missions, as well as fostering collaboration and coordination among funding agencies to address resource constraints and optimize the use of available funding.

## Q&A on the MMA Coordination Workshop

Kathy Baron asks a question regarding the availability of resources to follow up on interesting scientific findings in the field of astronomy. Baron asks about the prioritization process and whether there are enough resources to pursue all the interesting research ideas or if there is a need to prioritize certain projects over others. She wants to know if there was a consensus among the community on the priorities and what may not be as interesting or deserving of follow-up.

Andrews mentions the community plays a significant role in determining the allocation of resources through proposal submissions. She also acknowledges there may be cases where certain projects may not receive as much attention or resources due to various factors such as feasibility or community interest. She emphasizes the importance of strategic planning and collaboration to ensure the best utilization of available resources.

Martin Still poses a question that he says should go for all the agencies. From an NSF perspective, he says, there are big resource questions. One is how to best support multi-messenger in time domain astronomy with their grants programs. NSF is hoping to focus on ground-based coordination in future versions of the Windows on the Universe program, which is up for renewal right now. They want to lobby renewal with the MPS director. They will be taking the report from this workshop and using that to strategize, prioritize, and encourage the community to put in strategic proposals into a future call.

Secondly, Still adds, this report will help them strategize how to best organize infrastructure and services within and determine how much focus do we put on time domain and multi-messenger astronomy, and how much effort do we put into supporting that community to deliver the science? And then, thirdly, what are the right focus points to attack problems jointly with the other agencies? How can they work together potentially to find funding resources together, or to strategically work together to solve some of these tricky problems. He notes Valerie and Brian mentioned joint guest-observer facilities and the ability to get awarded observing time on space and ground-based observations simultaneously.

Still notes that NSF does some of that awarding already, but probably needs to take a much deeper and more thoughtful look at that going forward. Not that it's not a brilliant thing to think about and talk about and plan for, but it goes well beyond time-domain, astronomy as well, and there'll be a much broader impact, or if you start talking about this, but we must do that.

There is a related question about the relative balance between more traditional observations and time-domain approaches to line surveys. What fraction is time-domain, especially as these surveys become more sensitive? It's there where most of the time could be devoted to those time domains.

Still says this is a good question for Jennifer Andrews from NOIRLab, but it’s going to be different for each facility. He says it will be a long and complex analysis. The answer is likely going to be different for every facility, and we need to be strategic for each one. Certain facilities are loaded with instrumentation to support ground-based astronomy, but others are not. Still remarks that this is going to be a long and complex analysis and strategic plan.

Andrews says people put in proposals, and the community decides where, what, and how the time is allocated. It's not necessarily a NOIRLab decision. At this point it’s what the community decides. The time should be spent on what the community decides is a high priority. They have to think about what the facilities are most optimized for, but also listen to what the community is most interested in.

The committee breaks for lunch.

## Satellite Constellations: Dark and Quiet Skies Update

Ashley VanderLey (NSF) delivers a presentation about how the large number of satellites might affect astronomical observations.

VanderLey addresses several issues in her presentation. She says the committee will hear a lot more from Connie Walker and others. The context of all of this is that constellations of thousands of NGSS Satellites are coming our way, such that from any location on Earth, you're always going to see at least one, and probably up to three or four satellites or more, depending on your field of view and the type of telescope being used. A new concern is how the aggregation of a large number of smaller satellites could have an impact. Other concerns include mobile telecommunications, cell phone satellites, and potentially high-altitude platform systems.

The Dark and Quiet Skies test has had quite a response to some of the new spectrum challenges. In the last couple of years, they have officially broadened the scope of the Electromagnetic Spectrum Management (ESM) unit to include the optical infrared impact. The other important thing is that they do have a funding program because they recognize that to catalyze the kind of research in Congress, they might need to mitigate these impacts and that does require funding and resources. This program, the Spectrum Innovation Initiative, was in place in 2020. That is also an important response to the spectrum challenges— that the community does have resources.

### ESM Staff Updates

VanderLey gives an ESM Unit Staff update: She will be doing a detail in in MPS that will help with the transition. But they will have a team of four people working on spectrum issues:

* Jonathan Williams: Williams is Chair of the NSF/ESM Coordination Group.
* John Tapen: Tapen is primarily responsible for important and critical work on spectrum science and the Spectrum Innovation Initiative, and a lot of R&D.
* Joshua Redding: Redding is a bestseller who joined last week. He comes from North Carolina, and he has a great interest in helping NSF solve the satellites challenge.
* Sarah Marie Bruno: A new assistant research scientist at Johns Hopkins, Bruno will be working a large portion of her research time helping on some of these challenges, especially the impact of satellites, and also the impact on opticals and satellite constellations. She has done work with the WES compass.

VanderLey welcomes Josh Redding and Sarah Bruno. She says NSF has grown the team because this is a challenge that needs a lot of effort and focus.

### NSF-ESM Coordination

VanderLey mentions the NSF-ESM Coordination Group. She states how important it is that there’s a representative from every directorate. There may be opportunities in engineering or computer science or in the geosciences where together they can contribute. She mentions some of the funding opportunities that come out of this group.

* The increasing number of satellite constellations and their potential impact on astronomy observations, particularly in the optical and infrared domains.
* The need for coordination agreements between satellite operators and the astronomy community to mitigate interference and protect scientific observations.
* The challenges of radio frequency interference and the importance of establishing quiet zones and best practice guidelines for satellite operators.
* The potential impact of supplemental coverage from space on radio and cellular bands, and the need for input and comments from the community on this issue.
* The importance of bridging the digital divide and providing broadband access, while also mitigating the impact on astronomy observations.
* The role of the International Telecommunication Union (ITU) and the United Nations Office of Outer Space Affairs in addressing space sustainability and radio frequency spectrum management.
* The ongoing work of the NSF Spectrum Innovation Initiative and the coordination efforts with other agencies and organizations to address spectrum challenges and support research in the field.

### Spectrum Challenges

The NSF’s response to new spectrum challenges includes several initiatives and actions. Ashley VanderLey mentions:

* Broadening the scope of the NSF’s electromagnetic spectrum management to include optical and infrared impacts, in addition to radio frequency impacts.
* Establishing the Spectrum Innovation Initiative, a funding program aimed at catalyzing research and development to mitigate the impacts of spectrum challenges.
* Working on coordination agreements with satellite operators to address interference issues and protect scientific observations.
* Increasing the NSF’s team working on spectrum issues, including the addition of new personnel dedicated to spectrum management.
* Engaging in research and analysis to understand the impacts of satellite constellations and develop strategies for mitigation.
* Collaborating with international organizations like the International Telecommunication Union (ITU) and the United Nations Office of Outer Space Affairs to address spectrum management and space sustainability issues.

### Satellite Constellations

NSF is funding and supporting workshops and research on the impact of satellite constellations, particularly in the optical and infrared space. The workshops focus on mitigating the impact of satellite constellations on optical guides and lasers used in telescopes.

Coordination agreements with satellite operators are important to ensure the protection of scientific observations and mitigate interference.

The NSF Coordination Group and the broader team within NSF are aware of the challenges posed by satellite constellations and are working on addressing them.

The NSF participates in international efforts, such as the United Nations Office of Outer Space Affairs and the Committee on the Peaceful Uses of Outer Space, to address the impact of satellite constellations on optical, infrared, and radio frequencies.

VanderLey discusses radio regulation in her presentation. She highlights the importance of the radio frequency spectrum for satellite communication and transmission. Satellites rely on radio transmissions for communication purposes, and the availability of radio frequency spectrum is crucial for their operation. The International Telecommunication Union (ITU) is the international body responsible for regulating the use of radio frequencies. The ITU establishes regulations and guidelines for the allocation and use of radio frequency spectrum to ensure efficient and equitable access for different users, including satellite operators and astronomers. Coordination agreements play a large role in addressing radio interference issues between satellite operators and the astronomy community. These agreements aim to find mutually acceptable solutions to mitigate interference and protect radio astronomy observations. A database of radio quiet zones around the world has been established. This database provides information to satellite operators to help them avoid pointing their transmissions at radio telescopes and minimize interference.

### Importance of Allocations and Coordination

VanderLey explains there is a need for spectrum allocations to ensure that different users, including satellite operators and astronomers, can coexist without interference. This involves assigning specific frequency bands for different purposes and establishing guidelines for their use. Coordination agreements between satellite operators and the astronomy community are important. These agreements aim to mitigate interference and protect scientific observations. They involve discussions and negotiations to find mutually acceptable solutions that minimize the impact on astronomy observations. She mentions the importance of international coordination, particularly through organizations like the International Telecommunication Union (ITU) and the United Nations Office of Outer Space Affairs.

### Radio Astronomy Protections

Radio astronomy observations rely on specific frequency bands to detect and study celestial objects. These bands are carefully allocated and protected to minimize interference from other sources, such as satellite transmissions or terrestrial communication systems. Radio quiet zones are designated areas where radio interference is minimized to facilitate sensitive radio astronomy observations. Coordination agreements are established between satellite operators and the radio astronomy community to address potential interference issues. Efforts are made to mitigate the impact of satellite transmissions on radio astronomy observations. International organizations play an important role in establishing regulations and guidelines for radio astronomy protections.

### Interference and satellite streaks

VanderLey says interference levels can vary in radio astronomy observations. While international recommendations permit up to a two percent data loss in the radio astronomy band, there can still be peak losses of up to twenty-six percent in certain parts of the sky. She emphasizes that even with protections in place, there will still be some impact on science in the radio astronomy band. She also questioned at what point satellite transmissions may interfere with observations and cause a nuisance, and highlights the need to determine when satellites are faint enough to be easily mitigated.

Satellite streaks have an impact on ground-based astronomy, particularly in terms of the number of satellites and their distribution. Satellite streaks can affect different types of telescopes, with wide-field telescopes being more significantly impacted. VanderLey also mentions the efforts being made to mitigate the impact of satellite streaks, such as designing satellites with reduced reflectivity and working towards reducing their optical brightness. Additionally, there is a need to understand the specific details of satellite brightness and the ongoing work to predict and characterize satellite streaks.

To mitigate the impact of satellite streaks, several measures can be taken. Satellite operators can implement design changes to reduce the reflectivity and optical brightness of their satellites. This can include using dielectric films, tilting solar panels, and making other modifications to minimize the amount of light reflected to Earth. Satellite operators can enter into coordination agreements with observatories and astronomy communities. These agreements involve sharing information about satellite positions and trajectories to help observatories plan their observations and avoid satellite streaks.

Additionally, VanderLey explains, efforts can be made to reduce the brightness of satellites, particularly during twilight hours when they are more visible. Observatories can develop algorithms and software tools to detect and remove satellite streaks from their images. Continued research and development efforts can focus on understanding the behavior and characteristics of satellite streaks, as well as developing new technologies and techniques to mitigate their impact on astronomical observations.

### NSF and SpaceX Radio Spectrum Coordination

VanderLey says coordination agreements have been established between NSF and SpaceX regarding radio spectrum coordination. She highlights that these agreements include technical limits and recommendations to mitigate interference between satellite transmissions and radio astronomy observations. She also mentions that SpaceX has made efforts to reduce the impact on radio astronomy by implementing design changes and testing in the field. However, she notes that there is still ongoing work to ensure that coordination agreements are followed and that the impact on radio astronomy is minimized.

NOIRLab and Dark and Quiet Skies developed a list of best practices, guidance, and recommendations which were lifted from the Dark and Quiet Skies report and put directly into the coordination agreement. SpaceX has agreed to work towards reducing their optical brightness by both physical design changes. They use some dielectric films, painting, and other design changes to reduce optical reflection. The solar panel is not perpendicular; it is a little bit tilted and larger, so that it doesn't cause as much reflection back to the earth. Also, they are working towards keeping an orbital elevation of seven hundred kilometers or lower, and providing high accuracy information to astronomers. All of this was agreed to. There was a good back and forth, and SpaceX is working on implementing these ideas in their designs.

### Optical Coordination now required in FCC authorization.

VanderLey discusses the Federal Communications Commission (FCC) authorization of coordination agreements for satellites and mitigation efforts. The good update is that, since February, this requirement for optical coordination has become part of SpaceX's authorization. Similar requirements exist for Amazon Kuiper and One Web. All the big satellite companies have this requirement to coordinate and then to report back to the FCC whether or not they’ve reached the coordination agreement, as well as what steps they’ve taken to help mitigate for optical astronomy. Amazon Kuiper is launching two satellites around mid-October: one is going to have mitigations, and one will not. The Dark and Quiet Skies team hopes they’ll be able to see the impact, and then they'll learn from those initial two launches and hopefully make changes before they launch a lot more satellites. It's fantastic to already see that collaborative approach.

Dark and Quiet Skies are also initiating agreements with other smaller companies, including ICEYE and Planet Labs. Amazon must come up with a mutually beneficial agreement as approved by the FCC. Since August, the FCC has issued two more authorizations for smaller satellite companies where they're also requiring the coordination agreement. This is ICEYE and Salt Lab combined. VanderLey thinks they will have 200–300 satellites total—a much smaller set. But with a lot of these smaller constellations, the average amount could be a lot. It's very similar language to what you saw in the Amazon Kuiper authorization, but they must work to coordinate a mutually acceptable agreement, mitigate the impact and then report back to FCC.

### Overall Scientific Impacts

VanderLey says there's a lot of different things that satellite operators can do. Dark and Quiet Skies continually encourages operators to find ways to make our telescopes more robust. That's where the R&D programs fit. This year there was solicitation focused entirely on satellite code systems. The terrestrial system proposals and they are still expecting a couple more awards to be made as part of this, but more information will be forthcoming when they can share it.

### SWIFT-SAT solicitation included impact of satellites on astronomy.

VanderLey discusses NSF's Satellite-Terrestrial Coexistence (SWIFT-SAT) solicitation (NSF 23-567). Proposals for this funding opportunity were due May 11, 2022. On the international front, VanderLey highlights the optical, infrared, and long-term sustainability questions are largely handled by the United Nations Office of Outer Space Affairs (UNOOSA), and especially the Committee on the Peaceful Uses of Outer Space (COPUOS).

There has been some great effort to stand up an agenda item and an expert group. VanderLey hopes to see momentum growing in that regard on the radio side. She thinks this is important. She reiterates that the whole reason we have these satellites in orbit is because of the radio transmission. This is a good place to continue to work. Her team is focused on radio communication services and transmissions.

NSF has put together a proposal that was submitted to the U.S. process. It was approved and then sent to region two. All region-two countries approved the proposal, encompassing South America, Central America, North America, and the Caribbean.

This proposal will be going to the radio communication summary. VanderLey says the proposal will create a database of radio quiet zones around the world. The purpose is to provide information to satellite operators more easily to be able to know where the media quiet zones are. Who do we contact, and how can we voluntarily avoid pointing transmissions at those radio telescopes? This does not provide any additional protection, but VanderLey thinks considers it a good first step for getting some international recognition. She hopes it can be done quickly at the Radio Communication Assembly, which is a one-week meeting right before the big-four TV conference which actually makes changes. It's a much longer process.

**Summary**

VanderLey summarizes her presentation with the following points:

* NOIRLab, AAS, and the Rubin team have been critical to establish technical limits for us to put in coordination agreements (e.g., 7th magnitude, provision of telemetry, preferential choice of lower orbit) continued assessment of targets is helpful.
* What will be scientific impacts resulting from the increasing number of satellite operators and their constellations? This information is helpful.
* FCC has done an excellent job at taking expressed concern into account in authorizations, requiring coordination agreements.
* Coordination agreements with satellite operators, such as SpaceX, Amazon Kuiper, and OneWeb, are being established to outline mitigation measures and minimize the impact on optical astronomy.
* Ongoing efforts are being made to ensure that coordination agreements are followed and that the impact on scientific observations is minimized.
* The United States supports an international agenda and expert group at UN COPUOS for establishing best practices.

### Upcoming Opportunities

VanderLey highlights several upcoming opportunities. There is a potential rule making on supplemental coverage from space where satellites provide direct tier, mobile phones. A number of bands are under consideration. She is highlighting this information for folks on the AAAC who might see science of interest in the 600, 700, and 800 MHz bands. There are also a couple of opportunities in the 1800–2400 MHz range.

NSF is aware of several experiments that use these bands. Of course, VLA and Green Bank are observing these bands as well. She asks for any comments from the community on what or how this could impact their work, and what they are really looking to see.

VanderLey asks whether NSF can we establish new quiet zones. Can we establish some kind of dynamic sharing so that we don't lose the band forever if these bands become direct to cell? She wants to highlight these bands. These are all currently cellular bands. In the National Radio Quiet Zone there are cell towers that use these bands, and about 1300 cell towers have all been carefully coordinated in the quiet zone, so they don't provide too much interference to the Green Bank Telescope (GBT).

VanderLey says we don’t want to see those transmissions coming from above in a way that we're currently protected. NSF is providing comments back to the FCC, especially concerning radio. There will be optical impacts if a lot more satellites start providing direct to cell, and they need a larger satellite. This is just something to keep an eye on, and NSF would appreciate input from the committee.

VanderLey concludes with a slide on bridges and the digital divide. She reminds astronomers that one of the leading reasons that the satellite companies exist is to essentially close the gap in terms of broadband. In places like Africa, over ninety percent of the population is needs to find access to broadband. That's the big motivating factor. She asks whether that is something we want to be sensitive to, in terms of whether the satellites are a nuisance. She asks whether they are something we want to mitigate.

VanderLey refers to a rule-making process that would establish regulations or guidelines for satellite systems providing direct-to-cell coverage from space. The specific details and scope of this potential rulemaking are not provided in the given context. It would require further information to understand the specific objectives and implications of this rule-making process.

### Bridging the Digital Divide

Access to broadband is extremely import. Non-geostationary orbit satellites (NGSOs) will bridge the gap and help solve problems for astronomy while satellite companies are helping others access the internet.

VanderLey concludes by thanking the International Astronomical Union Centre for the Protection of the Dark and Quiet Sky (IAU CPS), the Committee for the Protection of Astronomy and the Space Environment (COMPASSE), the Committee on Radio frequencies, and the National Academies. She praises all the scientific papers that the community has written which have really been helpful in weighing into these coordination agreements.

## Q&A on the Dark and Quiet Skies Update

Britt Lundgren asks about the seventh magnitude agreements. When will that be reached? When is that practical? VanderLey mentions the goal of reaching seventh magnitude agreements in coordination agreements with satellite operators. She says satellite operators have been working towards reducing their optical brightness and implementing design changes to mitigate the impact on astronomy. The progress towards reaching seventh magnitude agreements will depend on the efforts and advancements made by satellite operators in implementing these changes and meeting the agreed-upon targets.

Mike McCarthy asks VanderLey to clarify what is required and what is desirable as far as regulations on coordination agreements. VanderLey says the coordination agreement with SpaceX was required for the radio astronomy very strict technical limits in the tiny little band 10.68 to 10.7. But when NSF wrote the coordination agreement, they added a voluntary section of optical goals. This is also an issue, and it wasn't required initially in their agreement. As all of this was being raised to the FCC, their next license got changed. So, the authorization does now require that SpaceX meet the optical section requirements, which is now required.

VanderLey continues to explain the radio and the optical are both required sections of the agreement. For Amazon Kuiper, the frequencies they're looking at are not adjacent to radio astronomy bands. The whole radio coordination is voluntary for them, and the obstacle is the requirement of their authorization. The agreement does not have technical limits that have been widely agreed upon—like at the International Telecommunication Union (ITU) or the UN Committee on the Peaceful Uses of Outer Space (COPUOUS). She says 6.5 is a limit everyone can achieve. Is that limit strict like between 6.1 and 6.2? It picks a limit everybody can achieve. This is where the language is still pretty soft. NSF is encouraging satellite operators to take steps to reach this target, and they want to see progress towards it.

VanderLey hopes we will reach a point where we'll be able to provide a much stricter technical limit where we expect it to be 6.0. This has been the strict limit that NSF put into the technical requirements for satellites. But at this point, operators are committing to make good-faith efforts and to report back that they're taking this step. Optical coordination is now required for Amazon Kuiper, SpaceX, and the new ICEYE.

McCarthy asks, regarding satellite launches, what relevant properties does the Dark and Quiet Skies program coordinate with that would be relevant to what could impact NSFs facilities? VanderLey replies that her team originally focused on the largest constellations, so they put a cut-off if a constellation had more than 300–400 satellites. They weren't initially concerned but have started to pay attention to the aggregate. They are not going to worry about the one-offs.

McCarthy asks how long the mitigation measures might remain. He remembers that at least SpaceX was exploring ways to reduce reflectivity. He asks whether VanderLey has more information about that effort. Because even if they're required to meet some standard for launch, he says, is that something that they're required to maintain—or could the satellites brighten and cause a problem for everyone?

VanderLey says operators would be required to maintain the standard as well. At this point, she doesn’t think we have enough data to see if the paint degrades over time. There is a black paint that they put essentially on curved parts of the satellite, and then all the flat parts they put in a dielectric film to essentially move the light off in the direction away from Earth. Those materials degrade some over time, but she reminds the committee these satellites only have a lifetime of about 5–7 years. She says we don't have a lot of data because these are mitigations that they've just been launching in the last year or so. But it’s important to continue making observations. Her team doesn't just observe immediately; they also do observations throughout the life cycle to ensure any mitigations are being maintained.

Carrie Black reminds everyone to state their names for the record. She says Connie and Bob will go back-to-back and then Q & A.

VanderLey ends her presentation.

## Current Deployment Status of Low Earth Orbiting (LEO) Satellites

Connie Walker (Co-Director IAU CPS and Head of NSF’s NOIRLab Office of Observatory Site Protection) presents on the deployment status of LEO satellites.

Walker introduces herself and her agency, stating there are currently ~7,700 active satellites in low-Earth orbit. She highlights the deployment status of SpaceX Starlink satellites, which account for over 4,600 of the active satellites. There is provisional permission from FCC to operate 42,000 satellites. There are many other companies planning to launch satellites, and the number of satellites requesting licensing could reach tens or even hundreds of thousands by the end of the decade. Walker presents a graph showing the increase in the number of objects in Earth’s orbit.

### Impact on Dark Skies

Walker notes the increasing number of satellites in low Earth orbit, particularly during twilight hours, can have a significant impact on the visibility of stars and other celestial objects. She explains that while not all satellites will be illuminated at any given time, the sheer number of satellites can still be a concern. She also highlights the efforts of the International Dark Sky Association and other organizations in raising awareness and advocating for the protection of dark skies. The goal is to coordinate efforts and unify voices across the global astronomy community, industry, and wider stakeholders to protect dark skies and minimize the impact of satellite constellations.

Walker discusses the simulation of 70,000 satellites in low Earth orbit. The simulation considered the number of satellites between 5–17 degrees above the horizon, and it did not take any mitigations into consideration. In this worst-case scenario, the simulation projected that there could be about 5,000 satellites above the horizon at any given time, with approximately half of them being visible. Only a few hundred or thousand would be illuminated at the same time, but the sheer number of illuminated satellites could still have a significant impact on the night sky.

Walker says different telescopes would be affected in different ways and to different degrees. Narrow field telescopes such as Gemini and Keck could see about 10% of frames affected at twilight. Wide-field telescopes such as Blanco could see 50% of frames impacted with several satellites per frame. Super-wide-frame telescopes such as Rubin could see every frame with multiple satellites.

**IAU CPS Mission and Organization**

Walker introduces how IAU CPS is coordinating efforts and unifying voices of the global astronomical community. The center is bringing together astronomers, industry, and the wider community. It acts as a bridge among all stakeholders to protect dark and quiet skies. They are producing and disseminating free and open information and resources to all stakeholders, not just astronomers.

Walker presents an organization chart for IAU CPS, including the following leadership roles:

* Piero Benvenuti, Center Director
* Connie Walker, NOIRLab Co-director
* Federico DiVruno, SKA Observatory (SKAO) Co-director

### Walker also mentions contributing and affiliated members, executive and steering committees, and an advisory board. There are four hubs, which aren’t siloed: SatHub, Policy Hub, Industry and Technology Hub, and Community Engagement Hub.

### SatHub

Walker also discusses the IAU CPS hubs. She says the co-leads for SatHub are Meredith Rawls, Siegfried Eggl, and Mike Peel. She explains SatHub is organized under the IU Center for the Protection of Dark and Quiet Skies from Satellite Constellations. SatHub is referred to as CPS’ data exchange. It facilitates observation campaigns in both the optical and radio domains. The hub also develops software tools and data repositories for observers to optimize their observations and avoid satellite interference. Additionally, SatHub collaborates with space situational awareness data providers to improve orbital solutions and ensure accurate satellite tracking.

Walker lists SatHub achievements on a slide. Achievements include the successful organization of two observation campaigns: BlueWalker 3 and Starlink Gen 2. These campaigns are important for modeling the brightness behavior of satellites. There is a BlueWalker 3 paper coming out in *Nature* magazine. SatHub has improved company contacts with space situational awareness data providers and satellite operators. They are also developing software for predicting passes.

### Policy Hub

Walker introduces the Policy Hub co-leads Richard Green and Andy Williams. She explains the Policy Hub is actively engaged in raising awareness and advocating for strong requirements in space policy-making circles. The hub’s four main goals are as follows:

1. Raising awareness of the impact of satellite constellations on astronomy and advocating for policies that address these concerns.
2. Collaborating with national societies and searching for ways to influence policy work performed by them.
3. Addressing policy issues related to infrared and optical observations, similar to the work done for radio spectrum management processes.
4. Facilitating proposals for new regulations (in coordination with national points of contact) on impact assessments, launch requirements, design requirements and on-orbit policies.

Walker mentions Policy Hub achievements include:

* Drafting a position paper and organizing town halls to solicit feedback from the community to gather input and perspectives on policy issues related to satellite constellations and their impact on astronomy.
* Streamlining recommendations from previous workshops to make them more digestible and actionable.
* Conducting comparative analysis of national policies, international law, and other multinational instruments to understand the current landscape and identify areas for improvement.
* Drafting Conference Room Paper submitted to COPUOS delegations proposing the creation of a UN Expert Group.
* Creating in-roads to future mitigations of harm such as cislunar policy.

### Industry & Technology Hub

Walker introduces co-leads Chris Hofer and Tim Stevenson, as well as adviser Patricia Cooper. She explains the Industry and Technology Hub conducts three main tasks:

* **Outreach**: Enlist satellite constellation operators, manufacturers and other stakeholders to participate and collaborate.
* **Research**: Develop references to inform and educate on astronomy’s concerns and share recommendations and best practices.
* **Exchange**: Foster sharing of mitigation techniques and their efficacy and encourage innovation in new approaches and tools (materials, test labs, simulation software, etc.)

Walker mentions the following Industry & Technology Hub achievements:

* Providing resources to companies (Astronomy 101, expanded reference library with key technical, and analytical and academic papers on brightness or spectrum interference).
* Identifying proprietary operators list and contacted them.
* Meeting with satellite operators (SpaceX, OneWeb, Kuiper Amazon, AST SpaceMobile, etc.).
* Meeting with space situational awareness data providers (Privateer, Slingshot, etc.).
* Signing up companies for the planned Technical Advisory Committee and providing them with astronomer guides.
* Working with astronomers and satellite operators to set target brightness levels and other mitigation parameters towards best practice guidelines.

### Community Engagement Hub

Walker mentions the following achievements of the Community Engagement Hub:

* Completing foundational documents of the hub.
* Creating SATCon’s 101 curriculum, including videos on the basics on satellites, constellations, and various impacts.
* Establishing initial contacts with several constituencies to invite them to share perspectives on constellations and the night sky.

### COPUOS and the Science and Technology Sub-committee (STSC)

Walker discusses the COPUOUS Science and Technology Sub-committee (STSC). She says IAU CPS requests support from member states in protecting the dark and quiet sky from satellite constellation interference. STSC is a means of reaching decision makers from different countries. She explains that, as permanent observers, the IAU have attended meetings and are now at the point of acquiring an agenda item on the topic. They are also forming an expert group. One country disapproved of their agenda item because it did not include military uses.

Walker ends her presentation.

## Rubin Observatory and Satellite Constellation Impact on LSST Science

Bob Blum (Rubin Observatory Operations Director) delivers a presentation on the impact of satellite constellations on LSST science at the Rubin Observatory. Blum also discusses how to mitigate these impacts.

Blum credits his coworkers for their help in this endeavor, including the following:

* Željko Ivezić.
* Tony Tyson and his students at UC Davis.
* Meredith Rawls at the University of Washington. Rawls is also part of the Rubin team. She works with Walker on the CPS, but also works with Tony and others at Rubin on specific issues surrounding the mitigation of the satellites on their data.
* Peter Yoachim. An expert at scheduling the telescope, Yoachim has helped in understanding the distribution of satellites, and how to move the telescope around to mitigate some of that just by position.

Blum mentions the quantitative assessment depends on several imperfectly known quantities, including the following factors: the number of satellites and their orbital distribution, satellite brightness distribution, and the impact on LSST images and mitigation. He next discusses each of these factors in greater detail.

### Number of Satellites and Their Orbital Distribution

Blum mentions that there are already over 5,000 satellites and tens of thousands more are planned. There is a tradeoff between lower altitude orbits vs the increased number of them and how they are distributed. He explains the presence of satellite streaks in astronomical images will have an impact on ground-based observations. There is no combination of mitigations that can eliminate the impact of these streaks on images.

### Satellite Brightness Distribution

Blum says the brightness of satellites is a function of various factors, including their physical size, reflectance properties, and geometry. It is important to understand and predict the brightness of satellites in different situations. Blum mentions a paper by a student named Forrest Fankhauser, who has developed a framework to predict satellite brightness based on satellite geometry and reflectance properties. He says it is likely a magnitude of 6.5–7 or fainter would not be detected by the unaided human eye and would not saturate Rubin detectors.

This framework is being used to predict satellite brightness and verify the model as new satellites are launched. There have been efforts to mitigate the brightness of satellites, particularly by companies like SpaceX. They have made changes to the design of their satellites, such as using larger solar panels that can be tilted to reduce reflections. However, Blum notes there are still some brighter satellites observed, and further research is needed to understand their impact.

Blum says the first generation of Starlink satellites have an approximate brightness of +5–6 apparent magnitude (m). SpaceX is trying to make them fainter, and their team recently made some technological breakthroughs with dialectic Bragg mirrors with specular optical reflection, which are transparent at long wavelengths used for communication. SpaceX also improved space-qualified “black paint.” V1.5 has been deployed with these changes (+4–6 m).

Blum says Rubin staff are working with Amazon, NSF, and SpaceX to find brightness mitigations. He says SpaceX is open to sharing their technology with other satellite providers. Hopefully, mature satellite constellations will reach >7 m.

### Impact on LSST Images and Mitigation

Rubin’s data management team has developed code to detect and mask satellite trails. Blum notes each trail requires a unique mask that depends on the following factors:

* Apparent brightness
* Size of satellite reflective elements
* Telescope primary mirror size (satellites are out of focus)
* Orbital height
* Seeing

Bright satellite trails in the highly sensitive LSST Camera can induce image artifacts which lead to electronic crosstalk between output amplifier on 16 segments (non-linear, with intensity). At 6.5 m, a 10% error on any crosstalk coefficient could create a false faint galaxy image in a coadd. Fainter satellites are an important mitigation.

Blum says the data management team has already worked to find streaks or glints in Rubin data products. Science pipelines use the kernel-based Hough transform to find and mask streaks in coadds. The UC Davis team uses a similar technique to find streaks in lab-simulated streak images.

Blum highlights three status updates for the project:

* **Soon:** Streak detection in single-frame processing.
* **Remaining challenge**: Glints as false alerts.
* **Future**: Using real satellite streaks in Rubin data to measure impacts of optical satellite interference on science and make decisions about dodging etc.

Blum concludes his presentation by summarizing the impacts of satellites on LST. With tens of thousands of LEO satellites, he says, generally no combination of mitigations can completely avoid the impacts of the satellite trails on LSST science programs. Current predictions on the impact correspond to a few percent of pixels lost rather than a catastrophic impact of >10% pixels lost. This will depend on the ultimate brightness distribution. He says we need to continue to constructively communicate with satellite providers to maximize on-orbit brightness mitigations. Impact via systematics in the processed images and catalogs is a significant challenge for Rubin and the community.

Blum ends the presentation on satellite impacts to LSST science.

## Q&A on LEO, the Rubin Observatory, and LSST Science

Anne Zabludoff wants to follow up regarding LSST’s mission to follow Earth-bound objects and the idea that something important could be missed due to the confusion. She asks how much of a concern that is, and whether Blum’s team is still modeling. Blum replies he doesn’t know how likely it is that they would miss a large rock headed to earth because of streaks. He says it is a good question, but he doesn’t have a good answer.

Britt Lundgren wonders if the simulations include raising and lowering parts of the satellites’ orbit when they seem to be much brighter. She says that seems to be a significant amount of their lifetime. Blum replies they haven't really factored that phase. He thinks Lundgren is right that it's an important thing we should probably take a harder look at. He notes the satellites have a finite lifetime, so there's going to be a constant replenishing of them. That's something that they should probably look at. He suggests Ashley VanderLey might like to comment, as well.

VanderLey says she thinks it’s good to look at the benefit. Satellite operators tend to do the orbit-raising in a big cluster, and they also can move over on bookends such that the satellites are not as reflective as they move them to the right position. It definitely helps that the satellites aren’t all spread out. There are other questions in orbit lowering, especially if it's a couple at a time. She asks what that will that look like in a steady state. And then there's also questions about the materials burning up in the atmosphere. VanderLey asks what impact that might have on the atmosphere. She says that is a good research question.

Blum says the last point is good, especially when not much attention has been paid to all aspects of these constellations. One aspect is the satellites will dump a huge amount of metals into the atmosphere all the time.

Zabludoff asks about the stipulations being put forward, which she says sound eminently reasonable. She hopes they will bear out through modeling. There is a lot of focus on LSST and its capabilities and use cases, but LSST will hopefully not be the last facility or a survey. Are people brainstorming with regard to what might be next, she asks, and making sure these requirements cover additional possible future missions and surveys?

Walker comments that they are brainstorming. At this point in time, the widest field telescope is the Rubin. That telescope bears significant consequences and has the greatest impact of all telescopes to this point, and even to the near future. It is a very good test to go by, and that's what they are using at the moment.

Blum adds that Rubin is already thinking about next-generation surveys, and this question is a good one to keep in mind. He asks the committee to consider what things might be done with Rubin. He wonders whether they are more or less susceptible to this problem, and he states that is something his team will certainly think about. He says they have thought about very simple things, such as different filter sets, cadences, and narrowband filters. Some of those might be less impacted, but there also could be new, large, spectroscopic facilities that can be impacted in certain ways. It is important to keep that in mind during the development of the next generation.

VanderLey comments that narrow field is important for brainstorming potential impacts to the ELTs, which is important to the astronomy community. As long as we can make sure that coordination with SpaceX is voluntary, she says, they shouldn't require delays or closures. Her team is working on a modification to that ruling for astronomy ground-based lasers, which will help ensure the ELTs can use their laser-guided star optics.

VanderLey adds that, just for the wider field of view, one of the challenges is the current charge-coupled device (CCD) for Rubin. There is crosstalk just from the way the CCD was built and designed, and maybe that is an R&D opportunity for the future. VanderLey asks whether there could be brighter streaks that don't saturate or don't cause cross talk in the back-end electronics. She notes that's something Blum mentioned, but probably more work needs to go into that.

Blum agrees CCD development is a good idea for the next focal point of a Rubin survey.

McCarthy asks what fraction of satellite constellations are launched from outside the United States. Do they have a sense of how many will be launched by other countries? To the extent one country did not vote for this proposal, he asks, how do they see that playing out?

Walker replies that at this point it's a very hard question to answer. For instance, the E-Space company in Rwanda initially proposed over 330k satellites. She thinks maybe 100k satellites might be launched, which is still a huge number. That scale dwarfs what SpaceX is doing at the moment, so it's something to keep an eye on in the future. E-Space doesn’t necessarily have to get licenses with the FCC unless they're going to be broadcasting.

Walker adds there are smaller constellations like in China. One of the bigger ones is 13k. There are other nations around the world that want to be a player in all of this. NSF is coming up to speed and will probably have to use the UN as a way of getting involved with their governments. It is going to be a big learning curve right now, and her team doesn’t really have any answers for McCarthy at this point.

Black thanks the presenters and says Mark Clampin is on the line. Clampin comments from the point of view of the NASA Astrophysics Division. He says they don’t have the issues from light pollution but are concerned about conjunctions from the growing number of satellites. There is a growing number of yellow or red conjunction assessments. NASA has agreements with some companies, like SpaceX, who move away when there is a conjunction. NASA has a Conjunction Office, and NASA is looking at what it will need to do in the future. The agency is involved at other levels in understanding future impacts of these constellations. It was already noted that they don't have any major scientific constellations; the biggest constellation is still a very small number of satellites. Most of the other constellations flying at the moment are actually heliophysics, and their plan to go to other orbits. Clampin says it is not really an issue.

Clampin adds that, from his personal perspective, it is a growing problem. Certainly, in the future there will be impacts for NASA science. Some of the Earth Science missions also do light detection and ranging (LIDAR) work, where there's all firing down. There's concern that if you're firing down, and there's something underneath you—missions like ICEYE or the Global Ecosystem Dynamics Investigation (GEDI) on the space station are two examples—then there are growing concerns about the same radio band issues that have been discussed. Clampin says that is all he can say. If the committee needs any more specialized briefing on this topic, then he needs a fairly detailed briefing on what members want to hear.

Willie Rockward says he wanted to follow up from the previous discussion. Given the number of satellites going up and those who want to get in the game, he asks, do the presenters foresee international involvement and a NATO-type policy that might be put in place? Walker answers that through their work with the UN, they would give recommendations. The CPS Hub is working on collaboration.

VanderLey adds the UN and COPUOS have a long-term sustainability working group that has been thinking about issues around debris mitigation. Some of the issues in terms of numbers of satellites are going to be addressed in those kinds of conversations. There is also work to try to establish best practice guidance. This effort is mostly leading by example instead of regulation. She mentions a radio satellite conference and planned discussions about interference mitigation.

Lundgren addresses a question to Clampin. She mentions the last report and asks about the paper published in *Nature* suggesting about 6% of Caldwell 3 (C3) images in Hubble were peppered with satellite trails. Lundgren also asks for comments about tracking hazardous objects in near-Earth orbit, given twilight observations seem to be preferentially impacted.

Clampin says they are not concerned about the Hubble issues. Asteroid trails are removed during image processing. They don’t see contamination of Hubble images as an impact to science, as opposed to the issues with Rubin. Most of the imaging is pointed rather than survey.

Regarding the question about near-Earth objects, Clampin says another part of the Science Mission Directorate, at the Planetary Division, is putting together a mission called Nearest Observer which will be dedicated to looking for nearest objects. So, there is a program underway that will address this problem in addition to things done in the past. Their next big survey mission is going to be the Roman Space Telescope, which will be operating at the Sun-Earth Lagrange Point (L2).

Lundgren asks if folks are actively simulating the expected satellite populations. Is NASA taking brightness, distributions, and spatial distributions into account when planning future missions and seeing if the goals are impacted? Clampin responds that when people write proposals, they probably look at these factors. But many missions are not occurring in orbits where this is a consideration. Some are, but many are not as well.

Lundgren also wants to know if this is a fertile area for NASA, NSF, NOIRLab, and other people involved to share information and talk about what applies. Clampin responds that NASA is happy to engage in a conversation with NSF. He would talk to Lori Glaze who runs the Planetary Division, about the Near-Earth Surveyor. That said, right now he sees the growing risk of conjunctions as a bigger concern from the space perspective. He clarifies that this is purely anecdotal. He is seeing more red conjunctions. It’s a growing concern. Either the other satellite takes action, or they are able to point their satellite in a different direction. Often, they have to figure out what they have a conjunction with, because they haven’t heard of it.

Black thanks the presenters and moves onto the final speaker.

## AAAC Laboratory Astrophysics Task Force (LATF) Update

Harshal Gupta (Program Director, AAG Laboratory Astrophysics, NSF/AST) gives a presentation on the activities of the LATF, which is a subcommittee of the AAAC.

Gupta says the task force is working to conduct a robust assessment of the scientific utility and priorities of laboratory astrophysics. He says it aims to identify the most impactful ways to enhance the scientific return of observatories by supporting laboratory research, including observational, theoretical, and laboratory aspects of the mission.

### Task Force Mission and Organization

The task force is led by Dr. Lucy Ziurys at the University of Arizona. Agency members include Manual Batista and Bill Latter, who are NASA scientists in the laboratory astrophysics discipline. The subcommittee also includes 19 other members from various disciplines, including experimentalists, theorists, observational astronomers, modelers, and database curators. They have been meeting internally and engaging with the community since March 2024.

Gupta explains the purpose of the task force is to take a holistic look at the charge given to them and to identify the need for laboratory data, national resources, and new approaches or programs. At its core, the task force is focused on experimental and theoretical studies of properties and processes important to astrophysics. Gupta says the task force has been formulating plans to address these elements, and it is gathering input from the community through surveys and sessions at conferences.

Gupta gives a brief overview of laboratory astrophysics, which spans a board range of studies, including experimental and theoretical investigations of properties and processes that are important for the accurate interpretation of observations and the optimum exploitation of observatories. Laboratory astrophysics plays a foundational role in astronomy research and enables discoveries and advancements across the field of astrophysics. It involves conducting experiments and theoretical studies to understand the fundamental properties and processes that occur in astrophysical environments.

Gupta's slides reference several objects of study, including atoms, molecules, astrophysical plasmas, and dust & ices. By studying and simulating astrophysical phenomena in controlled laboratory settings, Gupta says, scientists can gain insights into the physical mechanisms and processes that occur in space.

### Decadal Survey Activities

Gupta notes the Decadal Survey deemed laboratory astrophysics critical enabling science across astrophysics and realizing the potential of recent and imminent major observatories. He refers to the Astro2020 panel on “An Enabling Foundation for Research,” which was charged with assessing the current state of resources in the field, identifying major challenges, and making suggestions regarding support for laboratory astrophysics.

Astro2020 findings included:

* Laboratory astrophysics is important for advancing astronomical discoveries, and its small funding envelope would limit advances in astrophysics over the coming decade. The panel emphasized the need for laboratory data and measurements for the accurate interpretation of observations and maximizing the scientific return of observatories. Erosion of support and infrastructure and attrition in the community are an issue.
* Workforce development is a major challenge in the field. They highlighted the need to attract and retain talented individuals in astronomy and astrophysics, as well as the importance of providing adequate resources and support for training and education.
* There is a need for continued investment in infrastructure and facilities to support cutting-edge research. Maintaining and upgrading existing observatories is important, as is the need for new facilities and instruments to address emerging scientific questions.
* There is also a need for robust data management systems and advanced analysis techniques to handle the large volumes of data generated by modern observatories and surveys. The panel emphasized the importance of developing tools and resources to effectively process, analyze, and interpret astronomical data, enabling scientists to extract meaningful insights and discoveries from the vast amount of information available.

Gupta discusses the Astro2020 conclusions and recommendations. The panel recommended making Lab Astro a higher priority, and it said NASA and NSF should convene a broad panel of experts to:

* Survey the current state of laboratory astrophysics.
* Identify needs for laboratory data to maximally exploit observatories.
* Identify resources that are currently available to address these needs.
* Consider new approaches and programs for building the requisite databases.

Gupta stresses that the panel should include experts not only in Lab Astro, but users of the data as well. He flags several sub-elements of the panel’s charge, emphasizing its holistic purpose.

AAAC reiterated this recommendation in 2021–22, and it advised a panel instead of an advisory group to identify the needs and set priorities for laboratory astrophysics. The charge is based on 2020 Astro recommendations. It begins with an assessment of the current state of the field and draws from a wide range of available material.

### AAAC LATF Activities

Gupta discusses community engagement and committee structure. He says there have been discussion sessions at summer AAS, the American Chemical Society (ACS), and the International Symposium of Molecular Spectroscopy (ISMS). There has also been progress on charge elements (tasks).

Gupta focuses on work completed during the September 2023 LATF Workshop, which was jointly sponsored by the Harvard Center for Astrophysics (CfA) and the Smithsonian Institutions. This workshop aimed to accomplish the following objectives:

* Address progress.
* Address knowledge gaps and seek additional input, including:
	+ Astro 2020 panel member perspectives;
	+ incorporating laboratory astrophysics into mission planning; and
	+ identifying speakers for October LATF meeting.
* Commence report for AAAC (submission planned for 2024).

Gupta says the LATF has completed Task 1 (Field Survey) and Task 2 (Needs Identification). They are focused on completing Task 3 (National Resources) and Task 4 (New Approaches or Programs). An upcoming meeting will be held at CfA and, there is a larger remote meeting planned for October. LATF will start writing their report for submission in January, in time for the community to read it in February.

There’s a lot to be done, and Gupta is excited to see what the task force recommends.

## Q&A on the AAAC LATF

McCarthy notes a slight change of schedule as far as when certain reports are finished, when meetings will be held, and how findings will be incorporated into future reports. Gupta says January is the target month for having enough material for the committee to consider in February.

There are no further questions from members. Black invites the public to put their questions in the chat. There are no questions asked.

Black invites McCarthy to give a committee perspective. McCarthy thanks NSF and the other agencies. He says there is a lot to consider, and he will leave it to the committee to provide its perspective.

McCarthy suggests reconvening by email in the coming weeks, and he welcomes anyone’s comments, feedback, questions, or recommendations. He says the next event is a virtual one-day meeting, in November, where the committee will ask for clarification or additional information from this group.

Black ends the meeting, explaining that Chris Smith was unable to stay until the end of the meeting. McCarthy notes action items include meeting minutes and a Doodle Poll to schedule the upcoming meetings. Black forwards a motion to adjourn, which the committee approves.