AURA Appoints New STScI Director
HUBBLE SPACE TELESCOPE

Continue studying full global images of Mars from ground and space-based observatories
Hubble 25th Anniversary Commendations

- To HST Team members – Government, Academic, Industry
- Over 1000 distributed via invitation, mailings continue
- 200+ to STScI employees
- 200+ to Ball Aerospace
- Planning ‘self-selection’ announcement

Presents this Hubble 25th Anniversary Commendation to:

Makenzie Lystrup
of the Hubble Space Telescope Industry Team
for contributions that rival the best that NASA has achieved
in innovation and overcoming challenges

Signed and sealed in Washington, DC, this seventh day of October in two thousand fifteen

Charles F. Bolden, Jr.
Administrator
Hubble Finds That the Nearest Quasar is Powered by a Double Black Hole

Optical-to-UV Spectrum of Markarian 231

Credit: NASA, ESA, and P. Jeffries (STScI)
Hubble Finds That the Nearest Quasar is Powered by a Double Black Hole

Artist’s View of a Binary Black Hole
NASA and ESA • STScI-PRC15-31a
Hubble Uncovers Clues of Earliest Galaxies

Credit: NASA, ESA, and K. Mitchell-Wynne (University of California, Irvine)
• The FY16 budget request provides funding for NASA astrophysics to continue its programs, missions, and projects as planned
  – The total funding (Astrophysics including JWST) is flat at ~$1.3B through FY20
  – Fully fund JWST to remain on plan for an October 2018 launch
  – Fund continued pre-formulation and technology work leading toward WFIRST; rate of progress depends on FY16 appropriation level
• The operating missions continue to generate important and compelling science results, and new missions are under development for the future
  – Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Swift, XMM-Newton all operating well; next Senior Review is Spring 2016 for FY17+; Suzaku mission ended
  – SOFIA is in prime operations as of May 2014; Senior Review is Spring 2018
  – WFIRST being studied, New Explorers being selected (SMEX in 2015, MIDEX in 2017), NASA joining ESA’s Athena and ESA’s L3 gravitational wave observatory
• Progress being made against recommendations of the 2010 Decadal Survey
  – Update to the Astrophysics Implementation Plan released in December 2014
  – NRC Mid Decade Review (with NSF, DOE) underway; Jackie Hewitt (MIT) is chair; report expected in May 2016
  – NASA initiating large mission concept studies as input for 2020 Decadal Survey
• All ongoing work continuing under FY16 Continuing Resolution
<table>
<thead>
<tr>
<th>Space Telescope/Project</th>
<th>LRD</th>
<th>EOPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hubble</td>
<td>1990</td>
<td>Delta SR; Hubble Panel Due Jan 22, 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Site Visit STScI March 8-10, 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NASA Direction: May-June 2016</td>
</tr>
<tr>
<td>Chandra</td>
<td>1999</td>
<td>Delta SR; Chandra Panel</td>
</tr>
<tr>
<td>XMM (ESA)</td>
<td>1999</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>Spitzer</td>
<td>2003</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>Swift</td>
<td>2004</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>Suzaku (JAXA)</td>
<td>2005</td>
<td>No review; EOM plan approved</td>
</tr>
<tr>
<td>Fermi</td>
<td>2008</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>Kepler/K2</td>
<td>2009</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>NuSTAR</td>
<td>2012</td>
<td>Standard SR; Main Panel</td>
</tr>
<tr>
<td>SOFIA</td>
<td>2014</td>
<td>Review NET 2018</td>
</tr>
<tr>
<td>LISA Pathfinder (ESA)</td>
<td>2015</td>
<td>Out of cycle review, if needed</td>
</tr>
<tr>
<td>LISA Pathfinder (ESA)</td>
<td>2016</td>
<td>Out of cycle review, if needed</td>
</tr>
</tbody>
</table>
Background – FY15 Budget provides $42M for NASA Science Education
• Why Restructure? To further enable NASA scientists and engineers to engage more effectively with learners of all ages. SMD will no longer have minimum of 1 percent set-asides through our missions, or issue disparate 3-year grants. But we are taking a strategic approach, building on our science-disciplined based legacy, and looking for new approaches given Stakeholder priorities.
• Objectives?
  • Enable STEM Education
  • Improve US Scientific Literacy
  • Advance National Educational Goals
  • Leverage Through Partnerships
• How? Through the competitive selection of organizations that utilize NASA data, products, or processes to meet education objectives; and by enabling our scientists and engineers with education professionals, tools, and processes to better meet user needs. Science Education Cooperative Agreement Notice posted at https://nspires.nasaprs.com/
  • Proposals submitted May 4, 2015
  • Selections announced Sept 25, 2015
Selections build upon legacy of excellence, balanced across diverse audiences, and fit within annual budget of $42M/year towards meeting NASA Science Mission Directorate’s desired Outcome and Objectives

- 27 of 73 compliant proposals selected (37%) for negotiations leading to cooperative agreement awards

- 15 are from “Legacy” institutions (56%)

- 3 selections support the 2017 Total Solar Eclipse, allowing for one full academic year of preparation

- Negotiations will be based on either full selection or partial selections based on peer evaluations or funding limitations

- Awards planned to be completed by the end of calendar year 2015
Nominal Federal Budget Cycle

<table>
<thead>
<tr>
<th>FY 2015</th>
<th>Negotiate Operating Plan</th>
<th>Execute Fiscal Year Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2016</td>
<td>Negotiate &amp; finalize budget proposal w/ OMB via passback &amp; appeals</td>
<td>Budget Release: • Budget Resolution 302(a) &amp; (b) alloc. • Hearings</td>
</tr>
<tr>
<td>FY 2017</td>
<td>Planning within Agency</td>
<td>Agencies receive strategic guidance from OMB</td>
</tr>
</tbody>
</table>

Start of Calendar Year 2015
We are here.
Start of Fiscal Year 2016
Congress is here.
Start of Calendar Year 2016

Adapted by Kevin Marvel (AAS)
https://aas.org/files/budgetprocess_adaptedfromaaas.jpg
from budget presentation by Matt Hourihan (AAAS)
http://www.aaas.org/page/presentations
Continues preformulation of WFIRST-AFTA as the “Astrophysics Decadal Strategic Mission.”

Grows Astrophysics Research and Analysis (including Astrophysics Data Analysis Program) from ~$80M/yr to ~$90M/yr in FY16.

Supports completion of missions under development, including LPF/ST7, ASTRO-H, NICER, TESS, and Euclid.

Enables selection of a SMEX mission and an Explorer Mission of Opportunity from the 2014 AO, and notional release of a MIDEX AO in late CY16/early FY17.

Provides full funding for SOFIA operations and places SOFIA into the 2016 Astrophysics Senior Review. (Subsequently SOFIA was deferred to the 2018 Senior Review.)

Plans for the 2016 Astrophysics Senior Review.

**Plans for continued Hubble operations through FY20 providing overlap with JWST.**

Plans for mission concept studies and technology development (within the three Program SR&T budgets) leading up to the 2020 Decadal Survey.

* Excludes “SMD STEM Activities” in all years.
Astrophysics Budget by Project
FY05-FY14 Actual, FY15 Op Plan, FY16-FY20 Request

Real Year $Million

FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16 FY17 FY18 FY19 FY20

includes SMD E/PO and SMD STEM activities

Managed by Astrophys Div
Managed by JWST Program
Total Astrophysics

JWST Program
Rest of Astrophysics
Astrophysics Budget by Project
FY05-FY14 Actual, FY15 Op Plan, FY16-FY20 Request

- JWST Program
- WFIRST-AFTA
- Rest of Astrophysics

includes SMD E/PO and SMD STEM activities
## FY16 Congressional Appropriation Markups

<table>
<thead>
<tr>
<th></th>
<th>FY15 Approp</th>
<th>FY16 Pres Request</th>
<th>FY16 House Budget</th>
<th>Delta House vs Request</th>
<th>FY16 Senate Budget</th>
<th>Delta Senate vs Request</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status</strong></td>
<td></td>
<td></td>
<td>Appropriation passed full House</td>
<td>Appropriation sent from Committee to Senate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NASA</td>
<td>18,010.2</td>
<td>18,529.1</td>
<td>18,529.1</td>
<td>0</td>
<td>18,289.5</td>
<td>-239.6</td>
</tr>
<tr>
<td>SMD</td>
<td>5,244.7</td>
<td>5,288.6</td>
<td>5,237.5</td>
<td>-51.1</td>
<td>5,295.0</td>
<td>+6.4</td>
</tr>
<tr>
<td>JWST</td>
<td>645.4</td>
<td>620.0</td>
<td>620.0</td>
<td>0</td>
<td>620.0</td>
<td>+0</td>
</tr>
<tr>
<td>Astrophysics w/ SMD Education</td>
<td>726.8</td>
<td>709.1</td>
<td>735.6</td>
<td>+26.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astrophysics w/o SMD Education</td>
<td>684.8</td>
<td>689.1</td>
<td></td>
<td></td>
<td>730.6</td>
<td>+41.5</td>
</tr>
<tr>
<td>WFIRST</td>
<td>50.0</td>
<td>14.0</td>
<td>49.8</td>
<td>+35.8</td>
<td>90.0</td>
<td>+76.0</td>
</tr>
<tr>
<td><strong>Hubble</strong></td>
<td><strong>98.6</strong></td>
<td><strong>97.1</strong></td>
<td></td>
<td></td>
<td><strong>98.3</strong></td>
<td>+1.2</td>
</tr>
<tr>
<td>SOFIA</td>
<td>70.0</td>
<td>85.2</td>
<td></td>
<td></td>
<td>85.2</td>
<td>+0</td>
</tr>
<tr>
<td>Rest of Astrophysics</td>
<td>634.8</td>
<td>675.1</td>
<td>653.8</td>
<td>-21.3</td>
<td>653.8</td>
<td>-35.7</td>
</tr>
<tr>
<td>SMD Education</td>
<td>42.0</td>
<td>20.0</td>
<td>32.0</td>
<td>+12.0</td>
<td>42.0</td>
<td>+22.0</td>
</tr>
</tbody>
</table>
# FY16 Congressional Appropriation Markups

<table>
<thead>
<tr>
<th>Astrophysics Project</th>
<th>House Language (paraphrased)</th>
<th>Senate Language (paraphrased)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Follow the Decadal Survey</td>
<td>Follow the Decadal Survey</td>
</tr>
<tr>
<td>JWST</td>
<td>Do not overrun</td>
<td>Do not overrun</td>
</tr>
<tr>
<td>WFIRST</td>
<td>Include coronagraph; accelerate exoplanet program</td>
<td>Accelerate formulation start, with goal of KDP-A by January 15, 2016</td>
</tr>
<tr>
<td><strong>Hubble</strong></td>
<td></td>
<td><strong>Hubble is wonderful</strong></td>
</tr>
<tr>
<td>SOFIA</td>
<td>Do not put SOFIA in 2016 Senior Review; do not terminate SOFIA</td>
<td>Any SOFIA participation in 2016 Senior Review is only for practice</td>
</tr>
<tr>
<td><strong>Explorers</strong></td>
<td></td>
<td>Increase AO frequency to at least every 3 years with goal of every 2 years</td>
</tr>
<tr>
<td>Kepler</td>
<td></td>
<td>Kepler has revolutionized the pace of planet finding</td>
</tr>
<tr>
<td>SMD Education</td>
<td>Reallocate funds among Divisions</td>
<td>APD should administer SMD-wide education activities</td>
</tr>
</tbody>
</table>
Assumes (1) President’s FY16 budget request and notional runout through FY20, (2) flat funding for Astrophysics for FY21 through FY35, (3) completion of WFIRST-AFTA and other missions planned for new starts in FY16-FY20.
Astrophysics Missions in Development

**LISA Pathfinder**
- ESA-led Mission
- NASA supplied the ST7/Disturbance Reduction System (DRS)
- 12/2015

**ASTRO-H**
- JAXA-led Mission
- NASA supplied the Soft X-ray Spectrometer (SXS) instrument
- 11/2015 (NET)

**NICER**
- NASA Mission
- Neutron Star Interior Composition Explorer
- 8/2016

**TESS**
- NASA Mission
- Transiting Exoplanet Survey Satellite
- 8/2017

**JWST**
- NASA Mission
- James Webb Space Telescope
- 10/2018

**Euclid**
- ESA-led Mission
- NASA is supplying the NISP Sensor Chip System (SCS)
- 2020
Large Infrared Space Observatory
Top priority of 2000 Decadal Survey

Science themes: First Light; Assembly of Galaxies; Birth of Stars and Planetary Systems; Planetary Systems and the Origins of Life

Mission: 6.5m deployable, segmented telescope at L2, passively cooled to <50K behind a large, deployable sunshield

Instruments: Near IR Camera, Near IR Spectrograph, Mid IR Instrument, Near IR Imager and Slitless Spectrograph

Operations: 2018 launch for a 5-year prime mission

Partners: ESA, CSA

FY2015 Accomplishments
- Completed instrument hardware replacements, and prepared ISIM for its final test before integration with the telescope
- Completed MIRI cryocooler flight units
- Conducted tests at JSC in preparation for 2016 full telescope plus ISIM test
- Delivered spacecraft bus structure to I&T

FY2016 Plans
- Assemble the Telescope
- Complete ISIM testing and integrate with the telescope
- Complete sunshield membrane manufacturing
- Begin integration of spacecraft bus components (e.g. electronics, propulsion) with the spacecraft bus structure
Astrophysics Missions in Pre-Formulation

WFIRST-AFTA

SMEX / MO – 2019/2020
see next chart for list of selections

MIDEX / MO – 2022/2023

WFIRST-AFTA – NLT 2026

Athena – 2028

All launch dates notional
Executive Summary

- Huge progress on WFIRST over the past two years
- SDT studies & NRC Harrison committee report confirm that WFIRST-AFTA exceeds NWNH requirements in all areas.
- $107M in FY14 & 15 has enabled major steps forward and NRC-Harrison committee recommendations have been addressed (H4RGs, coronagraph, mission design). Planning against $56M in FY16, exact amount depends on appropriations.
- Coronagraph on track, technology development on schedule. Wide Field detector technology development on schedule
- SDT 2014 & 15 studies completed
- Preparatory Science teams selected
- Pasadena conferences held
- Special session at AAS's & IAU
- Science team NRA released
- Industry study RFIs received
- Significant international interest (Canada, ESA, Japan, Korea)