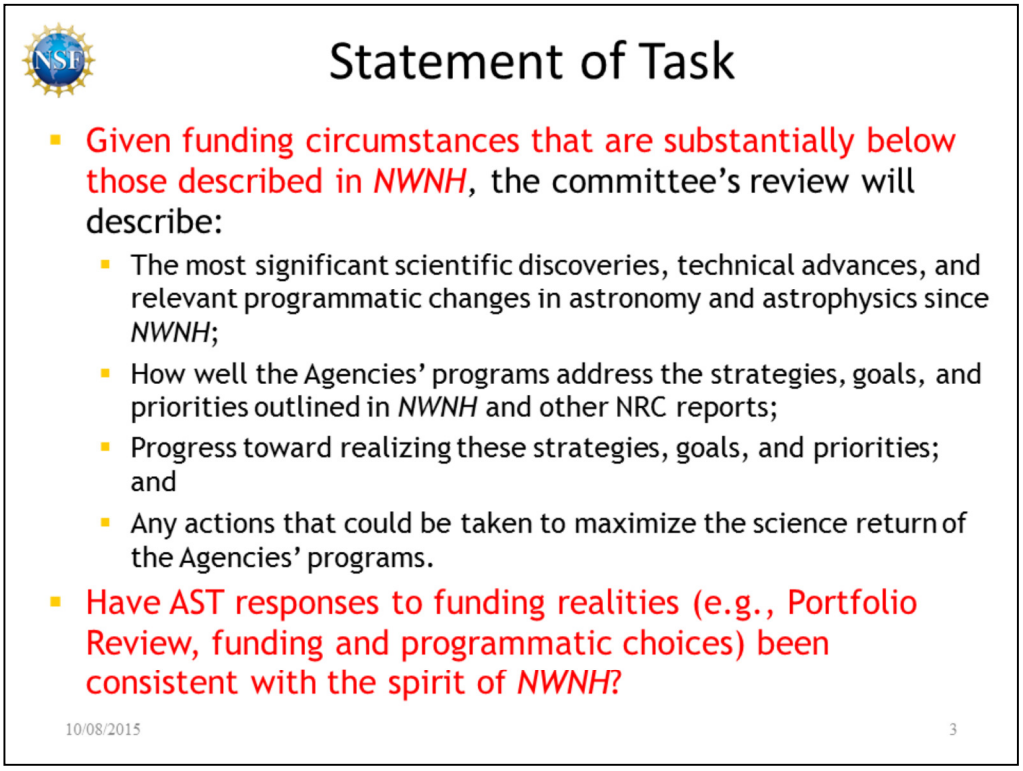
NSF Division of Astronomical Sciences (AST) Activities and Plans Pertaining to *NWNH*

October 8, 2015

Jim Ulvestad, Division Director, MPS/AST
@UlvestadNSF

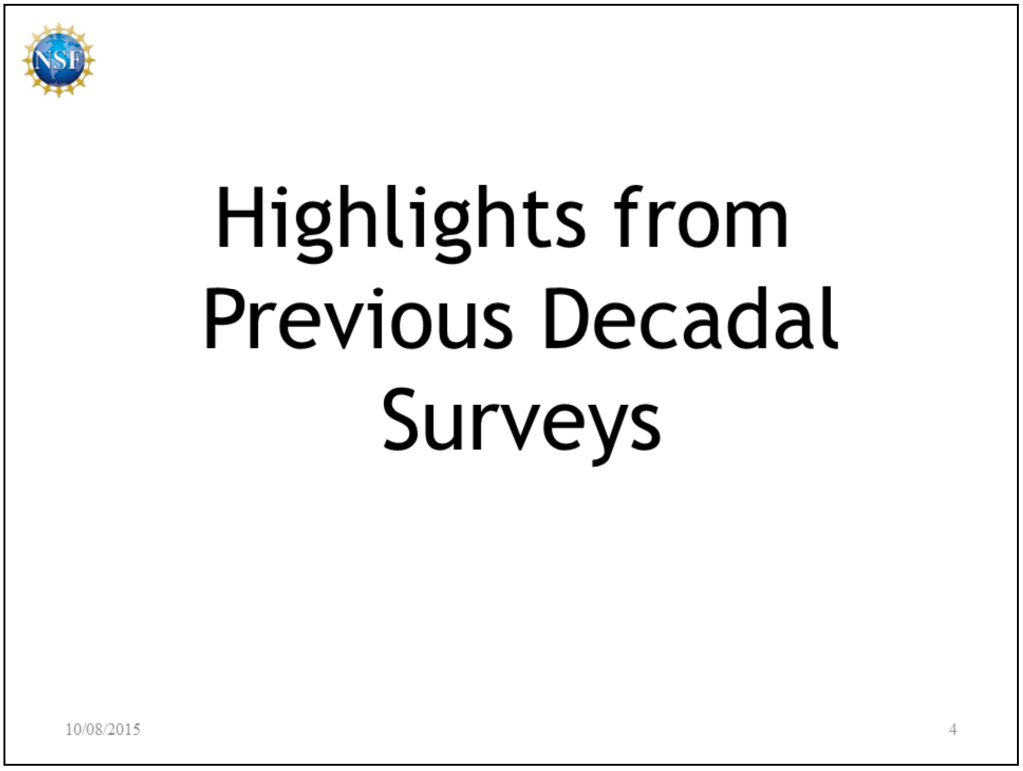
Outline

- NSF Goals for this Study
- Highlights from Previous Decadal Surveys
- Budget Status and Outlook
- Status of Responses to *New Worlds, New Horizons*
- Portfolio Review
- Summary



The four sub-bullet points are simply a statement of the four primary points in the Committee's Statement of Task.

Although the Committee and others can always wish that different choices had been made in particular circumstances, AST is most interested in whether it has responded appropriately to the spirit of NWNH, given the funding circumstances that are below even the lowest scenario contemplated in the NWNH report.


Highlights from Previous Decadal Surveys
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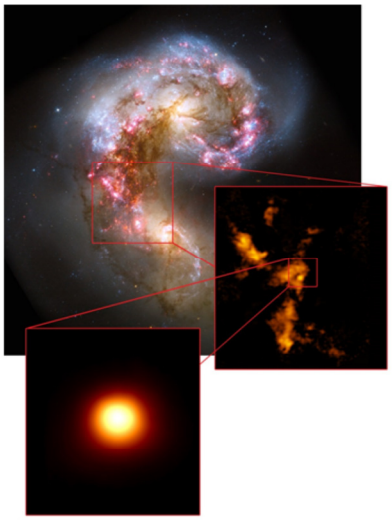
Atacama Large Millimeter/Submm Array (ALMA)

- 1990 and 2000 decadal surveys
- Construction of ALMA was officially completed in 2015.
- ALMA is a joint project of North America (led by NSF), the European Southern Observatory, and East Asia, with a total construction cost of $1.4 billion.
- At upper right, an optical image of the merging "Antennae" galaxies is shown, progressively zoomed into a compact but intense source of millimeter radiation imaged with ALMA. This massive, dense, star-free cloud may be the first known example of a globular star cluster about to be born.



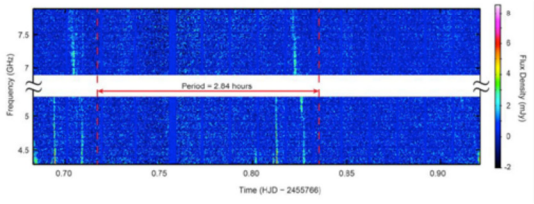
Credit: B. Saxton (NRAO/AUI/NSF); Images from NASA/ESA Hubble, B. Whitmore (STScI); K. Johnson (U.Va.); ALMA (NRAO/ESO/NAOJ). (ApJ, 2015, 806, 35)

NSF MREFC construction account showed a positive balance at completion.

ALMA has been carrying out early science with progressively increasing capabilities since 2011. The Antennae image shown used only about a quarter of the final number of 66 ALMA antennas.

Karl G. Jansky Very Large Array

- VLA Expansion—Phase 1—2000 decadal survey
- Construction project completed in 2013
- Built upon 27-element VLA infrastructure with new electronics, receivers, fiber optics, software, and correlator
- Complete 1-50 GHz frequency coverage; all VLA technical capabilities (except angular resolution) increased by at least an order of magnitude



"Exo-aurora" 10^4 times stronger than Jovian auroral emission discovered in brown dwarf 5.7 pc from Earth. (Hallinan et al. 2015, Nature, 523, 568)

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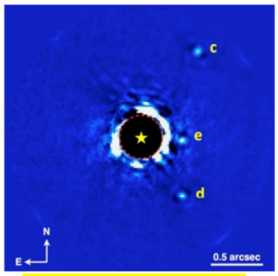
The VLA will remain the most versatile and capable centimeter-wavelength interferometer at least through the remainder of this decade, if not beyond.

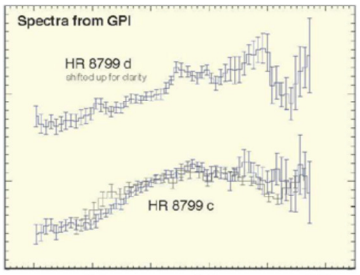
Funding for the VLA Expansion was done from within the AST operations budget, not in the NSF Major Research Equipment and Facility Construction account.

Total funding of $59 million in new funds was completed in 2011.

1990—Gemini: GPI First Results



Credit: Marois, Ingraham, & GPI Team

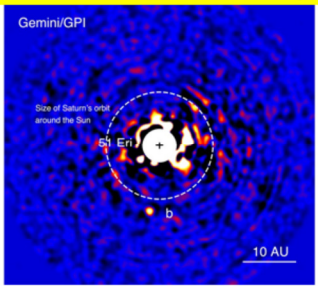


The GPI spectra, of HR8799c and d, shown here, indicate large differences in atmospheric clouds or composition

Credit: Ingraham, Marley, Saumon, & GPI Team

- Commissioning data from GPI, above left, show three exoplanets circling the nearby star HR8799
- The image to the right shows the exoplanet 51 Eridani b (bottom of frame); this object is the most similar to our Solar System's gas giants of any known exoplanet (Macintosh et al., Science, August 13, 2015).

Credit: J. Rameau (UdeM) and C. Marois (NRC Herzberg)



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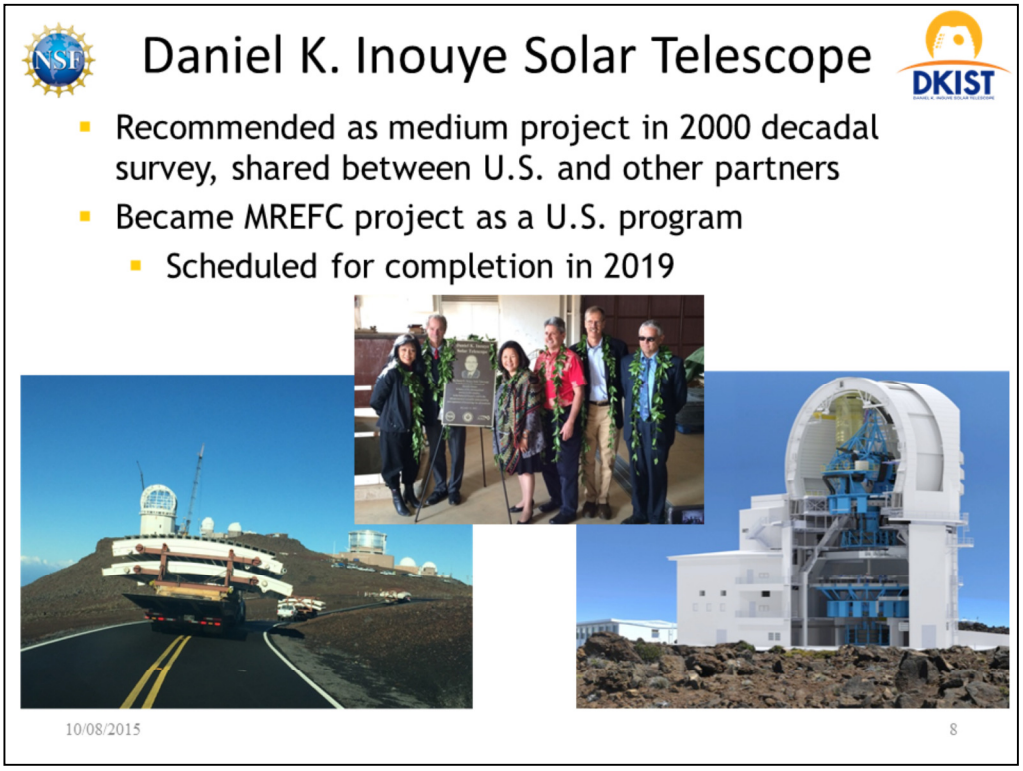
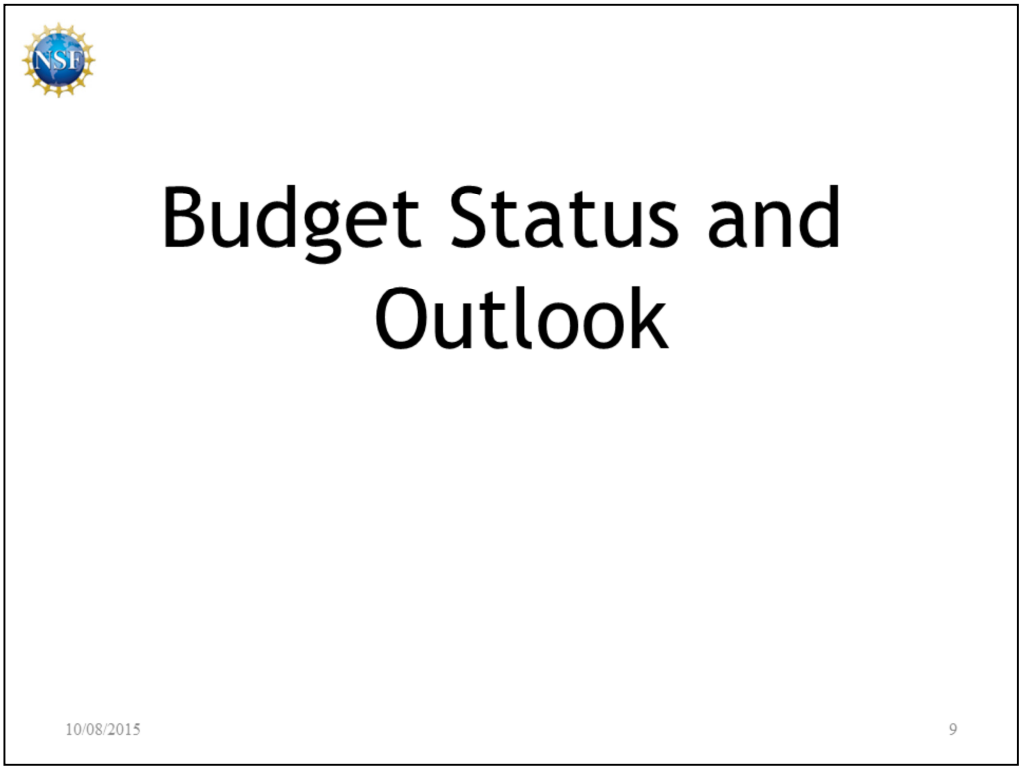
The capabilities of the Gemini Planet Imager show that AST still continues to work on developing the capabilities of observatories that have been built in response to previous decadal surveys. The large infrastructure investments supported by previous decadal surveys have scientific lifetimes measured in (several) decades, if the observatories can be supported for continued development and evolution.



The Advanced Technology Solar Telescope was renamed the Daniel K. Inouye Solar Telescope at a ceremony held atop Haleakala in December, 2013 (central image). The left-hand image shows transport of large pieces of the dome shutter in August 2015, to be installed on the DKIST dome shown in the background on the left of the picture. The right-hand image is a cut-away image of the completed DKIST telescope.

DKIST is primarily a U.S. program, but with non-U.S. partners in Germany and the U.K. contributing instrumentation in return for dedicated DKIST observing time.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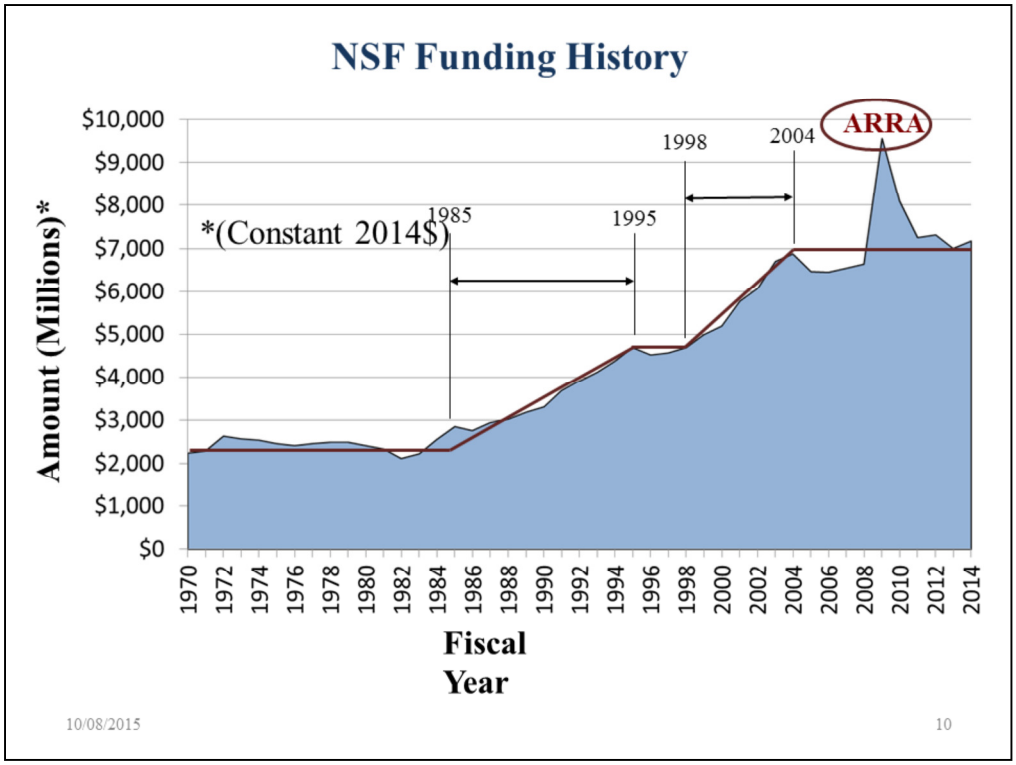
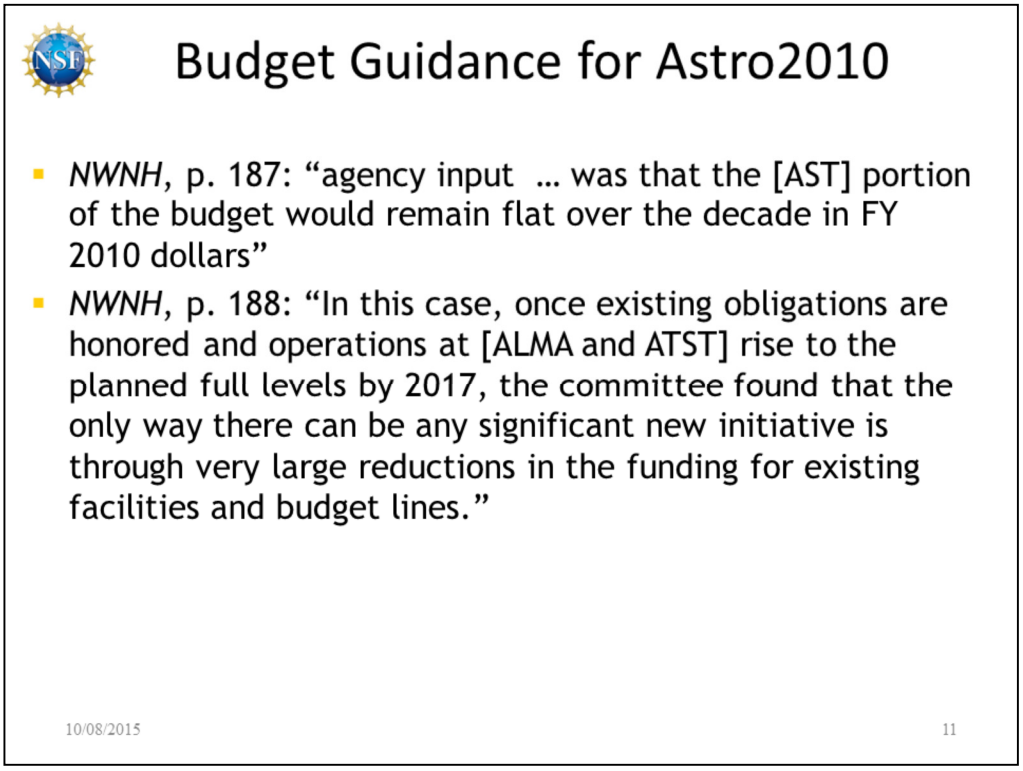
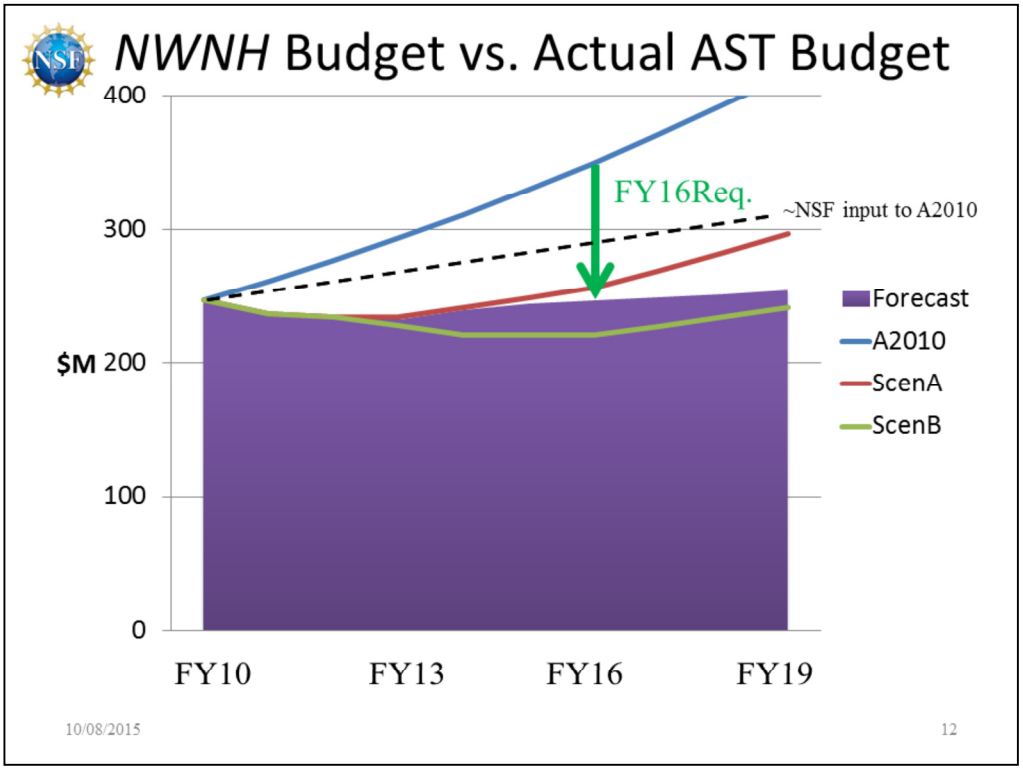


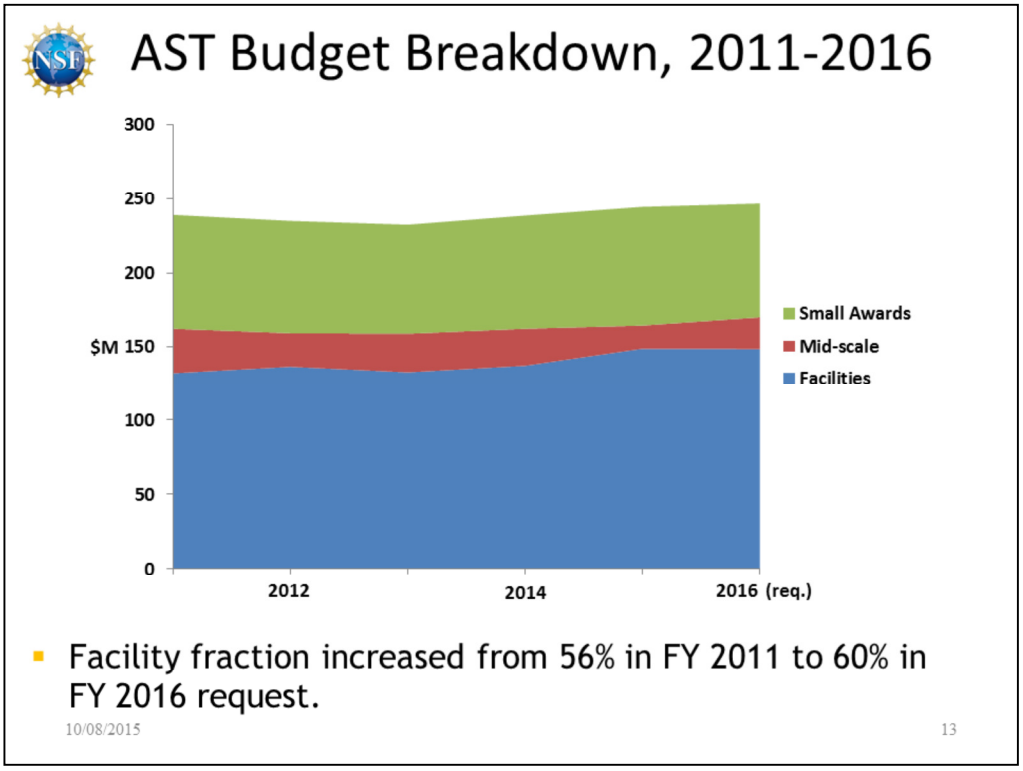
This slide shows that the smoothed history of NSF funding over the last 45 years can be approximated by long periods of flat funding punctuated by intervals of significant increases. In general, one can correlate these periods with general economic circumstances and nationwide decisions about fiscal policy, rather than being attributable to specific choices about the NSF. At present, we are in a prolonged "flat" period, with the exception of the economic stimulus funding of the American Recovery and Reinvestment Act (ARRA) in 2009.



These quotes from the decadal survey indicate that the decadal survey saw problems in doing anything new at a budget level that was well above what has actually occurred.

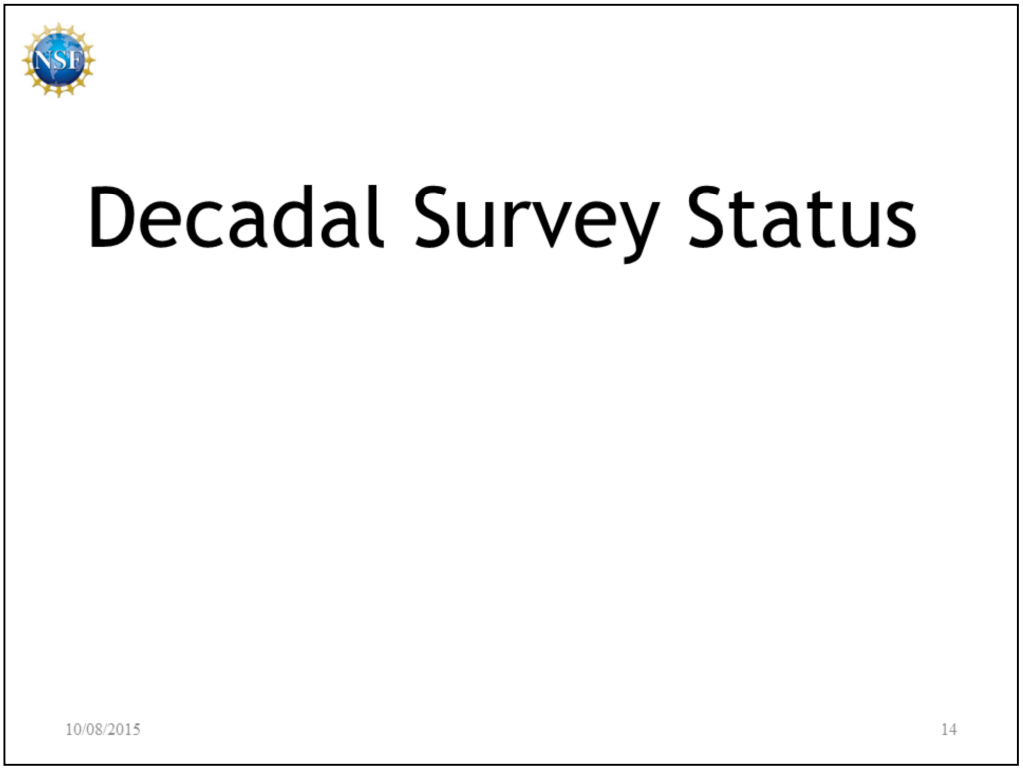


The large purple wedge gives the Actual Expenditures (then-year dollars) for AST from FY 2010 through FY 2015, and the President's Request Budget for FY 2016. The hypothetical forecast beyond FY 2016 assumes a 1%/yr increase, consistent with the slope from the FY 2015 actual spending to the FY 2016 President's Request Budget. The two lines labeled "ScenA" and "ScenB" are the two budget scenarios that were presented to the AST Portfolio Review in 2011, with the budget reality falling between those two scenarios so far. The increasing blue line labeled "A2010" is that assumed by the 2010 decadal survey, with an annual inflation of 2.5% used for the purposes of this chart.



This plot shows the actual AST expenditures from 2011 through 2015, and the President's Request Budget for FY 2016. In this chart, the "Mid-scale" wedge uses the expansive definition recommended by the AST Portfolio Review Committee, including traditional mid-scale programs along with University Radio Observatories, the Telescope Systems Instrumentation Program, and Design/Development of future telescopes.

Note here that the outcome of the FY 2016 appropriations process remains highly uncertain; given the lead time needed to make significant changes to facilities, any budget reductions are likely to hit the mid-scale and small awards disproportionately.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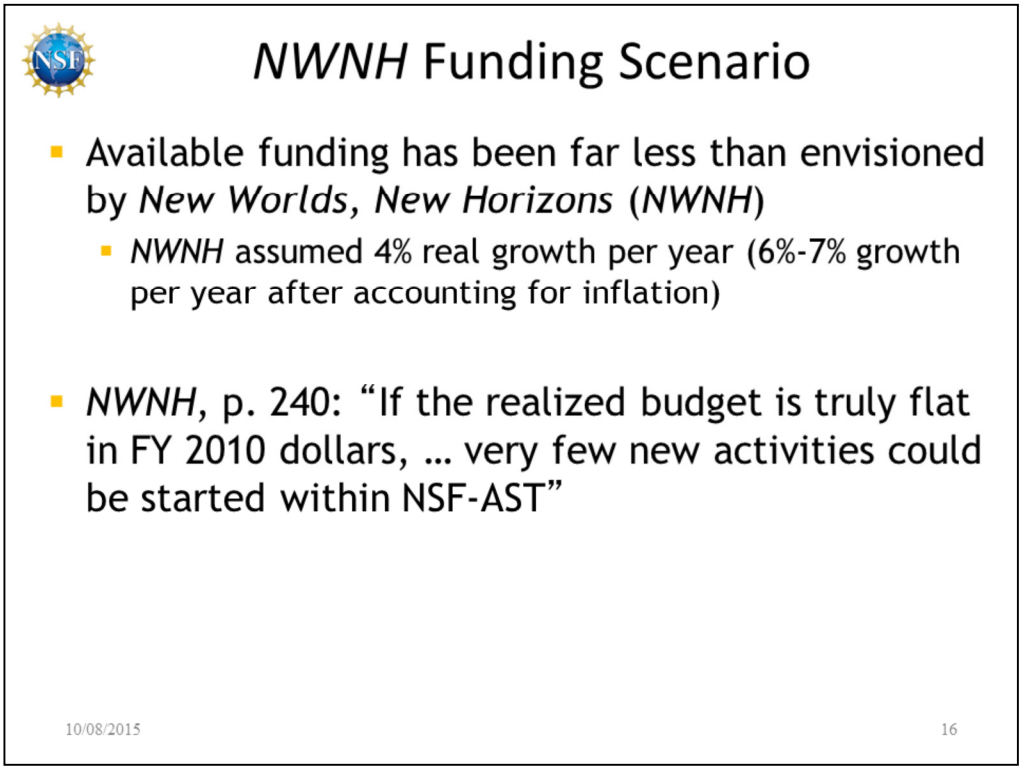
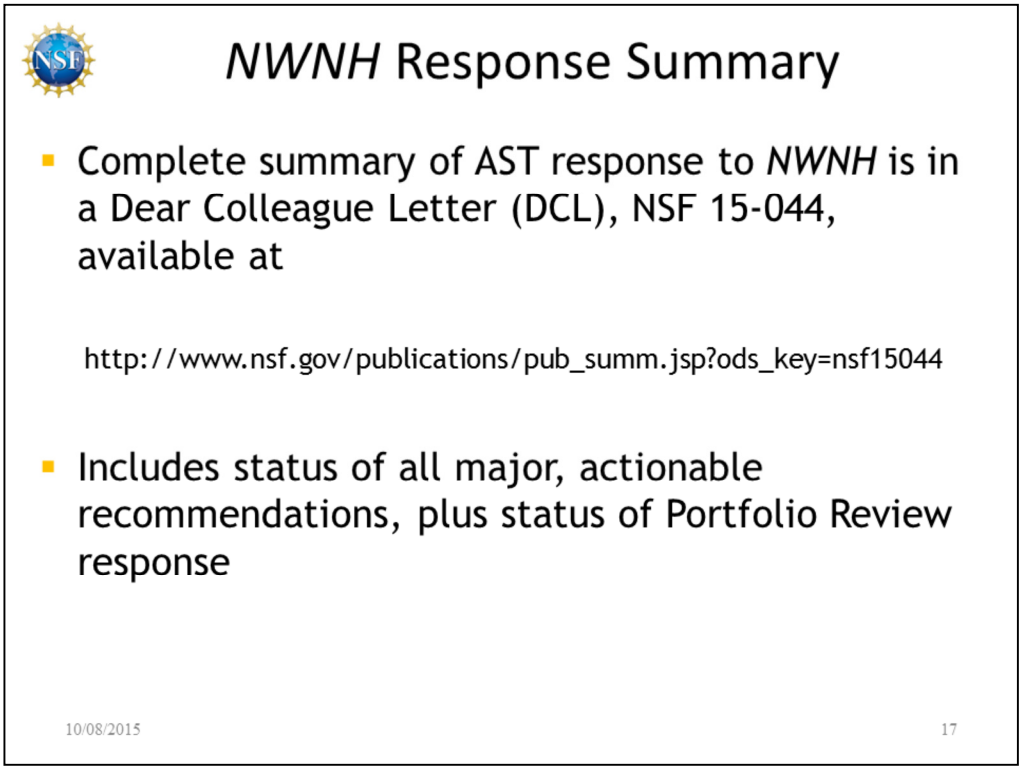
Note here that the FY 2016 President's Request Budget for the Division of Physics and the Division of Mathematical Sciences are both below their FY 2010 expenditures, while the FY 2016 requests for all five Divisions in the Directorate for Mathematical and Physical Sciences (MPS) are below the requests for FY 2012. Thus, the perceived funding stagnation for the Division of Astronomical Sciences is not unique to AST.

Since ALMA had a significant funding ramp to full operations in the first half of the decade, within the context of a flat/decreasing budget, little flexibility has been available to respond positively to the small-programs recommendations of NWNH.

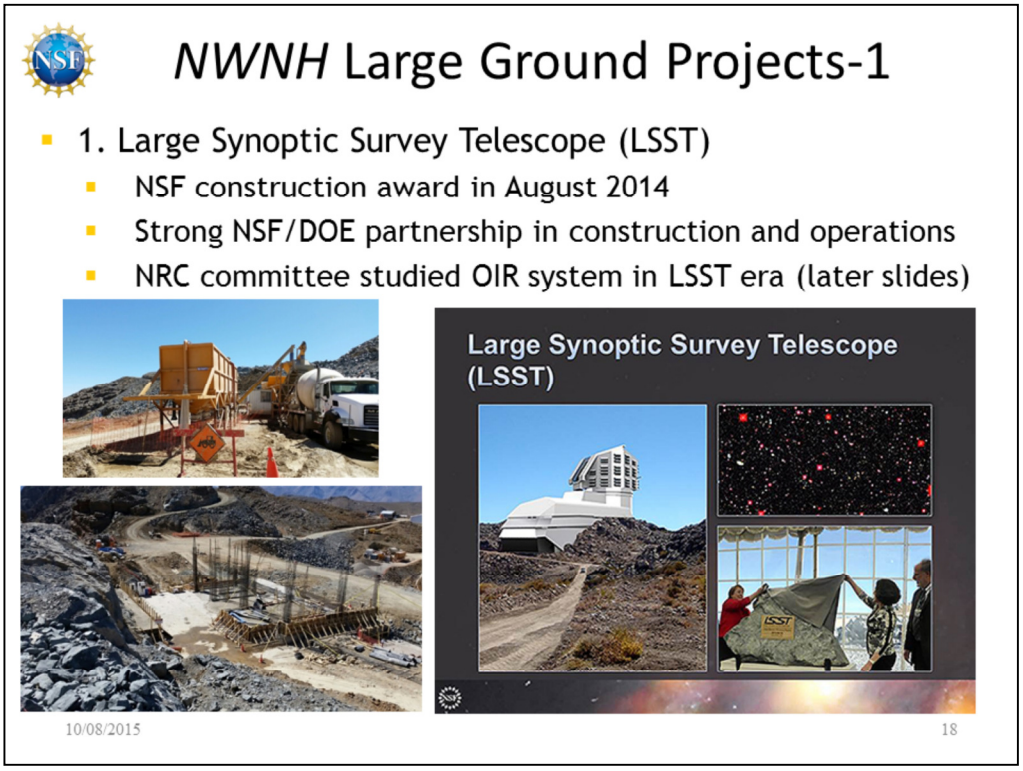
Starting LSST and MSIP (later slides) has been difficult in this environment, and has required significant priority choices within NSF and AST.



A simple summary of AST actions (or non-action) in response to NWNH is in the following slides. As recognized by NWNH in their report, "very few new activities" could be started in the funding circumstances that have occurred.



The following slides will give brief summaries, but more details can be found in NSF 15-044 or can be discussed in answer to questions.



The right-hand montage shows an artist's conception of the completed LSST, a small portion of a field that would be imaged by LSST, and the first-stone ceremony in April 2015, with the unveiling by the President of Chile (left of picture) and the NSF Director (back to camera). On the left, a local concrete plant was implemented to expedite creation of the footing for the support building.

LSST Overview

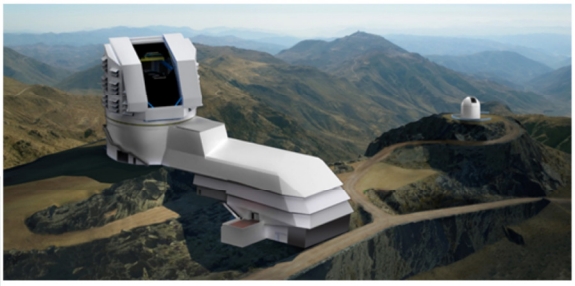
Massively parallel astrophysics - data enabled science
very large datasets allow for precision statistical analysis
and an automated search for very rare events

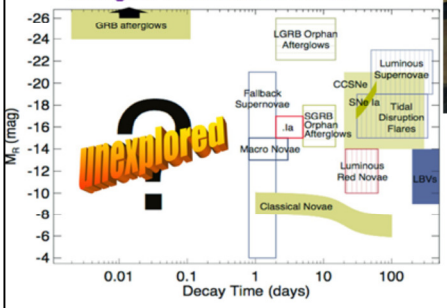
High dimensionality data exploration
automated discovery
automated data quality assessment

A new window on the Universe
expect the unexpected

Transformative impact of sky surveys
change in astronomical culture

A 10-yr survey of 20 billion objects in space & time





- ***Probing dark matter and dark energy***
  - *Order of magnitude improvement*
- ***Mapping the Milky Way***
  - *Formation and structure*
- ***An Inventory of the Solar System***
  - *Potentially hazardous asteroids*
- ***The Transient Optical Sky***
  - *Opening the Time Domain*

A unique discovery engine, transformative in science, in education & outreach, and in data-enabled science & cyberinfrastructure

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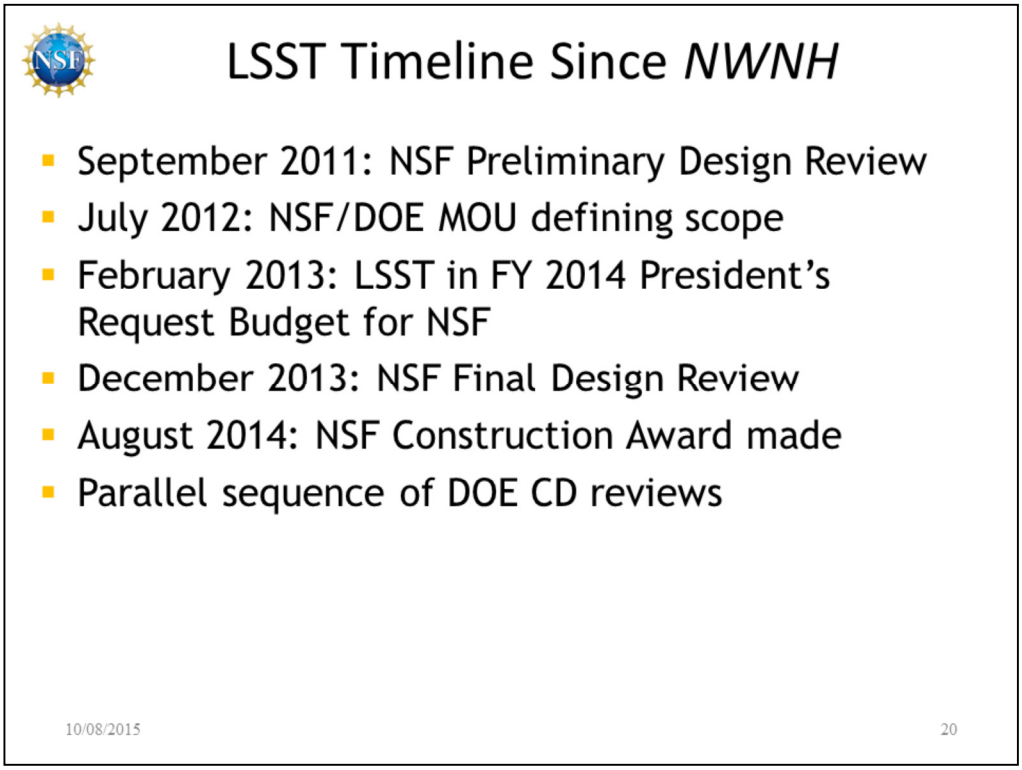
This is what LSST is all about, in one slide.

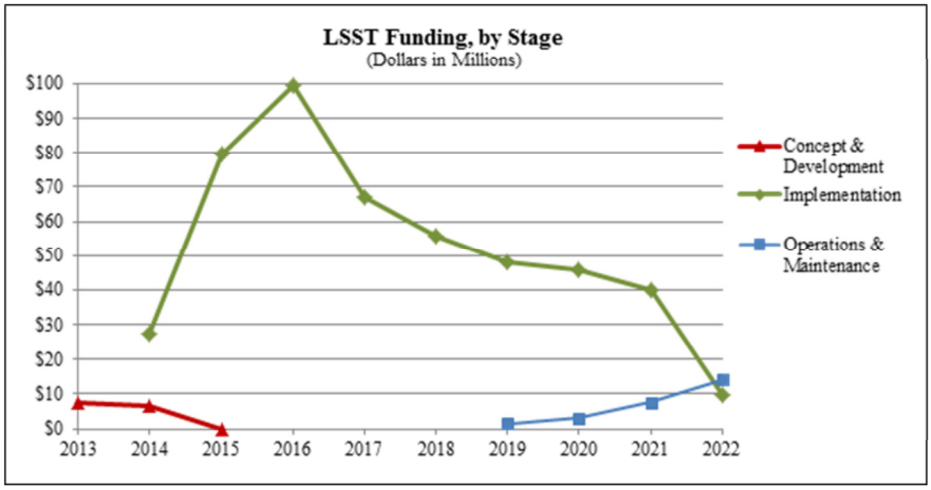


A number of other reviews, such as Joint Interface and Cost Estimation reviews also have been held.

NSF/DOE Joint Oversight Group was formed at the end of 2010, meets weekly. Twice yearly briefing of OSTP and OMB helps keep agency budget requests synchronized.

NSF scope is telescope, site, and data management. DOE scope is the camera.

LSST Planned NSF Funding



Planned LSST funding from FY 2016 Budget Request

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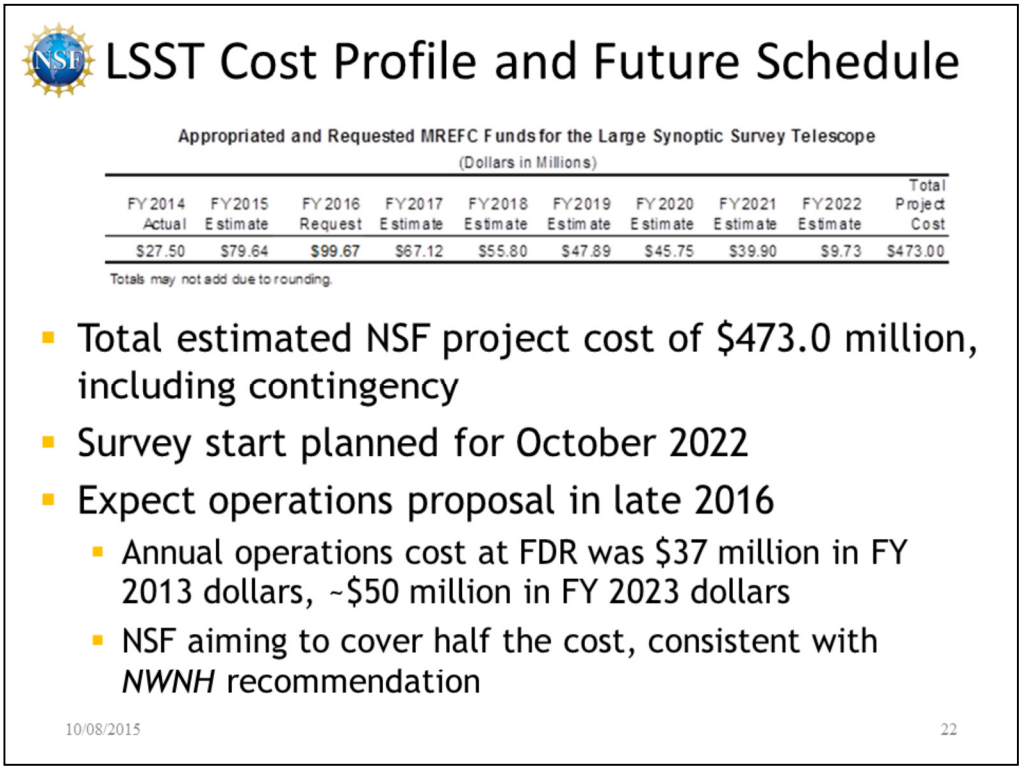
This is the budget profile shown in the FY 2016 budget request.



LSST Cost Profile and Future Schedule

Appropriated and Requested MREFC Funds for the Large Synoptic Survey Telescope

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	FY 2019 Estimate	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	Total Project Cost
$27.50	$79.64	$99.67	$67.12	$55.80	$47.89	$45.75	$39.90	$9.73	$473.00

Totals may not add due to rounding.

- Total estimated NSF project cost of $473.0 million, including contingency
- Survey start planned for October 2022
- Expect operations proposal in late 2016
  - Annual operations cost at FDR was $37 million in FY 2013 dollars, ~$50 million in FY 2023 dollars
  - NSF aiming to cover half the cost, consistent with *NWNH* recommendation

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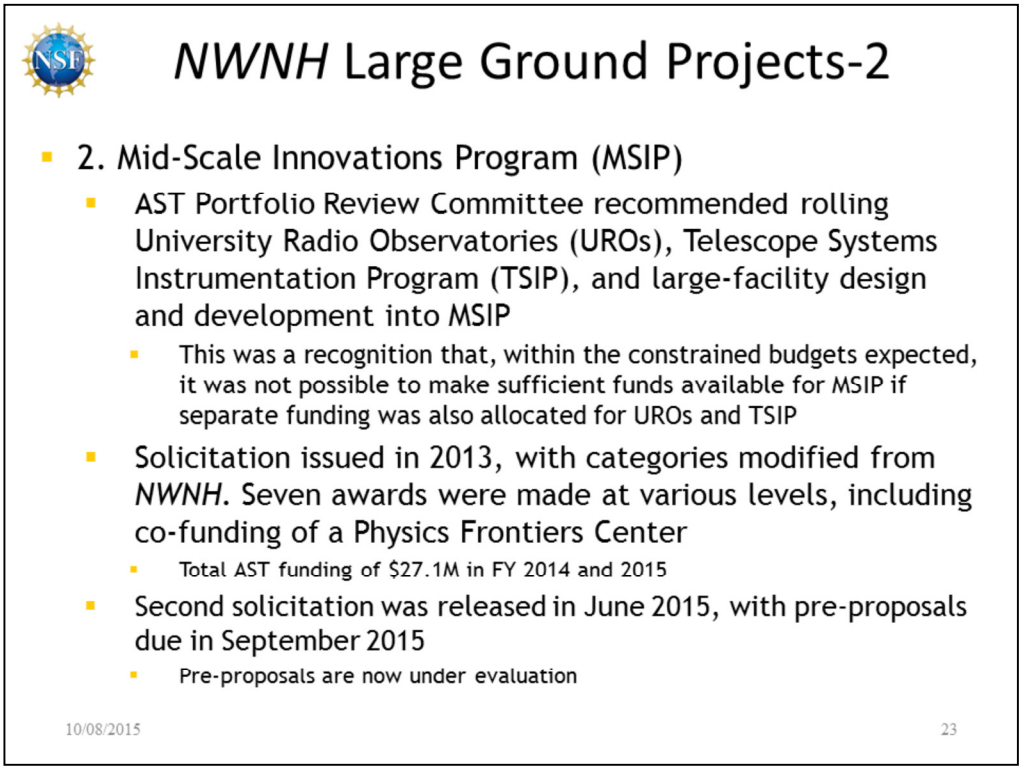
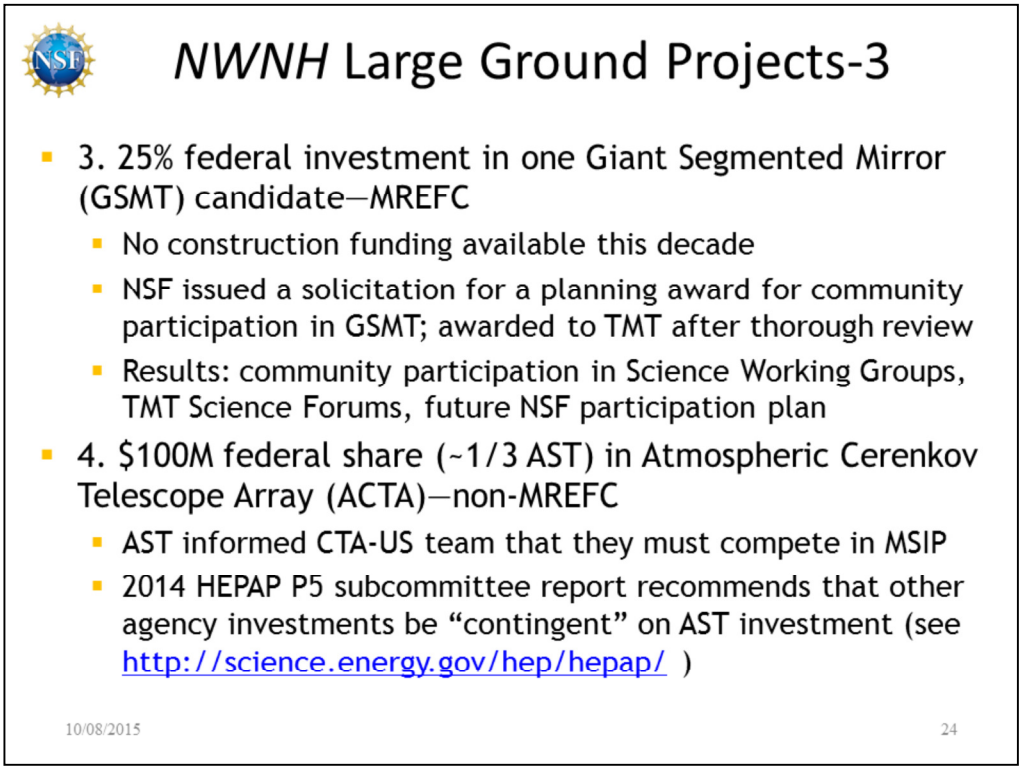
NWNH hypothesized a start in FY 2013. Getting a start in FY 2014 was a “miracle” brought about by hard work from the project, DOE, NSF, and especially the NSF program officer.

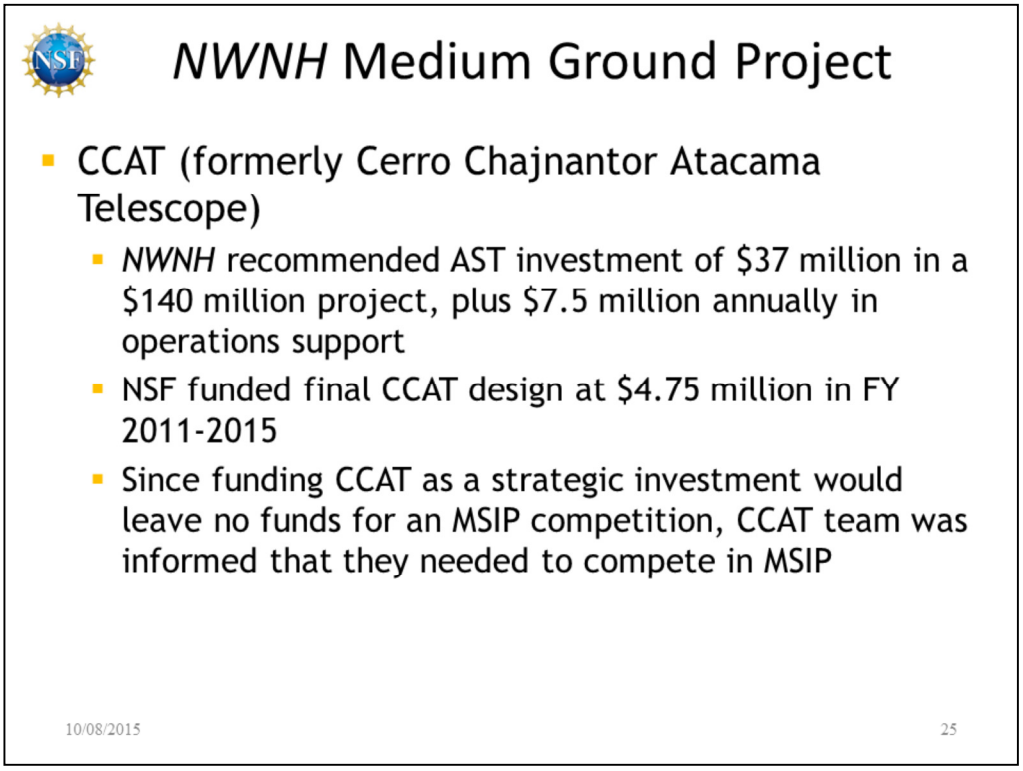


The 2015 solicitation is anticipated to lead to awards using FY 2016 and FY 2017 funds. Further details to be presented in separate MSIP talk.

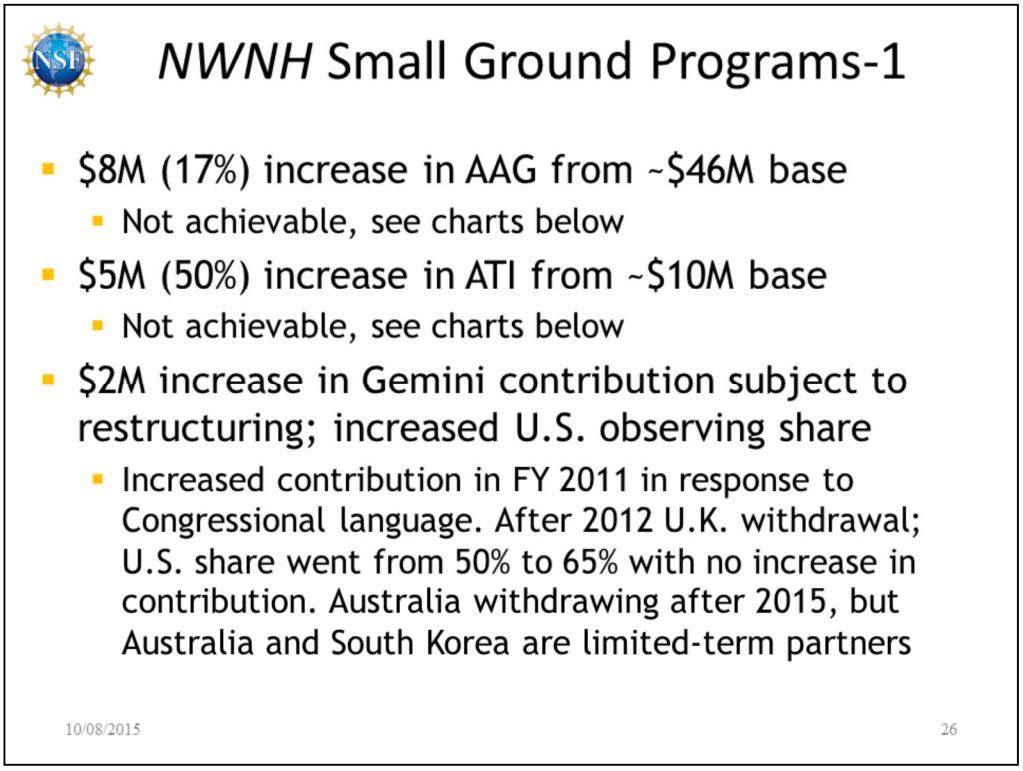


NSF has expressly made no commitment to construction of any GSMT, as written explicitly in the solicitation for the GSMT planning competition.

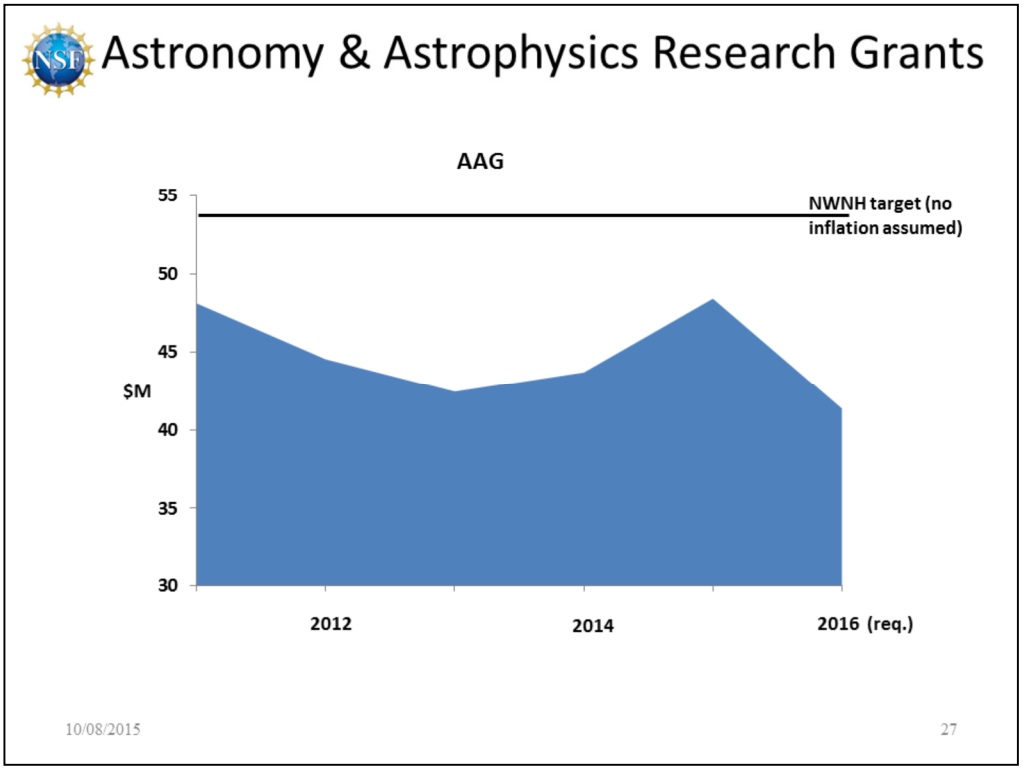
DOE is not presently funding further development of CTA. A telescope development project was funded in the NSF MRI line through a proposal reviewed by NSF-PHY. NSF and DOE sent a joint letter to the US-CTA team explaining the future outlook.



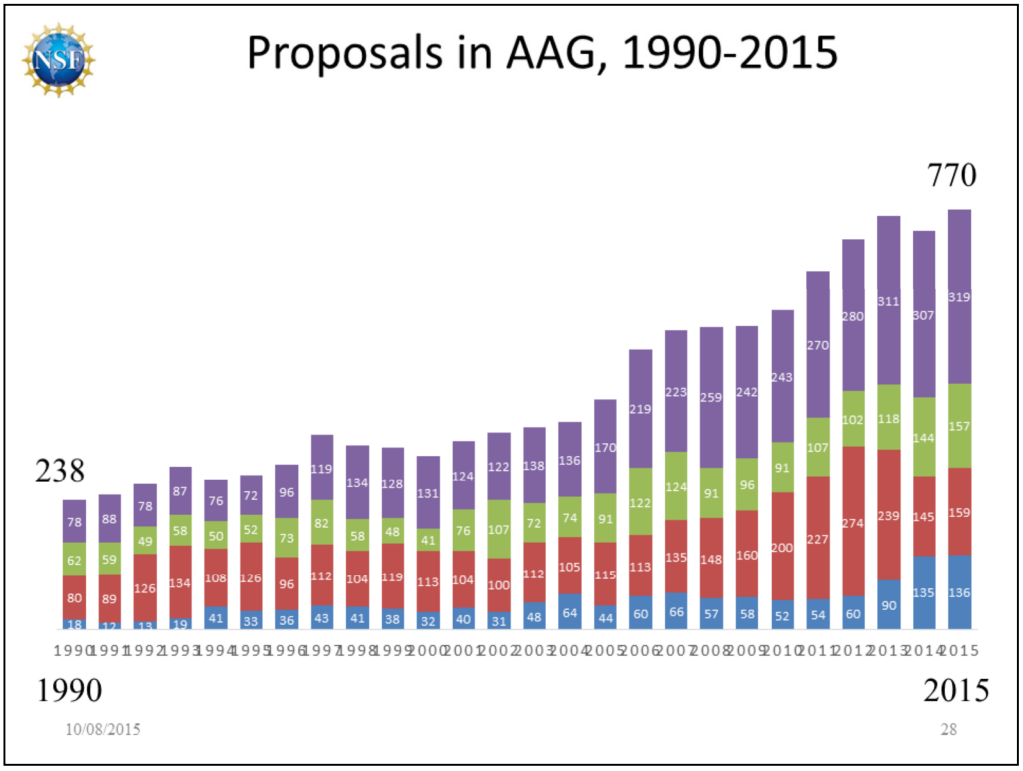
The NWNH-recommended CCAT investment is equal to approximately three years of MSIP funding with the MSIP definition that was recommended by the Portfolio Review, or about six years of funding in the NWNH definition (without UROs and TSIP folded into MSIP). Thus AST had to choose either (1) fund CCAT as a strategic initiative and have no MSIP program until late in the decade, or (2) fund an MSIP program. Since NWNH gave no priority between the only medium-size program and the second-ranked large program, the approach taken by AST was to let community-based merit review guide the decision of the relative priority between CCAT and other programs of mid-scale size.



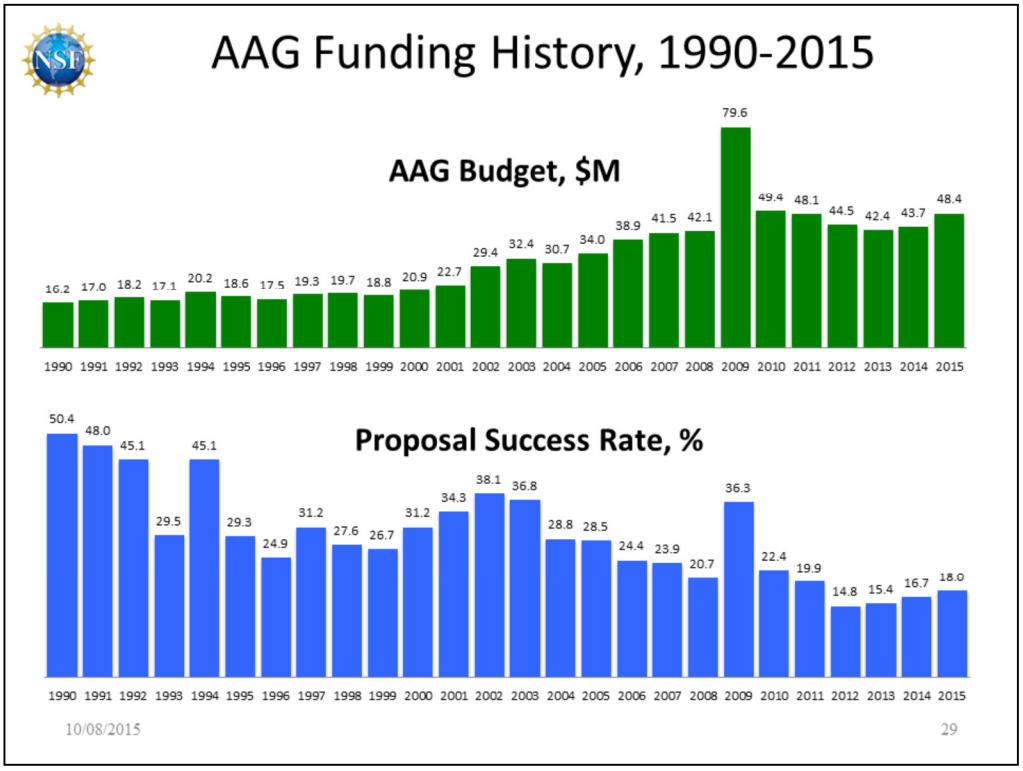
In a budget that has been flat in then-year dollars, and decreasing in purchasing power, with growing facility commitments, it has not been financially possible to fund the recommended increases in small programs. AST made a decision over the first half of the decade to ramp down the overall funding in the mid-scale size range (UROs, TSIP, other mid-scale) in order to protect the smaller individual investigator programs to the extent possible.



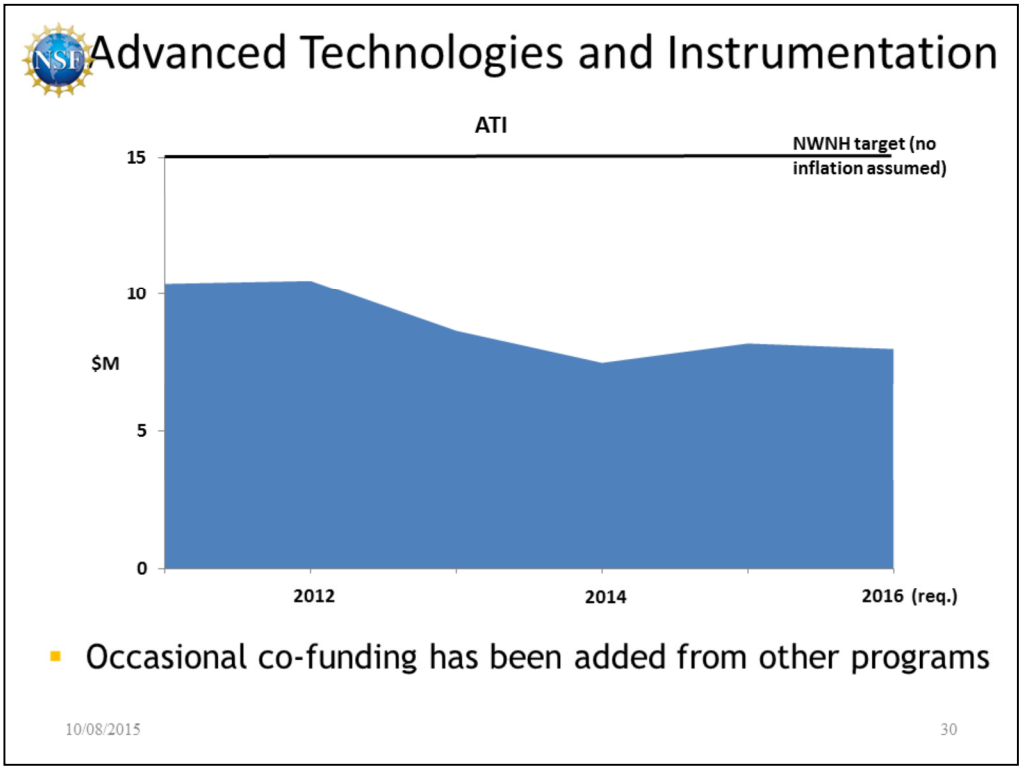
In each year, AST includes about $2-3 million in its request for individual investigator funds that are not initially allocated to a given program. This enables AST to take advantage of opportunities that come up during the year. In recent years, given the stress on the AAG program, most of these funds are re-allocated to AAG late in the fiscal year, enabling the achieved budget for AAG to be $2-3 million above the request. Of course, if the actual NSF appropriation for FY 2016 is below the President's Request Budget, this may not be possible in FY 2016.



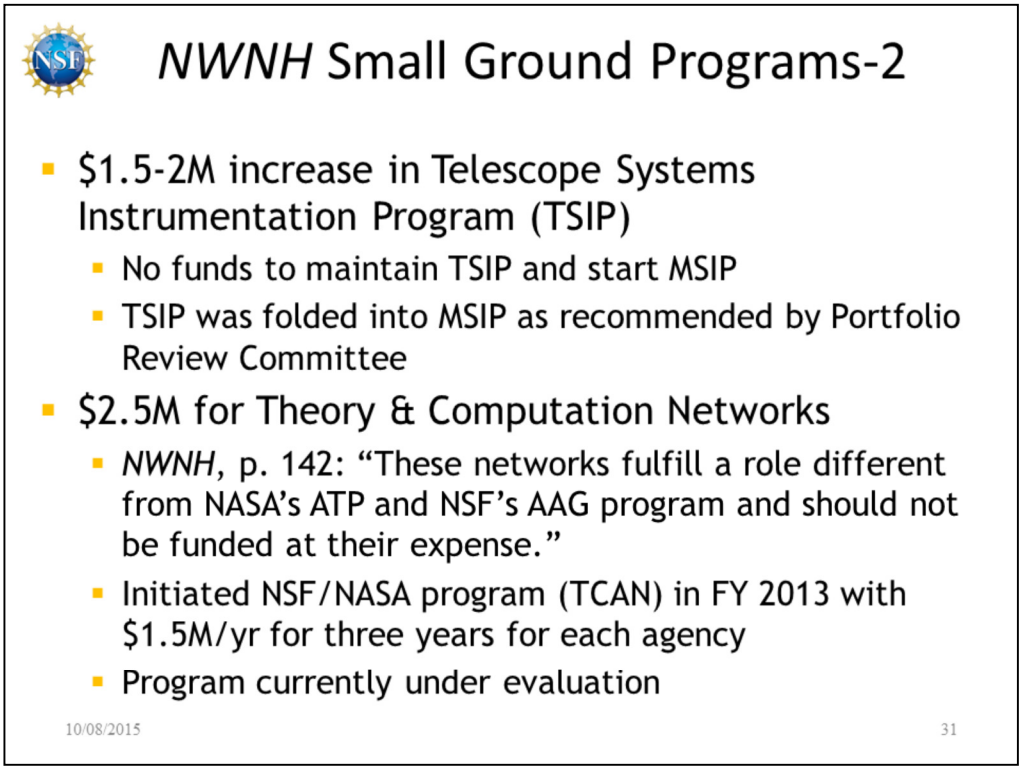
Number of proposals received may be leveling off. From the top, the different colors categorize proposals as EXC (Extragalactic Astronomy and Cosmology), GAL (Galactic Astronomy), SAA (Stellar Astronomy and Astrophysics), and PLA (Planetary and Exoplanetary Astronomy). The recent growth in PLA at the expense of SAA has been caused by redefining the PLA program to include exoplanet proposals, which used to be part of the SAA class.



The funding recovery in FY 2015 was made possible by several issues, including a slight budget increase for AST and the transition of LSST to the Major Research Equipment and Facility Construction line (hence removal from the AST base budget). The President's Request Budget for FY 2016 returns AAG closer to its 2012-2014 levels.

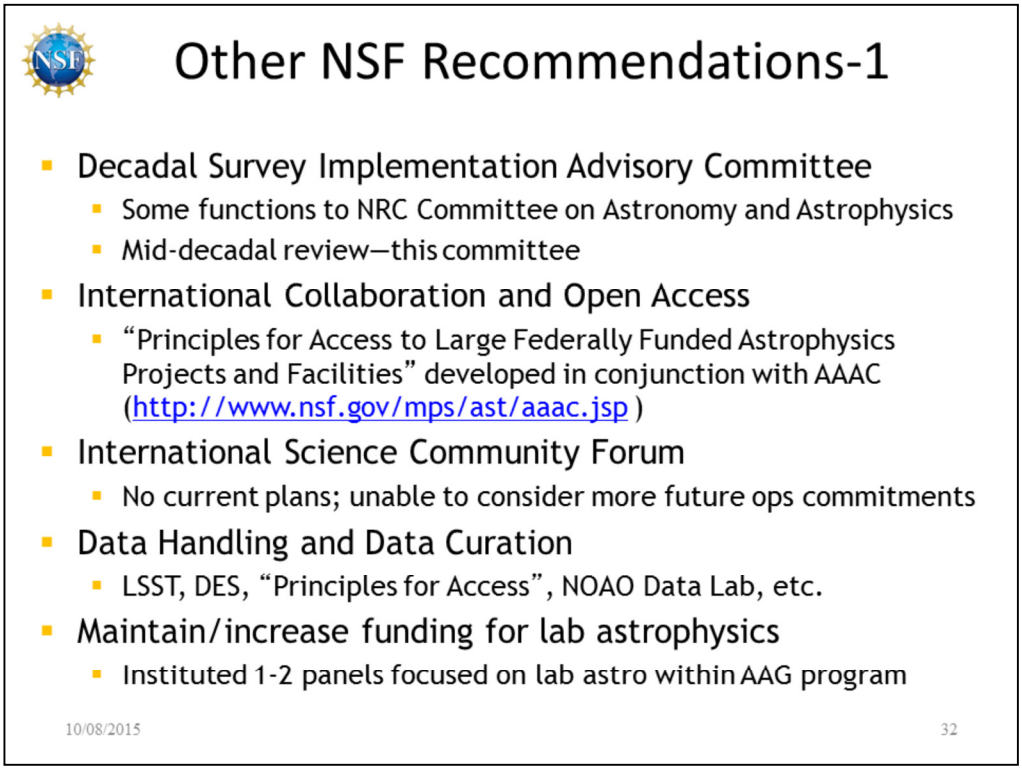


In recent years, AST has seen numerous investigators trying to squeeze pieces of mid-scale proposals into the ATI program, particularly in FY 2012 and FY 2013, before any MSIP funds were made available. In FY 2014 and FY 2015, ATI was allowed to decrease somewhat in order to enable allocation of more funds to MSIP. Since both ATI and MSIP programs are well below the levels recommended by NWNH, this portfolio balance has been guided by the recommendations of the Portfolio Review Committee and by the very high demand for MSIP in its initial call.



One of the weaknesses of TSIP was the lack of multi-year commitment of telescope time that would enable significant research programs to be carried out. Through MSIP, it is possible to have a commitment of telescope time up to five years. However, no TSIP-like proposals were funded in the first MSIP round, although some were invited for full proposals. In the second MSIP solicitation, AST stated the possibility of having a separate evaluation of open access proposals and will look at them closely for the possibility of similar community benefits.

DOE declined to participate in TCAN, believing that they already fund similar efforts through their existing research programs. (Note that the NWNH recommendation for DOE was only for $1 million/yr.) Funds for TCAN were not "taken away" from AAG, but given highly constrained budgets, it is inevitable that funds spent on TCAN are funds that are not available for other worthwhile programs.

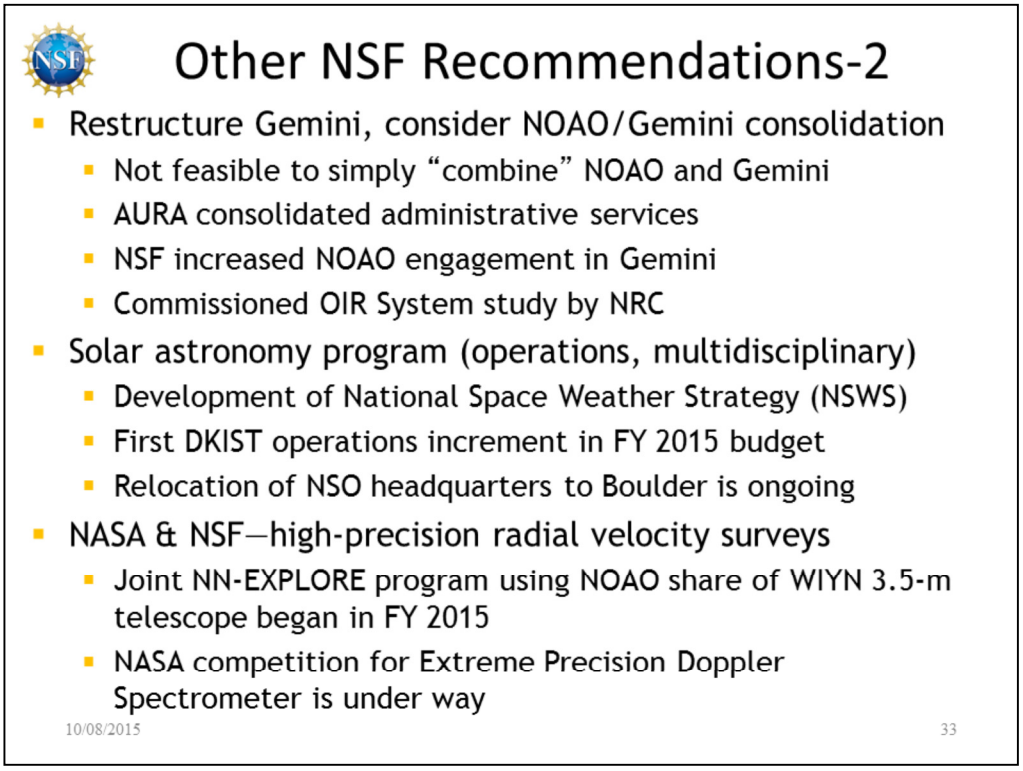


The "Principles for Access" are being applied to new collaboration possibilities. Adherence to the Principles is explicitly written into the NSF/NASA Memorandum of Agreement for the NN-EXPLORE exoplanet program.

For the International Science Forum, AST is unable to commit to additional large construction projects at this time, because it is not prudent to make future large operations commitments that might supersede any recommendations of the 2020 decadal survey. AST continues to talk to its international colleagues in the context of our ongoing partnerships on ALMA, Gemini, DKIST, and LSST, for example.

The primary mechanism for data handling and data curation has been through the national observatories and data availability from large surveys. NSF also has been funding individual programs that commit to making data available (e.g., digitizing the Harvard plates, Zwicky Transient Facility), and also is supporting the transition of NOAO and the development of the NOAO Data Lab as a way to make more useful data available to the community.

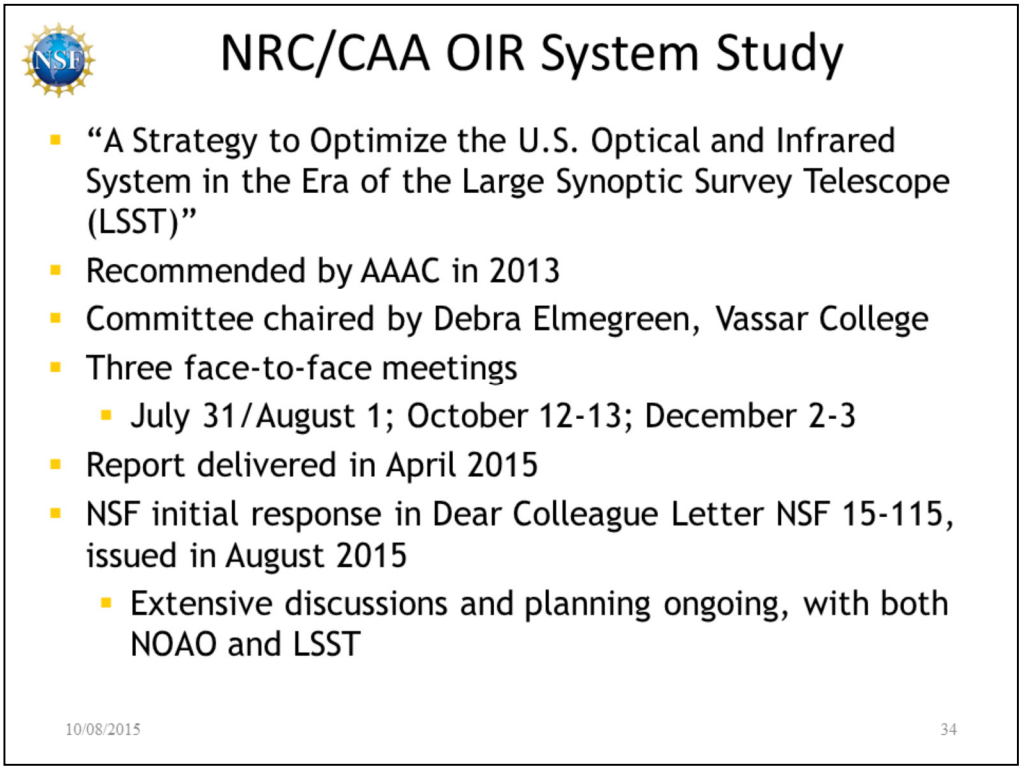
AST has chosen to form individual panels within the AAG program that focus on laboratory astrophysics, or combinations of laboratory astrophysics and modeling simulations, so that at least some such proposals rank at the top of panels and are highly likely to be funded. Typically, these panels have about 15 proposals to be evaluated.



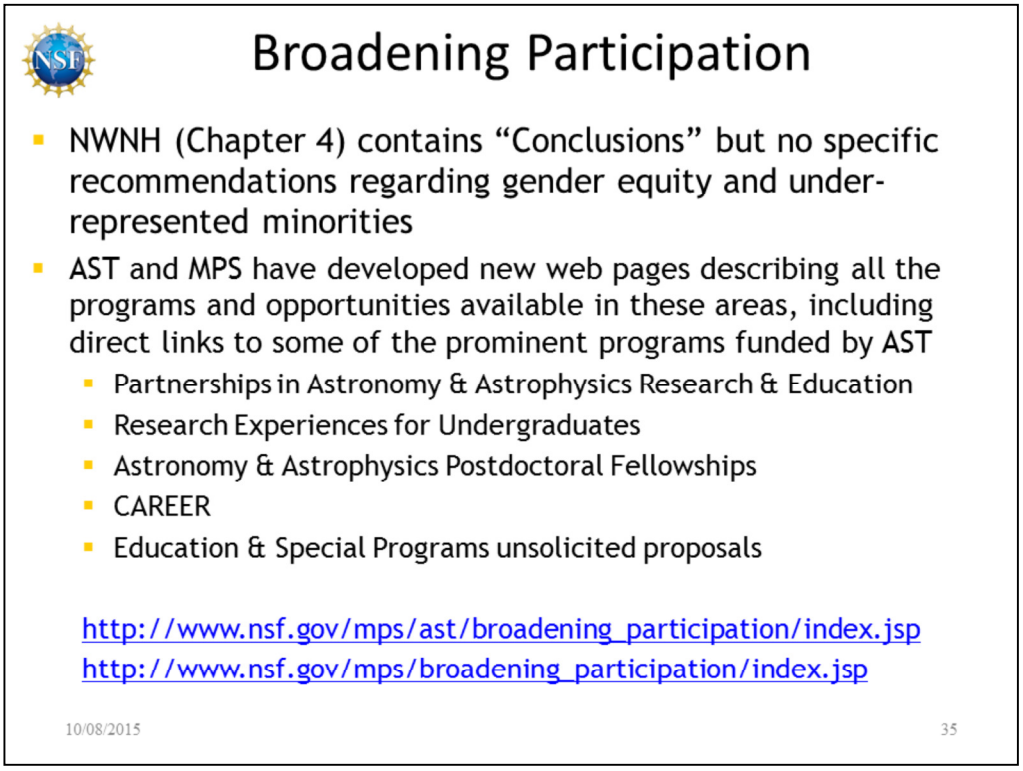
The increase in U.S. time on Gemini was covered in an earlier recommendation. NOAO staff members have been appointed to the Gemini Science and Technical Advisory Committee, and the NOAO Director was appointed to the Gemini Board by NSF. The OIR System committee was asked to consider science synergies between NOAO and Gemini, but made no specific recommendations along this line.

NSF-AST has been participating actively in a year-long, multi-agency effort for development of a National Space Weather Strategy, which has been released in draft form, and also was successful at getting an increase for robust GONG operations in the President's Budget Request for FY 2016. Support of DKIST operations began in FY 2015 and continues to ramp up in the FY 2016 Request.

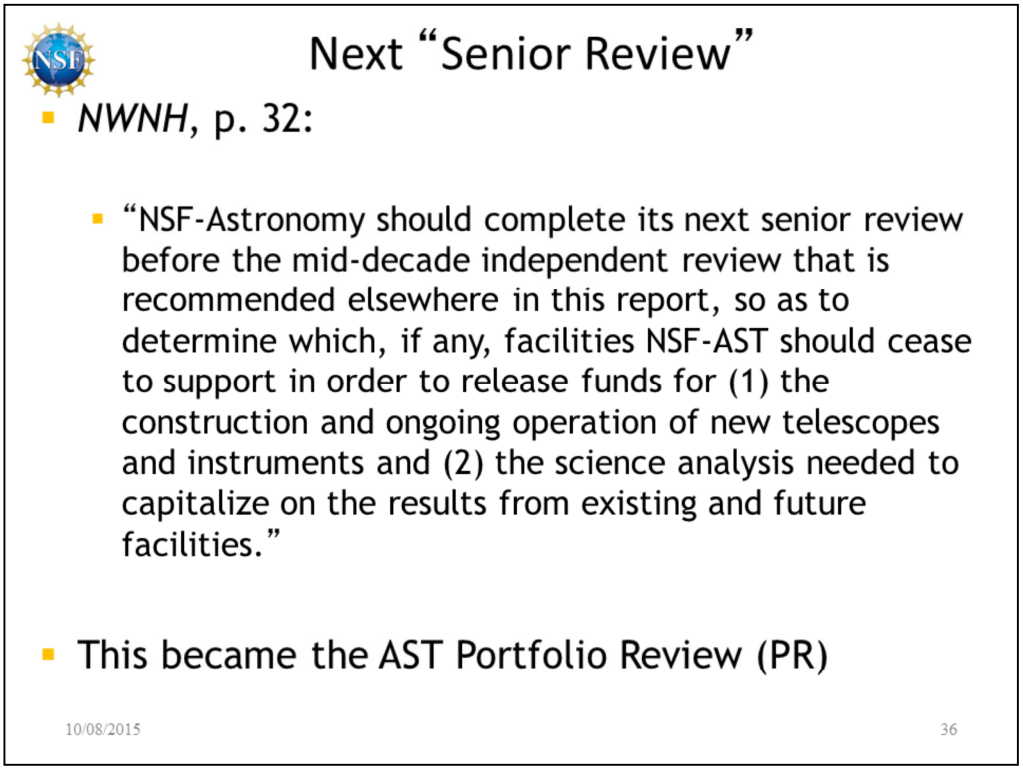
The NWNH recommendation to NSF for ground-based radial velocity surveys was within the New Worlds Technology Development Program recommended for NASA (NWNH, p. 20). The joint program involving the WIYN telescope will provide an improved capability to carry out the recommended high-precision surveys.



This report was not explicitly recommended by NWNH, but is responsive to the need to maximize the science return from LSST and the lengthy discussion of the status of the OIR system in NWNH (pp. 87-92). Specific recommendations are listed in the backup slides. The NSF responses to those recommendations are beyond the scope of this presentation, and are outside the scope of the mid-decadal review.

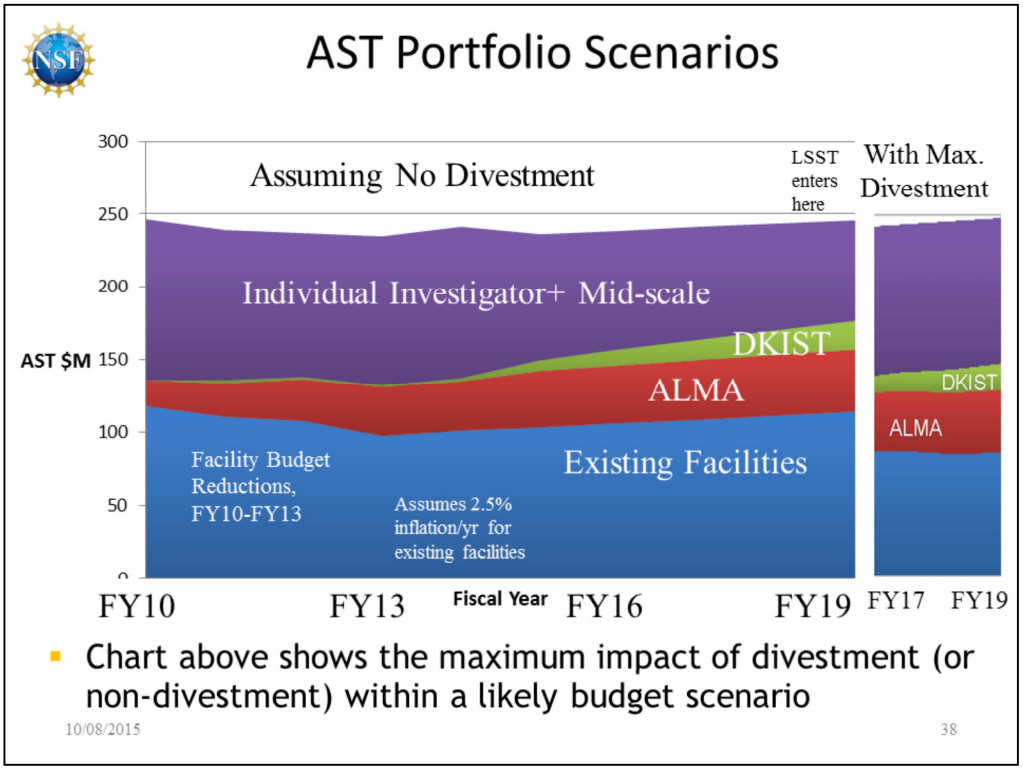


NWNH and similar reports would need "actionable" recommendations to generate concrete responses. For example, in the section on "Under-represented Minorities in Astronomy" (pp. 125-128 of NWNH), a listing of six possible approaches is given. The second of those is a partnership recommendation that is the goal of AST's PAARE program; an increase of PAARE from $1.0 million to $2.0 million is in the President's Request Budget for FY 2016.

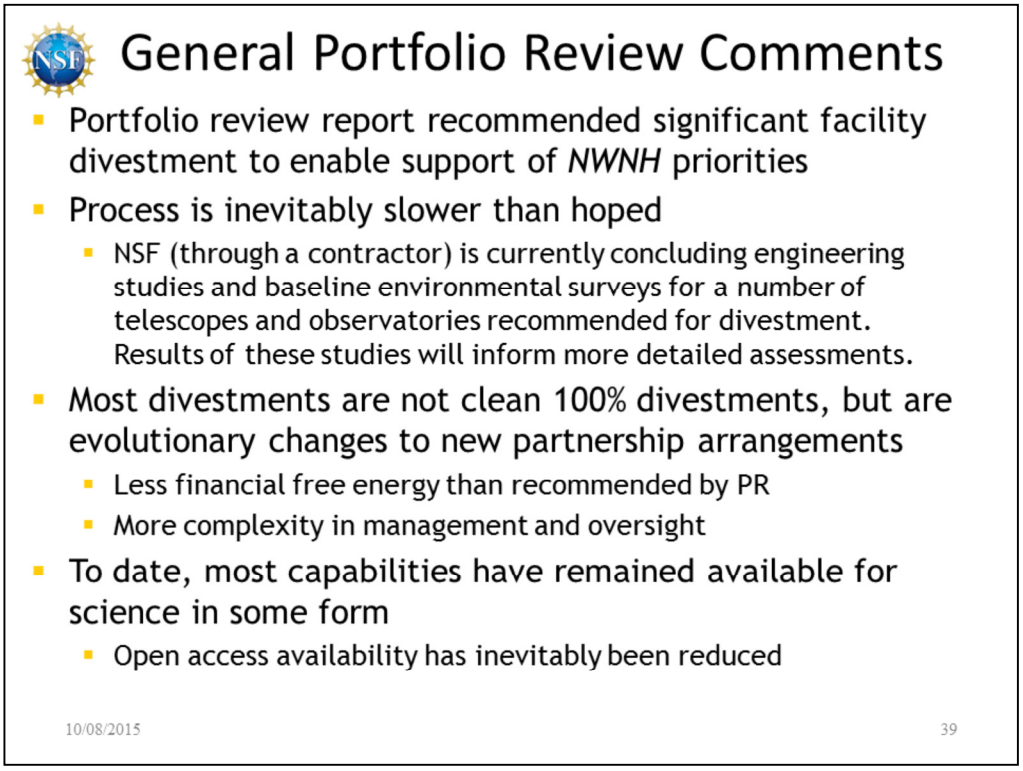


This NWNH recommendation was made independent of the highly constrained budget scenario. It became even more critical than had been envisioned by NWNH in the funding circumstances that have occurred.

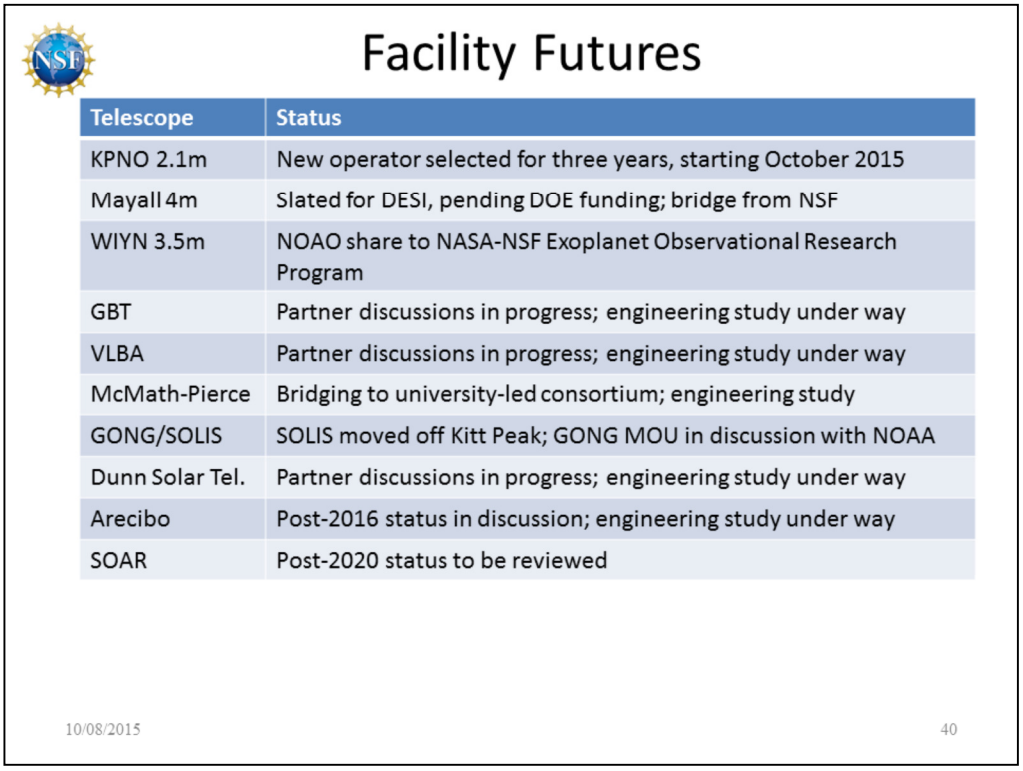
Portfolio Review Status



Facility divestment will not take place to the degree envisioned in the right-hand side of this chart, indicating that facilities will inevitably occupy a larger fraction of the AST budget in the latter half of the decade than they did in FY 2010.



Engineering/environmental studies have taken longer than hoped. They will yield data that NSF will use to determine feasible alternatives for any future formal environmental studies. See backup slide for more details of process.

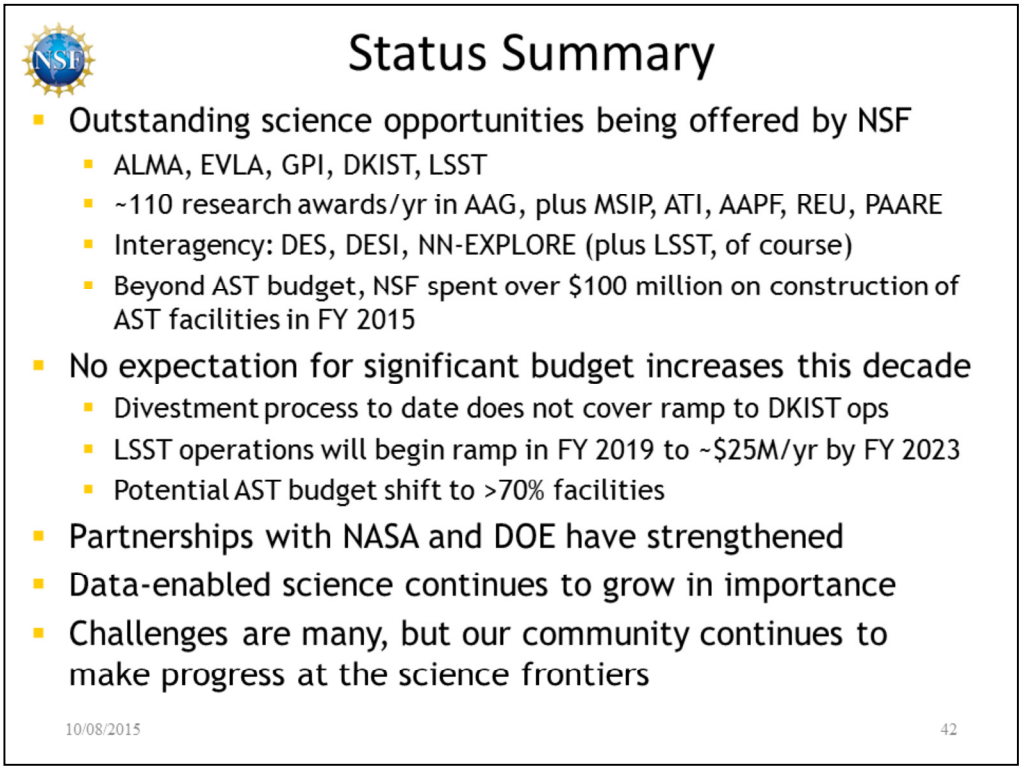


Facility Futures

Telescope	Status
KPNO 2.1m	New operator selected for three years, starting October 2015
Mayall 4m	Slated for DESI, pending DOE funding; bridge from NSF
WIYN 3.5m	NOAO share to NASA-NSF Exoplanet Observational Research Program
GBT	Partner discussions in progress; engineering study under way
VLBA	Partner discussions in progress; engineering study under way
McMath-Pierce	Bridging to university-led consortium; engineering study
GONG/SOLIS	SOLIS moved off Kitt Peak; GONG MOU in discussion with NOAA
Dunn Solar Tel.	Partner discussions in progress; engineering study under way
Arecibo	Post-2016 status in discussion; engineering study under way
SOAR	Post-2020 status to be reviewed

Note that the “divestment” process is evolutionary, and has no specific completion or end date. For example, the 2.1m on Kitt Peak has reached a stable state at the moment, but will require reconsideration after the 3-yr agreement expires. Many telescopes will not have reached final or metastable states by FY 2017, the goal laid out by the Portfolio Review report which turns out to have been more optimistic than can be achieved.

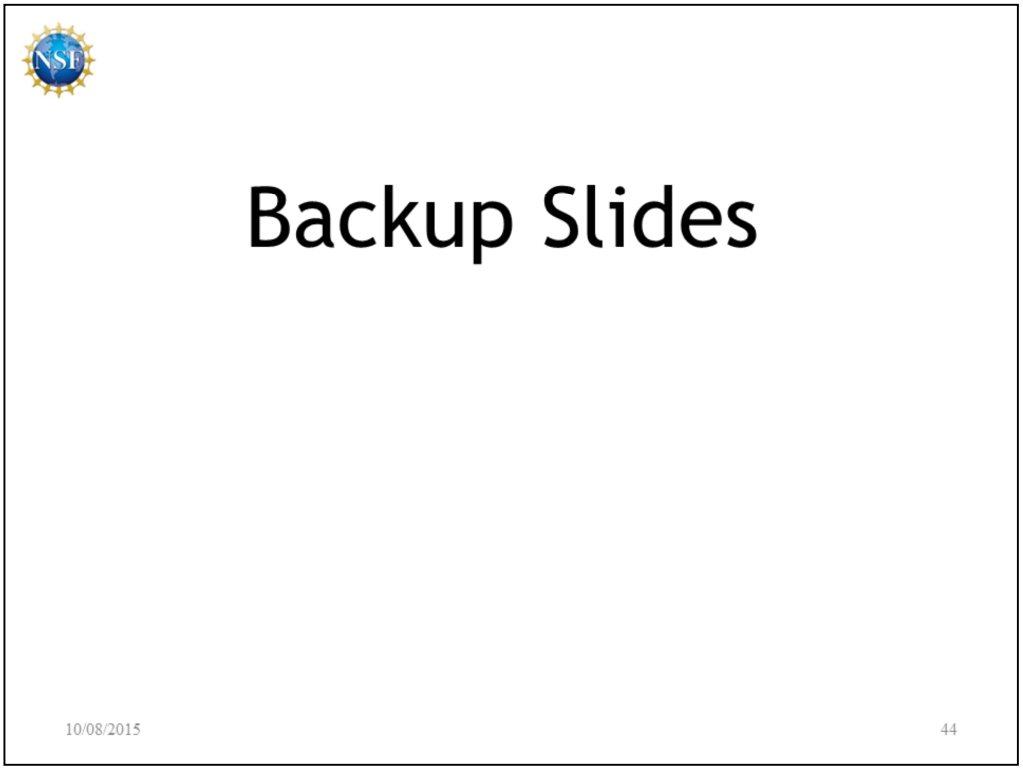
Summary



NSF and the U.S. taxpayers devote significant funding to programs overseen by AST, and both the community and the taxpayers receive substantial science capability and forefront research results from this investment.

Some Upcoming Strategy Issues

- Impact of facility divestment
  - Positive: some financial resources freed up; intellectual benefits of increased partnerships
  - Negative: partnership complexity, loss or restriction of some community capabilities
- Relation among NSF OIR observatories in Chile after initiation of LSST operations?
- Future relationships among telescopes on Maunakea?
- Facility choices take 5-10 years to implement, and are based on unknowable budgetary futures. What level of risk to grant funds is the community willing to accept in order to commit to operations of additional new facilities?
- What assumptions should be made for next decadal survey?


Backup Slides
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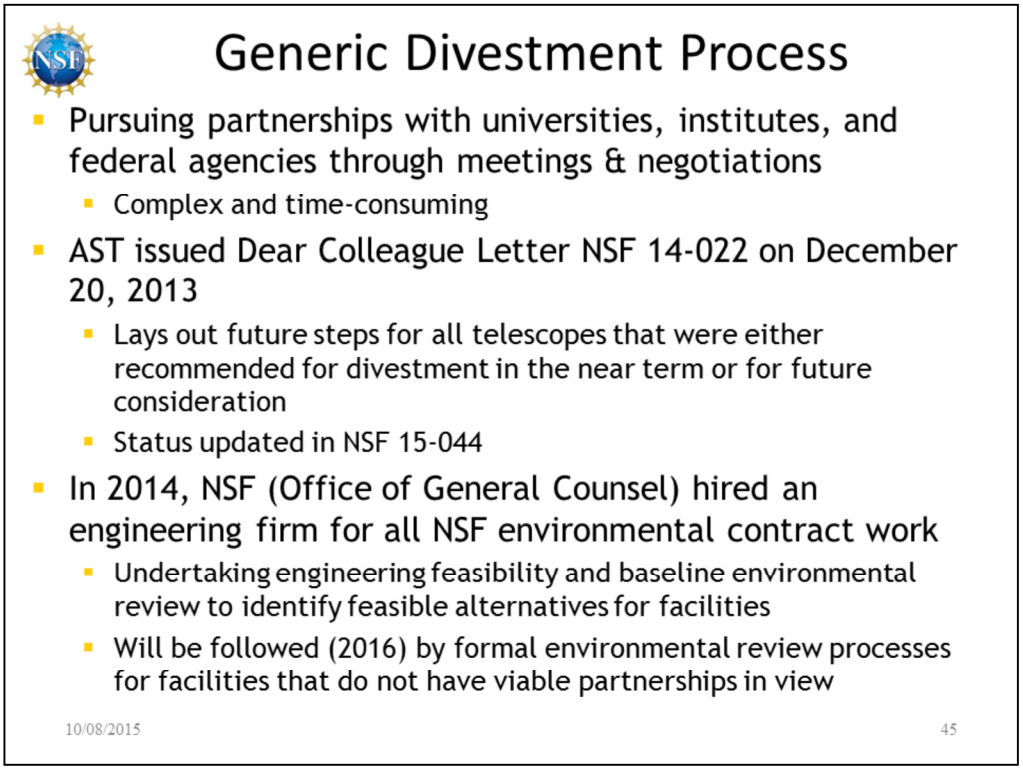

Many engineering studies will be finalized in late 2015 and early 2016.

Formal environmental review processes constitute studies of feasible alternatives and selection of alternatives.

The delays in engineering studies have provided three full years for partnerships to develop since the Portfolio Review report was delivered to NSF.

OIR System Recommendations-1

- R1: Direct NOAO to administer telescope-time exchange system
- R2: NOAO to lead community-wide planning process and facilitate System organizing committee. NSF would solicit proposals to meet prioritized capabilities.
- R3: Wide-field highly multiplexed spectroscopic capability
- R4a: Support development of event brokers for LSST
- R4b: Position Gemini-S for faint object spectroscopy early in era of LSST operations

OIR System Recommendations-2

- R4c: Ensure that OIR system time can be allocated for faint transient observations prioritized by LSST event broker
- R4d: Enhance coordination among federal telescopes in Southern Hemisphere to optimize LSST follow-up
- R5: Plan for an investment in one or both GSMTs
- R6: Continue to invest in development of critical technologies, including AO and precision RV
- R7: Coordinated suite of schools, workshops, and training networks for training in instrumentation, software, and data analysis