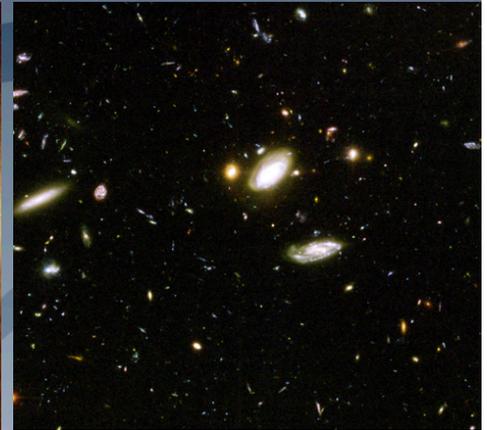




# Astrophysics

# NASA Headquarters Updates



**ExoPAG #14**  
San Diego, CA  
June 11, 2016

**Martin Still**  
ExoPAG Executive Secretary  
Astrophysics Division  
Science Mission Directorate  
[Martin.Still@nasa.gov](mailto:Martin.Still@nasa.gov)

# Content



1. ExoPAG Status
2. Current Mission's Status
3. Future Mission's Status
4. Decadal Studies Status
5. Research and Analysis Status
6. Budget Status



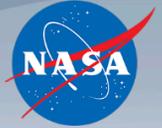
# ExoPAG Status

# Exoplanet Program Analysis Group



- The ExoPAG is an open, interdisciplinary forum that:
  - provides a conduit for community input into NASA's Exoplanet Exploration Program (ExEP)
  - conducts analyses in support of ExEP science objectives and their prioritization
- The ExoPAG Chair has a seat on the NASA Advisory Council Astrophysics Subcommittee

# The ExoPAG Executive Committee (EC)



- Helps the ExoPAG Chair:
  - capture and organizing community input
  - keep the community apprised of ongoing activities and opportunities within the exoplanet program
  - oversee ExoPAG analyses
  - prepare ExoPAG findings and inputs to the Astrophysics Subcommittee
- Is selected to reflect the broad range of scientific disciplines and interests represented in exoplanet exploration
- New members were selected by the Astrophysics Division Director in March 2016

# ExoPAG Executive Committee



Name	Home	Year
Alan Boss (chair)	Carnegie Institution	2/3
Rus Belikov	ARC	3/3
Maggie Turnbull	Global Science Institute	3/3
Lucianne Walkowicz	Adler Planetarium	3/3
Daniel Apai	Arizona	2/3
David Ciardi	NExSci	2/3
Shawn Domagal-Goldman	GSFC	2/3
Tiffany Glassman	Northrop Grumman	1/3
Dimitri Mawet	Caltech/JPL	1/3
Tyler Robinson	UC Santa Cruz	1/3

## Terms of service complete:

Peter Plavchan	Missouri State	-
Nick Cowan	Amherst College	-
Amy Lo	Northrop Grumman	-
Gene Serabyn	JPL	-

# Science Analysis Group Status



Year	SAG	Title	Lead
2010	1	Potential for Exoplanet Science Measurements from Solar System Probes	Bennett, Coulter
2012	2	Debris Disks & Exozodiacal Dust	Roberge
2013	5	Exoplanet Flagship Requirements and Characteristics	Noecker, Greene
2015	8	Requirements and Limits of Future Precision Radial Velocity Measurements	Latham, Plavchan
2015	9	Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics	Soummer
2015	10	Characterizing the Atmospheres of Transiting Planets with JWST and Beyond	Cowan
--	11	Preparing for the WFIRST Microlensing Survey	Yee
--	12	Scientific potential and feasibility of high-precision astrometry for exoplanet detection and characterization	Bendek
--	13	Exoplanet Occurrence Rates and Distributions	Belikov
--	14	Characterization of Stars Targeted for NASA Exoplanet Missions	Stassun
--	15	Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions	Apai
--	16	Spectral biosignature identification and characterization	Domagal-Goldman



# Current Mission's Status

# NASA Astrophysics Senior Review 2016



- The Senior Review, held every two years, assists NASA in maximizing the scientific productivity from its operating missions within a constrained budget
- NASA uses the findings from the Senior Review to define an implementation strategy and give programmatic direction to the missions and projects concerned through the next four fiscal years
- NASA uses the findings from the Senior Review to:
  - Prioritize continued funding of the operating missions and projects;
  - Define an implementation approach to achieve astrophysics strategic objectives;
  - Provide programmatic and budgetary direction to missions and projects for Fiscal Year (FY) 2017 and FY18; and
  - Issue initial funding guidelines for FY19 and FY20 (to be revisited in the 2018 Senior Review)



# NASA Astrophysics Senior Review 2016



Chandra X-ray  
Observatory Panel

Hubble Space  
Telescope Panel

Main Panel:

Fermi  
Kepler/K2  
NuSTAR  
Spitzer  
Swift  
XMM-Newton

Budgets already recognized in the notional run-out of the President's FY 2016 budget request. Mature and stable missions with no operational changes

Main panel

# 2016 Astrophysics Senior Review Main Panel Findings – Overall



Mission	Panel Rating	Panel Ranking
Swift	E	1
Kepler/K2	E	2
NuSTAR	E/VG	3
XMM-Newton	E/VG	4
Fermi	E/VG	5
Spitzer	E/VG	6

- “The SR2016 panel finds no scientific reason to discontinue or significantly reduce any of the six missions under this review.”
- “We strongly encourage NASA to find a way to continue all of these missions at their full funding level.”
- “The scientific value of the complete Astrophysics Senior Review 2016 portfolio is greater than the sum of its parts.”

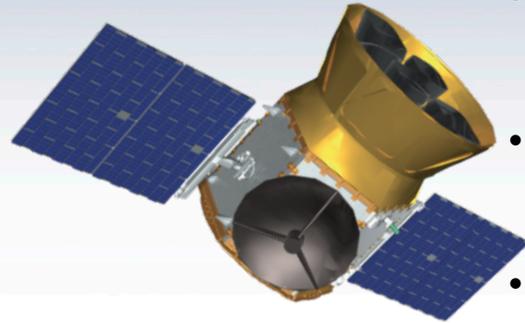
<http://science.nasa.gov/astrophysics/2016-senior-review-operating-missions>



# Future Mission's Status

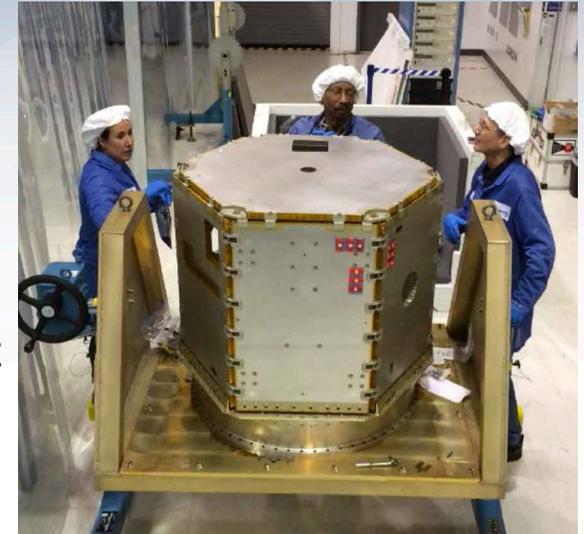
# TESS

## Transiting Exoplanet Survey Satellite



### CURRENT STATUS:

- CDR completed Dec 7, 2015; Mission in fabrication and assembly phase ✓
- Most spacecraft bus components have been delivered and s/c is being assembled ✓
- Flight instrument build underway; first flight CCDs have been produced ✓
- Flight camera optics in assembly ✓



### Medium Explorer (MIDEX) 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 Vis-IR spectrum (0.6-1  $\mu\text{m}$ )

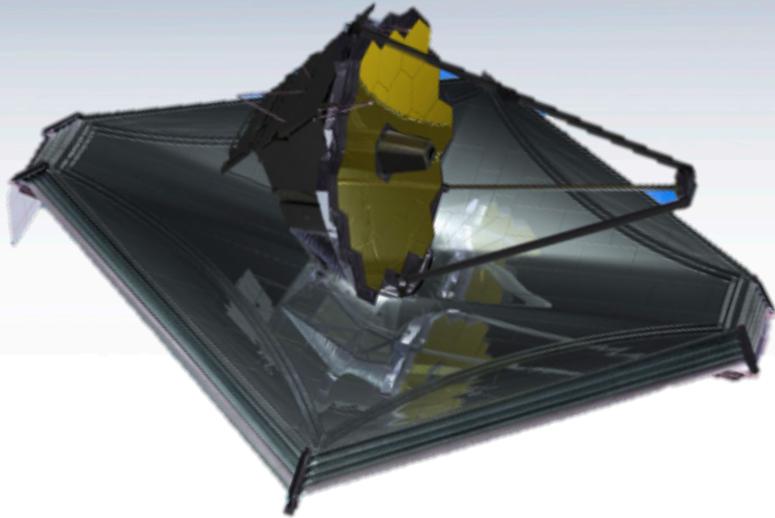
**Operations:** NLT June 2018 launch with a 3-year prime mission including 2 years of spacecraft operations and an additional 1 year ground-based observations and analysis. High-Earth elliptical orbit (17 x 58.7 Earth radii)

### UPCOMING EVENTS:

- Spring-Fall 2016 – TESS bus integration and instrument integration ongoing
- Winter-Spring 2017 – TESS Observatory integration and test
- Spring 2017 – System Integration Review (SIR) and KDP-D
- Fall 2017 – TESS delivery to KSC launch site.
- Dec 2017 – Launch readiness date from Canaveral FL

<http://tess.gsfc.nasa.gov>

# Webb James Webb Space Telescope



## 2015-2016 Accomplishments

- Telescope mirrors installed ✓
- Science instruments integrated with Telescope ✓
- MIRI cryocooler completed ✓
- Spacecraft bus powered on for first time ✓
- Completed 2nd test of Pathfinder Telescope and ground support equipment at JSC in support of 2017 test of flight hardware ✓

## 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

## 2016 Plans

- Complete ambient testing of combined Telescope and instruments
- Complete spacecraft bus
- Complete sunshield membrane fabrication
- Cryovacuum testing of combined Telescope and instruments at JSC
- Integrate Sunshield and Spacecraft

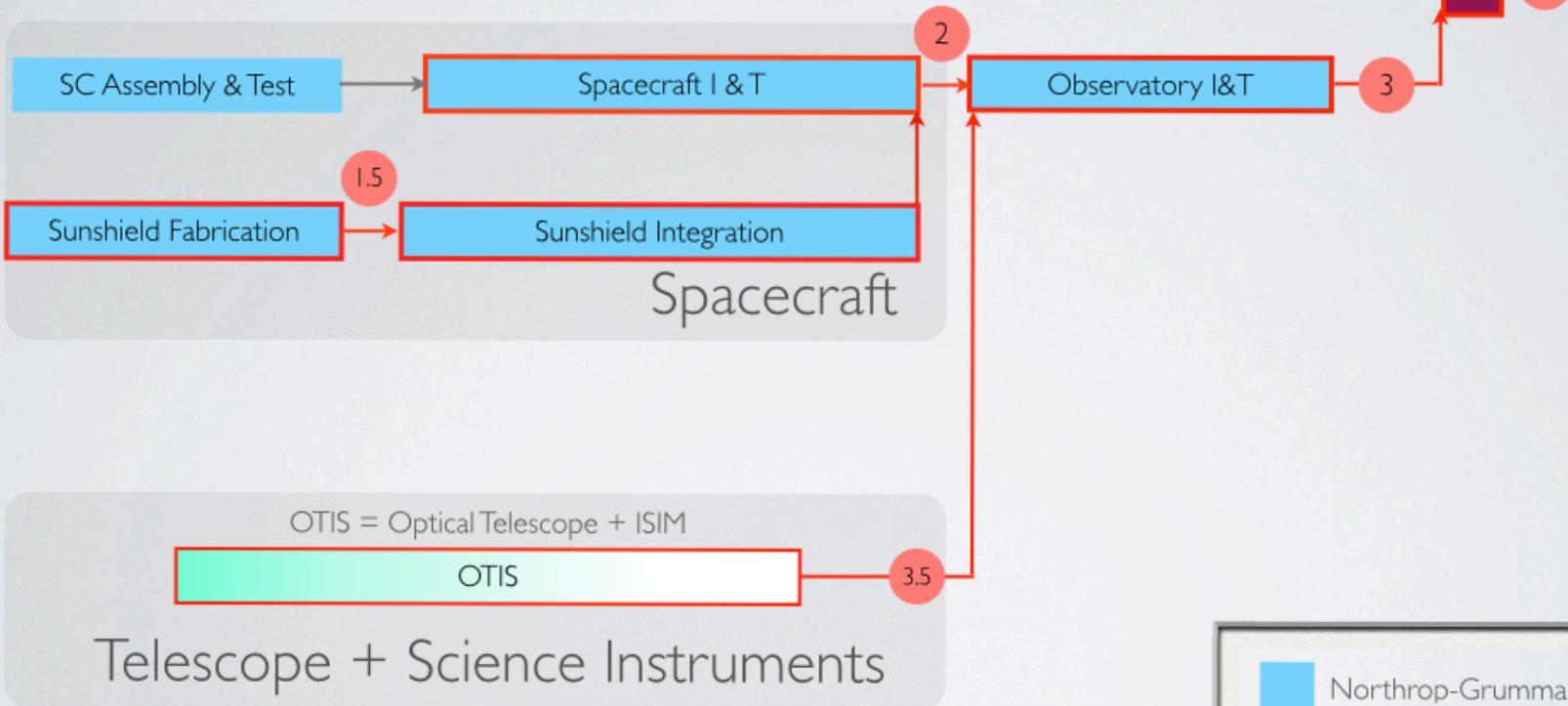
<http://www.jwst.nasa.gov>

# Webb Top Level Schedule



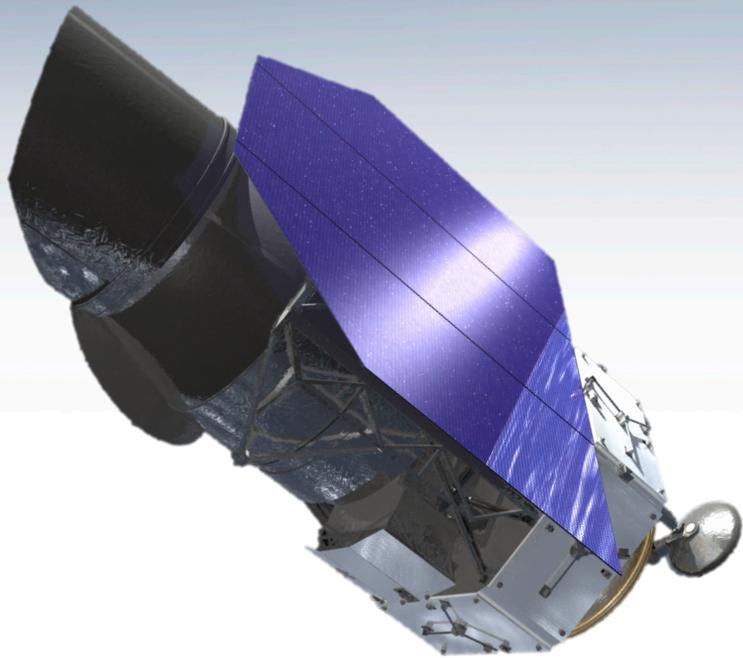
2016												2017												2018											
J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D

k months of project funded critical path (mission pacing) schedule reserve



- Northrop-Grumman
- Goddard Space Flight Center
- Johnson Space Center
- Guiana Space Center

# WFIRST Wide-Field Infrared Survey Telescope



## CURRENT STATUS:

- Completed Mission Concept Review (MCR) held in December 2015
- Formulation Science Investigation Teams selected in December 2015; first meeting held February 2016
- Ball and Lockheed Martin selected in February 2016 to support wide-field Instrument Concept Studies
- Passed Key Decision Point A (KDP-A) in Feb 2016
  - Official start of formulation phase
  - Established management agreement for total mission cost to govern formulation trades
  - Next major milestone is acquisition strategy meeting (ASM) in July 2016
- On track for TRL-6 of new technologies in 2017
- Working toward System Requirements Review (SRR) in June 2017 and KDP-B in October 2017

### Wide-Field Infrared Survey Telescope

Top priority of 2010 Decadal Survey

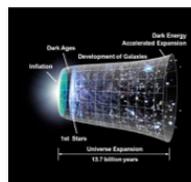
**Science themes:** Dark Energy, Exoplanets, Large Area Near Infrared Surveys

**Mission:** 2.4m widefield telescope at L2; using existing hardware, images  $0.28\text{deg}^2$  at  $0.8\text{-}2\mu\text{m}$

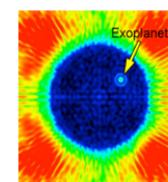
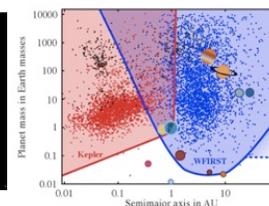
**Instruments (design reference mission):** Wide Field Instrument (camera plus IFU), Coronagraph Instrument (imaging/IFS)

**Phase:** Currently in Formulation (Phase A)

### Dark Energy



### Exoplanets



### Astrophysics



Microlensing

Coronagraph

HST

WFIRST

<http://wfirst.gsfc.nasa.gov>

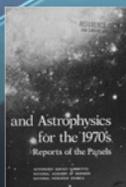


# Decadal Concept Studies

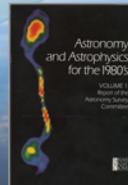


# ASTROPHYSICS

## Decadal Survey Missions



**1972**  
Decadal  
Survey  
*Hubble*



**1982**  
Decadal  
Survey  
*Chandra*



**1991**  
Decadal  
Survey  
*Spitzer, SOFIA*



**2001**  
Decadal  
Survey  
*JWST*



**2010**  
Decadal  
Survey  
*WFIRST*

# Preparing for the 2020 Astrophysics Decadal Survey



- NASA has begun to study large mission concepts as input to the 2020 Decadal Survey
  - A well informed Decadal Survey makes better recommendations
- NASA has appointed Science and Technology Development Teams and initiated four large mission concept studies
- Science and Technology Definition Teams have a significant role and responsibility
  - Develop science case
  - Flow science case into mission parameters
  - Contribute to technology gap list
  - Direct trades of science vs cost/capability
- NASA is also planning to issue a call for medium-size mission concept studies (Astrophysics Probes)

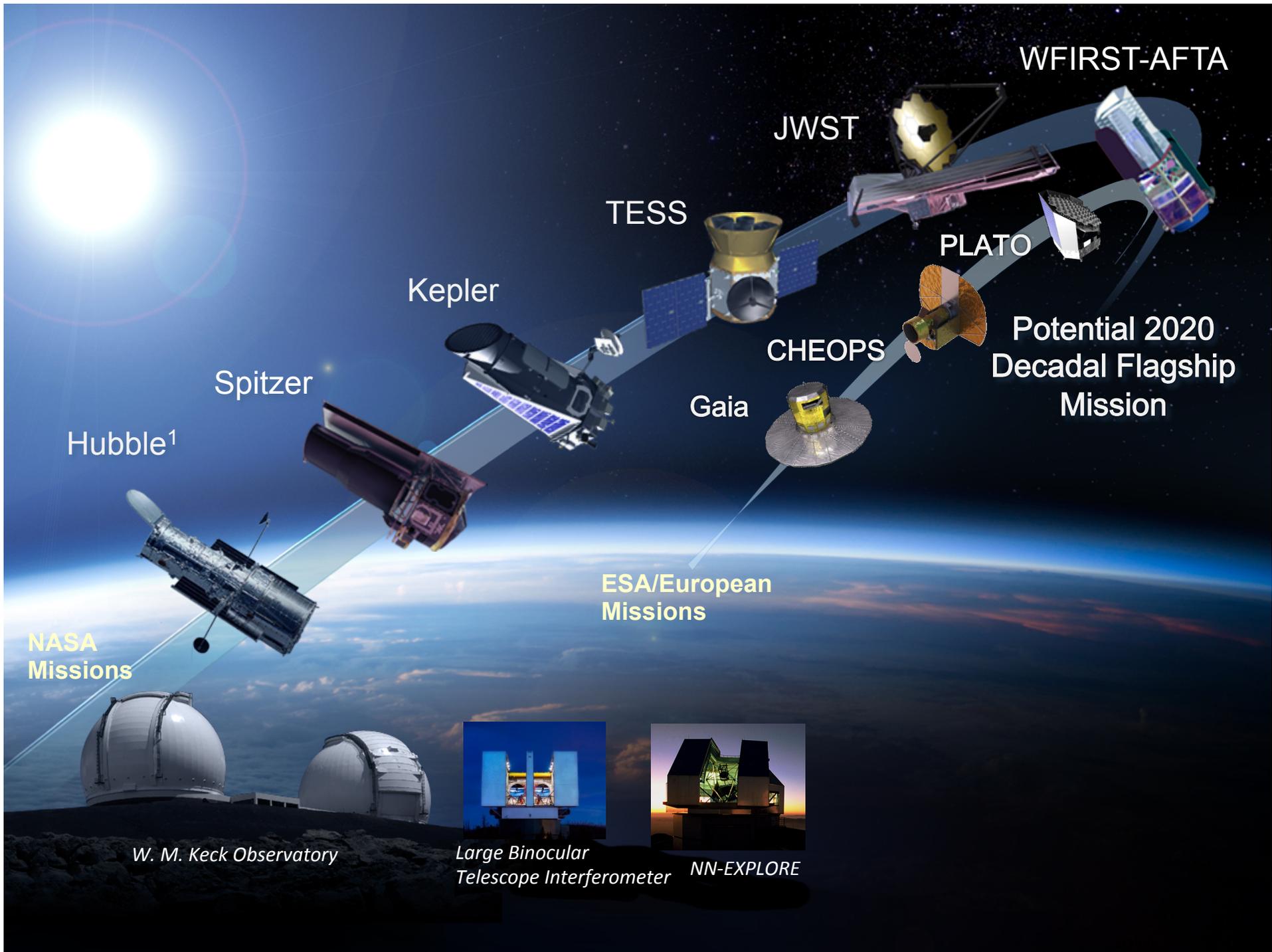
<http://science.nasa.gov/astrophysics/2020-decadal-survey-planning>

# Preparing for the 2020 Astrophysics Decadal Survey



NASA has assembled Science and Technology Definition Teams (STDTs) for each of the four large mission candidates to enable Mission Concept Studies as input to the 2020 Decadal Survey

	Community STDT Chairs	Center Study Scientist	Study Lead Center	HQ Program Scientist
Far IR Surveyor <a href="http://asd.gsfc.nasa.gov/firs">asd.gsfc.nasa.gov/firs</a>	Asantha Cooray Margaret Meixner	David Leisawitz	GSFC	Kartik Sheth
Habitable Exoplanet Imaging Mission <a href="http://www.jpl.nasa.gov/habex">www.jpl.nasa.gov/habex</a>	Scott Gaudi Sara Seager	Bertrand Mennesson	JPL	Martin Still
Large UV/ Optical/IR Surveyor <a href="http://asd.gsfc.nasa.gov/luvoir">asd.gsfc.nasa.gov/luvoir</a>	Debra Fischer Bradley Peterson	Aki Roberge	GSFC	Mario Perez
X-ray Surveyor <a href="http://www.wastro.msfc.nasa.gov/xrs">www.wastro.msfc.nasa.gov/xrs</a>	Feryal Ozel Alexey Vikhlinin	Jessica Gaskin	MSFC	Dan Evans



WFIRST-AFTA

JWST

TESS

PLATO

Kepler

Potential 2020  
Decadal Flagship  
Mission

Spitzer

CHEOPS

Gaia

Hubble<sup>1</sup>

ESA/European  
Missions

NASA  
Missions

W. M. Keck Observatory

Large Binocular  
Telescope Interferometer

NN-EXPLORE

# STDT Schedule (under review and subject to change)



M1	Comments on Study Requirements and Deliverables	Apr 29 2016
	<ul style="list-style-type: none"><li>– Accept the study requirements/deliverables and submit plan--- or</li><li>– Provide rationale for modifying requirements/deliverables</li></ul>	
O1	<b>Optional: Initial Technology Gap Assessment</b>	Jun 30 2016
	<ul style="list-style-type: none"><li>– <i>To impact PCOS/COR/ExEP 2016 technology cycle</i></li></ul>	
M2	Detailed Study Plan	Aug 26 2016
	<ul style="list-style-type: none"><li>– Document starting point CML</li><li>– Deliver detailed study plan for achieving Decadal CML</li><li>– Deliver resource required to meet the deliverables for the study duration</li><li>– Deliver schedule to deliver milestones</li></ul>	
M3	<b>Complete Concept Maturity Level 2 Audit</b>	Feb 2017
	<ul style="list-style-type: none"><li>– Identify, quantify and prioritize technology gaps for 2017 technology cycle</li></ul>	
O2	<b>Optional: Update Technology Gap Assessments</b>	Jun 2017
M4	<b>Interim Report</b>	Dec 2017
	<ul style="list-style-type: none"><li>– Substantiate achieving Concept Maturity Level 3</li><li>– Deliver initial technology roadmaps; estimate technology development cost/schedule,</li><li>– CML 4 tailored approach (optional)</li></ul>	
M5	Update Technology Gap Assessments	Jun 2018
	<ul style="list-style-type: none"><li>– In support of 2018 technology cycle</li></ul>	
M6	<b>Complete Decadal Concept Maturity Level 4 Audit and Freeze Point Design</b>	Aug 2018
	<ul style="list-style-type: none"><li>– Support independent cost estimation/validation process</li></ul>	
M7	<b>Final Report</b>	Jan 2019
	<ul style="list-style-type: none"><li>– Finalize technology roadmaps, tech plan and cost estimates for technology maturity</li></ul>	
M8	<b>Submit to Decadal</b>	Mar 2019



# Research & Analysis Status

# Recent Proposal Selections



	Proposal Due Date	Notify Date	Days past received	Number received	Number selected	% selected
APRA (Basic Research)	Mar 20, 2015	Aug 12, 2015	145	149	40	27%
SAT (Technology)	Mar 20, 2015	Aug 12, 2015	145	27	11	41%
Hubble GO – Cycle 23	Apr 10, 2015	Jun 24, 2015	75	1114	261	23%
EPDS (Doppler Spectr)	Apr 24, 2015	Jul 2, 2015	69	6	2	33%
ADAP (Data Analysis)	May 15, 2015	Sep 29, 2015	137	250	51	20%
Exoplanet Research (XRP)	May 22, 2015	Oct 15, 2015	146	43	7	16%
Kepler K2 GO – Cycle 3	Jul 1, 2015	Oct 14, 2015	105	72	32	44%
SOFIA GI – Cycle 4	Jul 10, 2015	Oct 22, 2015	104	155	82	53%
Spitzer GO – Cycle 12	Sep 11, 2015	Oct 26, 2015	45	104	31	30%
SOFIA 3 <sup>rd</sup> Gen Instrument	Oct 7, 2015	Dec 10, 2015	64	3	2	67%
WFIRST Sci. Inv. Teams	Oct 15, 2015	Dec 18, 2015	64	38	12	32%
Roman Tech Fellows	Nov 6, 2015	Feb 5, 2016	91	5	3	60%
NESSF-16	Feb 8, 2016					
Kepler K2 GO – Cycle 4	Mar 4, 2016					
NASA Keck	Mar 17, 2016					
APRA (Basic Research)	Mar 18, 2016					
SAT (Technology)	Mar 18, 2016					
Exoplanet Research at WYNN	Mar 31, 2016					
Hubble GO – Cycle 24	Apr 8, 2016					
ADAP (Data Analysis)	May 13, 2015					
Exoplanet Research (XRAP)	May 23, 2015					
Spitzer GO – Cycle 13	Jun 8, 2016					

**100% of 2015-16 selections announced within 150 days**

**R&A Selection Rate: 23%  
GO Selection Rate: 28%**

# Proposal Opportunities Expected 2016-17

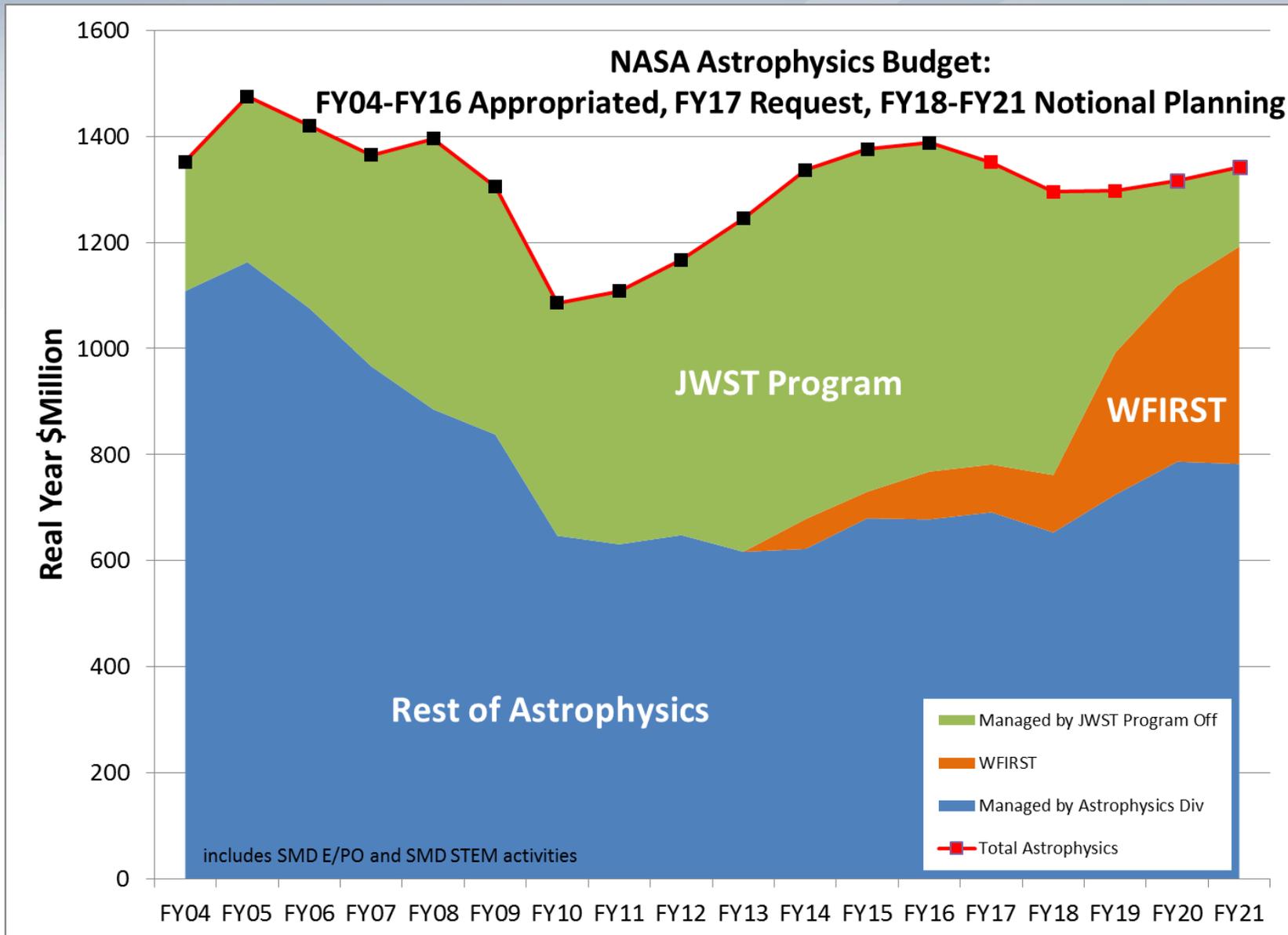


Jul 1, 2016	SOFIA GO Cycle 5	<a href="http://www.sofia.usra.edu">www.sofia.usra.edu</a>
Jul 8, 2016	Astrophysics Theory	ROSES-16 D.4
Sep 2016	NASA Keck	<a href="http://nexsci.caltech.edu">nexsci.caltech.edu</a>
Sep 2016	Exoplanets at WYNN	<a href="http://nexsci.caltech.edu">nexsci.caltech.edu</a>
Sep 23, 2016	Kepler K2 GO Cycle 5 (Step 1)	ROSES-16 D.7
Fall 2016	Explorers MIDEX & MO AO	NSPIRES
Nov 18, 2016	Habitable Worlds (Step 1)	ROSES-16 E.4
Mar 17, 2017	Astrophysics R&A	ROSES-16 D.3
Mar 17, 2017	Strategic Astrophysics Technology	ROSES-16 D.8
Mar 2017	NASA Keck	<a href="http://nexsci.caltech.edu">nexsci.caltech.edu</a>
Mar 2017	Exoplanets at WYNN	<a href="http://nexsci.caltech.edu">nexsci.caltech.edu</a>
Mar 2017	Exoplanet Research (Step 1)	ROSES-17
Apr 2017	Hubble Cycle 24	<a href="http://www.stsci.edu">www.stsci.edu</a>
May 2017	Astrophysics Data Analysis	ROSES-17
Jun 2017	Spitzer GO Cycle 14	<a href="http://ssc.spitzer.caltech.edu">ssc.spitzer.caltech.edu</a>
Late 2017	Webb GO Cycle 1	TBD



# Budget Status

# NASA Astrophysics Budget



# FY16 Appropriation



Outyears are notional planning from FY16 President's budget request

(\$M)	2014	2015	2016	2017	2018	2019	2020
Astrophysics*	\$678	\$685	\$731	\$707	\$750	\$986	\$1118
JWST	\$658	\$645	\$620	\$569	\$535	\$305	\$198
Total	\$1336	\$1330	\$1351	\$1273	\$1285	\$1291	\$1316

\* Excludes "SMD STEM Activities" in all years.

- Provides \$90M for WFIRST and directs NASA to start Formulation.
- Provides full funding (\$85M) for SOFIA operations and places SOFIA into the 2018 Astrophysics Senior Review.
- Provides full funding (\$98M) for continued Hubble operations.
- Provides \$37M for SMD STEM education activities.
- Requires reduction of \$36M in rest of Astrophysics portfolio.

(\$M)	FY16 Request	FY16 Approps	Delta
JWST	\$620	\$620	--
WFIRST	\$14	\$90	+\$76
SOFIA	\$85	\$85	--
Hubble	\$97	\$98	+\$1
Rest of Astrophysics*	\$493	\$457	-\$36 (-7%)
Total	\$1309	\$1351	+\$42

\* Excludes "SMD STEM Activities."

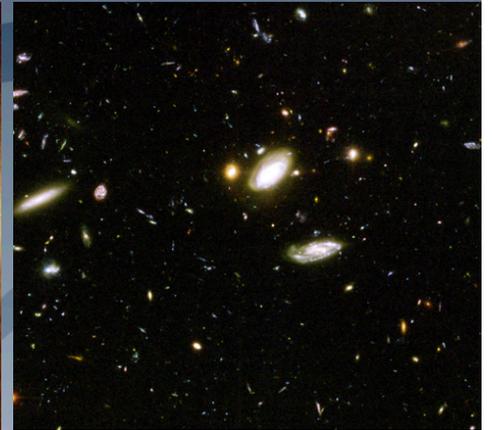
# Addressing the \$36M reduction across the rest of Astrophysics



Project	\$ FY16	Impact
Explorers Futures	\$11M	Two month delay in development of future Explorer missions
TESS	\$11M	Use of reserves not needed by the TESS project in FY16, with payback to the TESS project in FY17 and FY18 (rephasing of reserves)
ASTRO-H	\$7M	Use of reserves held by the ASTRO-H project in case of problems in I&T or a launch delay; not needed by ASTRO-H project because ASTRO-H launched on time
R&A	\$3M	One year reduction; fewer selections spread over FY16-FY17
Spitzer	\$3M	Additional support from SMD makes up for reduction

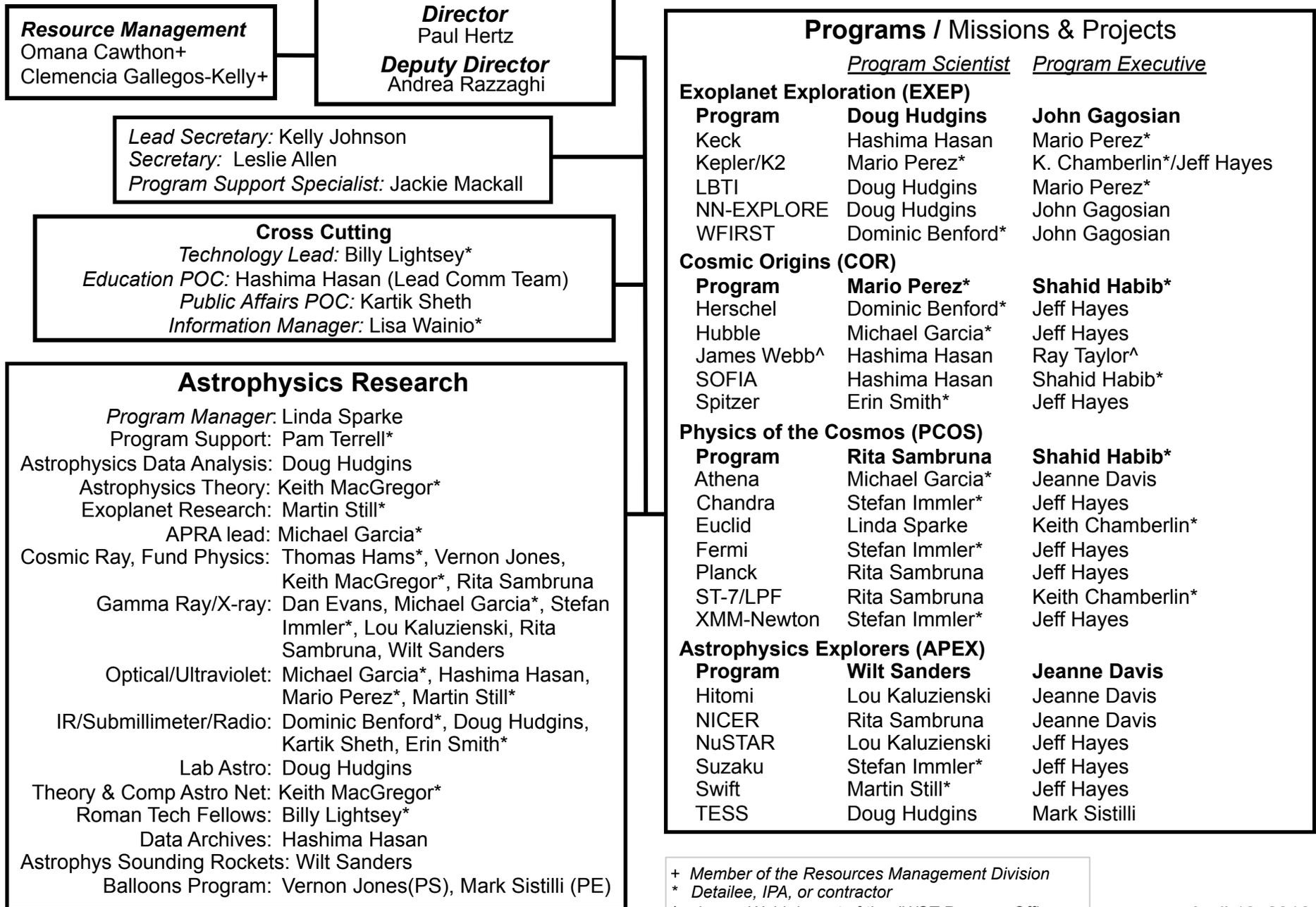


# Astrophysics



BACKUP

# Astrophysics Division, NASA Science Mission Directorate



+ Member of the Resources Management Division  
 \* Detailee, IPA, or contractor  
 ^ James Webb is part of the JWST Program Office.