ExoPAG TERMS OF REFERENCE
https://exep.jpl.nasa.gov/reportsAndDocuments

• ExoPAG: solicits and organizes community input into the development and execution of NASA’s Exoplanet Explorer Program (ExEP)

• Using the widest possible community outreach:
  - Articulate the key scientific drivers for exoplanet research
  - Evaluate the expected capabilities of potential missions
  - Articulate new technology focus areas
  - Identify related activities that enhance the ExEP, e.g. –
    • Ground-based observing
    • Theory & modeling
    • Community engagement
  - Regularly (re)evaluate ExEP goals and priorities
FY15 appropriation and FY16 budget request provide funding for NASA astrophysics to continue programs, missions, and projects as planned:

- Total funding (Astrophysics+JWST) is flat at ~$1.3B through FY20

- Fully fund JWST to remain on Oct 2018 launch plan

- Fund continued pre-formulation and technology work leading toward WFIRST-AFTA

- Restore SOFIA to the budget with a reduction in FY15 and full funding beyond

- Provide funding for SMD’s education programs
• Operating missions continue to generate important, compelling science results

  - Following the 2014 Senior Review, Chandra, Fermi, HST, Kepler/K2, NuSTAR, Spitzer, Suzaku, Swift, and XMM-Newton continue science operations

  - SOFIA is in prime operations as of May 2014

  - Next Senior Review is 2016, includes SOFIA
• New missions are under development for the future


- WFIRST-AFTA is being studied

- New Explorers are 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 Dec 2014 (http://science.nasa.gov/astrophysics/documents)

- NRC Mid Decade Review (with NSF, DOE) to begin in mid-2015

- NASA identifying concept studies for 2020 Decadal Survey
Notes

- Provides $77M more than the President’s Budget Request for FY15
- Includes $50M for continued pre-formulation of WFIRST-AFTA, an increase of $36M over the Administration request
- Includes $70M for continued SOFIA operations. Reduction of $14M from FY14. Directs NASA to
  a) seek partners to restore SOFIA to its full level, and
  b) not terminate mission without a Senior Review
- Includes $38M for scientific ballooning, an increase of $5M (15%) from FY14
- $42M for Education SMD-wide as a separate budget line (E/PO is no longer budgeted as 1% of every mission)
### Notes

- Continues pre-formulation of WFIRST-AFTA
- Supports completion of JWST for 2018 launch
- Supports completion of LPF/ST7, ASTRO-H, NICER, TESS, Euclid
- Plans for continued Hubble operations through FY20, providing overlap with JWST
- Provides full funding for SOFIA operations
- Grows Astrophysics Research and Analysis from ~$80M/yr to ~$90M/yr
- Enables selection of SMEX and Explorer Mission of Opportunity from the 2014 AO
- Enables notional release of a MIDEX AO in late-2016
- Plans for mission studies and technology development leading to 2020 Decadal Survey

---

**FY16 Budget (Administration’s Plan)**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Astrophysics*</td>
<td>$678M</td>
<td>$685M</td>
<td>$689M</td>
<td>$707M</td>
<td>$750M</td>
<td>$986M</td>
<td>$1,118M</td>
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<tr>
<td>JWST</td>
<td>$658M</td>
<td>$645M</td>
<td>$620M</td>
<td>$569M</td>
<td>$535M</td>
<td>$305M</td>
<td>$198M</td>
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*Excludes “SMD STEM Activities” in all years
# FY16 BUDGET (HOUSE-SIGNED)

<table>
<thead>
<tr>
<th>($M)</th>
<th>FY15 Appropriation</th>
<th>FY16 Request</th>
<th>FY16 House Mark-up</th>
<th>Δ$</th>
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<tbody>
<tr>
<td>NASA</td>
<td>18,010.2</td>
<td>18,529.1</td>
<td>18,529.1</td>
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<tr>
<td>SMD</td>
<td>5,244.7</td>
<td>5,288.6</td>
<td>5,237.5</td>
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<tr>
<td>JWST</td>
<td>645.4</td>
<td>620.0</td>
<td>620.0</td>
<td>0</td>
</tr>
<tr>
<td>Astrophysics</td>
<td>726.8</td>
<td>709.1</td>
<td>735.6</td>
<td>+26.5</td>
</tr>
<tr>
<td>WFIRST</td>
<td>50.0</td>
<td>14.0</td>
<td>49.8</td>
<td>+35.8</td>
</tr>
<tr>
<td>SMD Education</td>
<td>42.0</td>
<td>20.0</td>
<td>32.0</td>
<td>+12.0</td>
</tr>
<tr>
<td>Rest of Astroph</td>
<td>634.8</td>
<td>675.1</td>
<td>653.8</td>
<td>-21.3</td>
</tr>
</tbody>
</table>

## Notes

- Increase WFIRST-AFTA to $50M, include coronagraph development
- Prohibit SOFIA from 2016 Senior Review (as it is in prime-mission phase)
- Increase E/PO and STEM funding to $32M
ASTROPHYSICS TIMELINE

- Decadal Survey Mission
- MIDEIX/MO (AO NET 2016)
- Euclid (ESA)
- SMEX/MO (AO 2014)
- JWST (ESA, CSA)
- TESS
- NICER
- ASTRO-H (JAXA)
- ST-7/LPF (ESA)
- ISS-CREAM (South Korea)
- SOFIA (DLR)
- NuSTAR (ASI, Denmark)
- Kepler
- Fermi (DOE, Intl team)
- Suzaku (JAXA)
- Swift (ASI, UK)
- Spitzer
- XMM-Newton (ESA)
- Chandra (SRON)
- Hubble (ESA)

TIMELINE CY
ASTROPHYSICS

Decadal Survey Missions

1972
Decadal Survey
Hubble

1982
Decadal Survey
Chandra

1991
Decadal Survey
Spitzer, SOFIA

2001
Decadal Survey
JWST

2010
Decadal Survey
WFIRST
• **Study 3-4 concepts as prioritized candidate large missions**
  - Science case
  - Technology assessment
  - Design reference mission with strawman payload
  - Cost assessment

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>PAGs gather community input on selecting concepts for study</td>
</tr>
<tr>
<td>2016</td>
<td>Appoint Science Technology Definition Teams (STDTs) and Center study offices, STDTs assess technology</td>
</tr>
<tr>
<td>2017</td>
<td>Fund technology development through Strategic Astrophysics Technology (SAT)</td>
</tr>
<tr>
<td>2018</td>
<td>STDT submits Design Reference Mission (DRM) for cost assessment</td>
</tr>
<tr>
<td>2019</td>
<td>STDT issues report ➔ input to Decadal Survey</td>
</tr>
</tbody>
</table>
## PREPARING FOR THE 2020 DECADAL SURVEY
### Potential Large Mission Concepts

<table>
<thead>
<tr>
<th>Mission</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitable-Exoplanet Imaging Mission (HabEx)</td>
<td>The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 decadal survey.</td>
</tr>
</tbody>
</table>
| UV/Optical/IR Surveyor                 | i) The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 Decadal Survey  
ii) The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor as contributing through improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage. |
| FAR IR Surveyor                        | The Astrophysics Visionary Roadmap identifies a Far-IR Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.                                                           |
| X-ray Surveyor                         | The Astrophysics Visionary Roadmap identifies an X-ray Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.                                                               |
## 2015 ROSES AND GO OPPORTUNITIES

<table>
<thead>
<tr>
<th>Proposal Opportunity</th>
<th>Due Date</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kepler K2 Guest Observer – Cycle 2</td>
<td>Feb 27</td>
<td>ROSES-14</td>
</tr>
<tr>
<td>Astrophysics R&amp;A (APRA)</td>
<td>Mar 20</td>
<td>ROSES-14</td>
</tr>
<tr>
<td>Strategic Astrophysics Technology (SAT)</td>
<td>Mar 20</td>
<td>ROSES-14</td>
</tr>
<tr>
<td>Hubble Space Telescope – Cycle 23</td>
<td>Apr 10</td>
<td><a href="http://www.stsci.edu/hst">www.stsci.edu/hst</a></td>
</tr>
<tr>
<td>Astrophysics Data Program (ADAP)</td>
<td>May 15</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>Exoplanet Research Program (XRP)</td>
<td>May 22</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>SOFIA – Cycle 4</td>
<td>Jul 10</td>
<td><a href="http://www.sofia.usra.edu">www.sofia.usra.edu</a></td>
</tr>
<tr>
<td>Spitzer Space Telescope – Cycle 12</td>
<td>Sep 11</td>
<td>ssc.spitzer.caltech.edu</td>
</tr>
<tr>
<td>WFIRST Formulation Science</td>
<td>Sep 28</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>Kepler K2 Guest Observer – Cycle 3</td>
<td>Sep 23</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>N.G. Roman Technology Fellowships (RTF)</td>
<td>Nov 6</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>SOFIA 3\textsuperscript{rd} Generation Instrumentation</td>
<td>Pending</td>
<td>ROSES-15</td>
</tr>
<tr>
<td>Astrophysics Theory Program (ATP)</td>
<td>Not this year</td>
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</tr>
</tbody>
</table>

ROSES: https://nspires.nasaprs.com
ASTROPHYSICS DIVISION STAFF
visiting positions often available

Keck
PS: Hashima Hasan
PE: Mario Perez

Exoplanet Exp. Program
Program Scientist: Doug Hudgins
Deputy-PS: Martin Still
Program Executive: John Gagosian

LBTI
PS: Hashima Hasan
PE: Mario Perez

NExScI
PS: Hashima Hasan
PE: Mario Perez

Kepler
PS: Debra Wallace
Dep-PS: Mario Perez
PE: Keith Chamberlin

WFIRST-AFTA
PS: Dominic Benford
Dep-PS: Doug Hudgins
PE: John Gagosian

TESS
PS: Doug Hudgins
Dep-PS: Martin Still
PE: Mark Sistilli

JWST
Program Dir: Eric Smith
PS: Hashima Hasan

HST
PS: Mike Garcia
Dep-PS: Debra Wallace
PE: John Gagosian

XRP
PS: Mario Perez
Dep-PS: Martin Still
Backup
# Astrophysics Division - Science Mission Directorate

**Director**
Paul Hertz

**Deputy Director**
Andrea Razzaghi

**Lead Secretary:** Kelly Johnson  
**Secretary:** Leslie Allen  
**Program Support Specialist:** Jackie Mackall

**Cross Cutting**
- **Technology Lead:** Billy Lightsey*
- **Division E/PO POC:** Hashima Hasan (Lead Comm Team)  
- **Division Public Affairs POC:** Lisa Wainio*  
- **Information Manager:** Lisa Wainio*  
- **Hubble 25 Coordinator:** Amber Straughn*

**Astrophysics Research**
- **Program Manager:** Wilt Sanders*
- **Program Support:** Janet Larson*  
- **Astrophys Data Analysis:** Doug Hudgins*  
- **Astrophysics Theory:** Keith MacGregor*  
- **Exoplanet Research:** Mario Perez*  
- **APRA lead:** Michael Garcia*  
- **Cosmic Ray, Fund Phys:** Vernon Jones, Keith MacGregor*  
- **Gamma Ray/X-ray:** Michael Garcia*, Stefan Immler*  
- **Optical/Ultraviolet:** Michael Garcia*, Hashima Hasan, Mario Perez*, Martin Still*  
- **IR/Submillimeter/Radio:** Dominic Benford*, Doug Hudgins, Eric Tolstrep*  
- **Lab Astro:** Vacant  
- **Roman Tech Fellows:** Billy Lightsey*  
- **Data Archives:** Hashima Hasan  
- **Astrophys Sounding Rockets:** Wilt Sanders*  
- **Balloons Program:** Vernon Jones(PS), Mark Sistilli (PE)

## Programs / Missions

### Exoplanet Exploration (EXEP)
- **Program:** Doug Hudgins  
- **Program Scientist:** Debra Wallace*  
- **Program Executive:** John Gagosian

### Cosmic Origins (COR)
- **Program:** Mario Perez*  
- **Program Scientist:** Dominic Benford*  
- **Program Executive:** Jeff Hayes

### Physics of the Cosmos (PCOS)
- **Program:** Rita Sambruna  
- **Program Scientist:** Michael Garcia*  
- **Program Executive:** Jeff Hayes

### Astrophysics Explorers (APEX)
- **Program:** Wilt Sanders*  
- **Program Scientist:** Lou Kaluzienski  
- **Program Executive:** Mark Sistilli

## Programs / Missions Detailers
- **JWST:** Linda Sparke on detail to MSFC

* Member of the Resources Mgmt Division  
* Detialeer, IPA, or contractor  
* JWST now part of the JWST Program Office.
Kepler
Kepler Space Telescope

**CURRENT STATUS:**

- Kepler “K2” observation method was approved for operations through FY2016 after completion of the 2014 Senior Review.
  - Kepler is conducting observations along the ecliptic, changing its orientation four times per year.
  - The fifth 75-day Campaign started in April 2015 and runs until July 2015.
  - Targets are selected via proposals from the community. Step 1 cycle 3 proposals (covering Campaigns 8-10) are due June 2, 2015 and Step 2 proposals are due on July 1, 2015.
- K2 Campaign 9 will target the Galactic bulge in a focused Microlensing.
  - Campaign will measure parallaxes and obtain distances and masses for a significant number of microlensing events including those caused by bound and free-floating planets.
  - Efforts are underway to maximize scientific value by partnering with a ground-based, southern telescope to obtain multi-color photometry of the K2 field.
- December 18, 2014: First confirmed planet discovery using K2 observation method
- From 2009-13, Kepler continuously monitored 100 sq. deg. field in constellations of Cygnus and Lyra for 4+ years.
  - These observations ended after failure of 2nd reaction wheel.
- Analysis of first 4 years of Kepler data has revealed:
  - Approximately 4600 exoplanet candidates
  - Over 1000 candidates confirmed as planets to date
  - More than 100 planets discovered in their star’s “habitable zone”.
- Analysis of the full (4+ year) Kepler data set ongoing.

**NASA’s first space mission dedicated to the search for extrasolar planets, or exoplanets**

- **PI:** W. Borucki, NASA Ames Research Center
- **Launch Date:** March 6, 2009
- **Payload:** 0.95-meter diameter telescope designed to measure the tiny dimming that occurs when an orbiting planet passes in front of (‘transits’) a star
- **Scientific objectives:**
  - conduct census of exoplanet systems
  - explore the structure and diversity of extrasolar planetary systems
  - determine the frequency of habitable, Earth-sized planets in our galaxy
Standard Explorer (EX) Mission
PI: G. Ricker (MIT)
Mission: All-Sky photometric exoplanet mapping mission.
Science goal: Search for transiting exoplanets around the nearby, bright stars.
Instruments: Four wide field of view (24x24 degrees) CCD cameras with overlapping field of view—operating in the Visible-IR spectrum (0.6-1 micron).
Operations: 2017 launch with a 2-year prime mission

CURRENT STATUS:
- Downselected April 2013.
- Major partners:
  - PI and science lead: MIT
  - Project management: NASA GSFC
  - Instrument: Lincoln Laboratory
  - Spacecraft: Orbital Science Corp
- Tentative launch readiness date August 2017.
- High-Earth elliptical orbit (17 x 58.7 Earth radii).
- Development progressing on plan.
  - Preliminary Design Review (PDR) successfully completed Sept 9-12, 2014.
  - Confirmation Review, for approval to enter implementation phase, successfully completed October 31, 2014.
  - Critical Design Review (CDR) planned April 2015.
**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

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**2015 Accomplishments**

- All instruments re-integrated into ISIM after planned cryovacuum 2 rework (near-IR detector replacement, microshutter unit replacement)
- First pathfinder telescope cryo testing at JSC underway
- Flight Telescope Backplane assembly completed
- 1st Flight sunshield layer delivered, 3 more in manufacturing

**Remaining 2015 Plans**

- Complete MIRI cryocooler
- Start Assembly of the Primary mirror segments onto the Flight Backplane
- Start 3rd and final cryovacuum test of science instrument suite (ISIM)
- Deliver spacecraft bus to testing

[http://jwst.nasa.gov/](http://jwst.nasa.gov/)
**CURRENT STATUS:**

- May 2013, NASA Administrator Bolden directed study of WFIRST/AFTA and preserve option for FY17 new start if budget is available.
  - No decision expected before early CY 2016.
- Currently in pre-formulation phase.
  - Activities include technology development for detectors and coronagraph (with STMD), assessment of the 2.4m telescopes including risk mitigation, mission design trades, payload accommodation studies, and observatory performance simulations.
- Maturing key technologies by FY19.
  - H4RG infrared detectors for widefield imager.
  - Internal coronagraph for exoplanet characterization.
- March 2014 NRC study on WFIRST/AFTA offers positive view of AFTA, with concerns about technology and cost risks.
- WFIRST Preparatory Science (WPS) funds ROSES proposals that are relevant to WFIRST’s goals and WFIRST-specific simulations and models.
- SDT final report submitted January 31, 2015, and available online at wfirst.gsfc.nasa.gov.
- Solicitation for members of Formulation Science Working Group (F-SWG) to be released soon
NASA Astrophysics Strategy