National Aeronautics and Space Administration



The View from NASA

Astrophysics

Paul Hertz

Director, Astrophysics Division Science Mission Directorate @PHertzNASA

> WFIRSST Conference, Pasadena November 19, 2014

www.nasa.gov

Why Astrophysics?

Astrophysics is humankind's scientific endeavor to understand the universe and our place in it.



1. How did our universe begin and evolve?

These national strategic drivers are enduring





2. How did galaxies, stars, and planets come to be?

3. Are We Alone?



NASA Strategic Plan



NASA Strategic Objective

Discover how the universe works, explore how it began and evolved, and search for life on planets around other stars.

SMD Science Goals

- 1. Probe the origin and destiny of our universe, including the nature of black holes, dark energy, dark matter and gravity.
- 2. Explore the origin and evolution of the galaxies, stars and planets that make up our universe.
- 3. Discover and study planets around other stars, and explore whether they could harbor life.

Decadal Survey Priority



Keck Center of the National Academies August 13, 2010

NATIONAL RESEARCH COUNCIL

Priority 1 (Large, Space). Wide-Field Infrared Survey Telescope

A wide-field-of-view near-infrared imaging and lowresolution spectroscopy observatory will tackle the most fundamental questions in astrophysics:

- Why is the expansion rate of the universe accelerating?
- Are there other solar systems like ours, with worlds like Earth?
- How do galaxies, stars, and black holes evolve?

ASTROPHYSICS

Decadal Survey

LRD: 2018 LRD: 2020s **Missions** 2003 2001 Decadal 2010 1999 Survey Decadal JWST Survey 1991 1990 WFIRST Decadal Survey ASTRONOM 1982 Spitzer Decadal Survey Chandra 1972 Decadal Survey for the 1970 Hubble



Plan for WFIRST/AFTA Preformulation Widefield Infrared Survey Telescope using

Astrophysics Focused Telescope Assets

WFIRST/AFTA timeline

		w	FIRST/AFTA Pret	formulation		Formulation	
		Technolog	y Development f	or WFIRST/AFTA	Continues Throu	gh Formulation	
				Budget I for WFIR St	Request WFIRS ST/AFTA KDI art	T/AFTA P-A	
		NRC WE	FIRST/ Study	NRC Mid Stu	-decade Jdy		
20	12 20	13 20	i 14 20	l 15 20	l 16 20	17 20	18

WFIRST / AFTA

Widefield Infrared Survey Telescope with Astrophysics Focused Telescope Assets

- FY14 appropriation (\$56M) supports preformulation of WFIRST/AFTA, including technology development for detectors and coronagraph (with STMD).
- FY15 request (\$14M) supports Agency/ Administration decision for formulation to begin NET FY 2017, should funding be available.



- Recent NRC study on WFIRST/AFTA offers positive view of AFTA, with concerns about technology and cost risks.
- WFIRST Preparatory Science (WPS) is ROSES element that are relevant to WFIRST's goals and WFIRST-specific simulations and models.
 - Anticipate selecting ~12 proposals, total \$1.8M in first year, by end of CY14.

http://wfirst.gsfc.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 2016.
- Currently in pre-formulation phase.
 - AFTA endorsed by NRC study report released March 2014.
 - Interim SDT report posted April 30, 2014
 - SDT final report due Jan 2015.
- Maturing key technologies to TRL 5 by FY17 and TRL 6 by FY19.
 - H4RG infrared detectors for widefield imager.
 - Internal coronagraph for exoplanet characterization (two architectures identified December 2013; occulting mask coronagraph and phased induced amplitude apodization complex mask coronagraph).
- FY14 Appropriation and FY15 Request support technology development and assessment of the 2.4m telescopes, mission design trades, payload accommodation studies, and observatory performance simulations.

WFIRST Preparatory Science

- New ROSES 2014 Element for WFIRST/AFTA, announced April 21.
- Purpose: bridge from basic theory to observational modeling.
- Proposals must be both:
 - Relevant to WFIRST's primary astrophysics goals.
 - Predominantly WFIRST-specific development of detailed simulations and models.
- 53 Proposals received on July 11. Covered all areas of WFIRST science including supernovae, galaxy redshift surveys, weak lensing, exoplanet microlensing, coronagraphy, and other surveys & GO science.
- Anticipate selecting ~12 proposals, total \$1.8M in first year.
- Intend to select a range of scales (smaller and larger) and periods of performance (1, 2, 3 yr).
- Investigators selected will coordinate efforts with WFIRST Study Office and WFIRST/AFTA Science Definition Team.
 - Annual summary white paper on progress.

FY15 President's Budget Request

						Outyears are	notional
(\$M)	2013	2014	2015	2016	2017	2018	2019
Astrophysics	\$617	\$668	\$607	\$634	\$651	\$697	\$993
JWST	\$627	\$658	\$645	\$620	\$569	\$535	\$305

- Supports pre-formulation of WFIRST/AFTA, including technology development for detectors and coronagraph.
- Supports a growing Astrophysics Explorer program with continued development of ASTRO-H, NICER, and TESS, and initiation of the next Small Explorer mission.
- Supports operating missions: Hubble, Chandra, and other missions rated highly by the 2014 Senior Review.
- Continues a competed astrophysics research program and support of the balloon program.
- Seeks to work with current partner Germany and potential partners to identify a path forward for SOFIA with greatly reduced NASA funding. Unless partners are able to support the U.S. portion of SOFIA costs, NASA will place the aircraft into storage by FY 2015.
- Supports the commitment to an October 2018 launch date for JWST. Continues manufacturing of the flight sunshield structure and membranes. Completes and delivers the flight cryogenic cooler tower assembly. Delivers the Optical Telescope Element flight structure. Initiates integration of the 18 flight primary mirror segments. Conducts the final Integrated Science Instrument Module level cryo-vacuum test.



FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15 FY16 FY17 FY18 FY19

FY15 Budget Appropriation Status

- Administration request is \$607M for Astrophysics and \$645M for JWST.
- House appropriations bill and report includes:
 - Recommendation is \$680M for Astrophysics (an increase of \$73M) and \$645M for JWST
 - Restores \$5M reduction in Hubble operations
 - Rejects SOFIA termination; appropriates \$70M (an increase of \$58M) for SOFIA operations
 - Provides \$30M (an increase of \$15M) for EPO
- Senate appropriations committee markup and report includes:
 - Recommendation is \$750M for Astrophysics (an increase of \$143M) and \$645M for JWST
 - Restores \$23M reduction in Hubble operations
 - Provides \$56M for WFIRST (an increase of \$42M)
 - Rejects SOFIA termination; appropriates \$87M (an increase of \$75M) for SOFIA operations
 - Provides \$42M (an increase of \$27M) for EPO
- Continuing Resolution through December 11, 2014, funds the first 10 weeks of FY15.

Decadal Survey Priority



Priority 2 (Large, Space). Explorer Program

NASA should support the selection of two new astrophysics MIDEX missions, two new astrophysics SMEX missions, and at least four astrophysics MOs over the coming decade.



ASTRO-H: NASA-provided Soft X-ray Spectrometer delivered for integration and test. Launch planned for November 2015.



NICER: Passed confirmation and CDR, manufacturing experiment. Launch to ISS planned for NLT February 2017.



TESS: Passed confirmation, working toward CDR. Launch planned for NLT June 2018.

2014 SMEX AO: Proposals due December 2014.

2016/17 MIDEX AO: Planned.

Decadal Survey Priority

Priority 3 (Large, Space). Laser Interferometer Space Antenna (LISA)



New Worlds, New Horizons in Astronomy and Astrophysics

Report Release e-Townhall Keck Center of the National Academies August 13, 2010

NATIONAL RESEARCH COUNCIL

In the fall of 2013, ESA selected "The Gravitational Universe" science theme for its Cosmic Vision Programme third large (L3) mission, with a launch in 2034. NASA has expressed an interest in collaborating with ESA for a future L3 gravitational wave observatory.

Priority 4 (Large, Space). International X-ray Observatory (IXO)

In the Fall of 2013, ESA selected "The Hot and Energetic Universe" science theme for its Cosmic Vision Programme second large (L2) mission. In June 2014, ESA selected Athena as the mission concept to fulfill this theme. NASA is discussing a partnership with ESA on the Athena mission, including contributions to the payload and/or mission hardware.

Progress Toward Decadal Survey Priorities

The NASA FY14 Appropriation, the President's FY15 Budget Request, and its notional out years support:			
Large-scale 1. WFIRST	Preformulation and focused technology development for WFIRST/AFTA (a 2.4m version of WFIRST with a coronagraph) are underway to enable a new start NET FY2017. Planning budget proposed for an Astrophysics Decadal Strategic Mission.		
Large-scale 2. Augmentation to Explorer Program	Astrophysics Explorers planned budget increased to ~\$150M/yr by FY16; supports decadal cadence of AOs including AO for SMEX AO in Fall 2014 (FY2015) and EX AO in ~FY2017.		
Large-scale 3. LISA	Strategic astrophysics technology (SAT) investments including LISA Pathfinder plus discussing partnership on ESA's L3 gravitational wave observatory – participating in ESA-led assessments in 2014-2015.		
Large-scale 4. IXO	Strategic astrophysics technology (SAT) investments plus pursuing partnership on ESA's L2 Athena X-ray observatory. Athena study phase, with U.S. participation, is underway.		

Progress Toward Decadal Survey Priorities

The NASA FY14 Appropriation, notional out years support:	the President's FY15 Budget Request, and its
Medium-scale 1. New Worlds Technology Development Program	Focused technology development for a coronagraph on WFIRST, strategic astrophysics technology (SAT) investments, and exoplanet probe mission concept studies.
Medium-scale 2. Inflation Probe Technology Development Program	Three balloon-borne investigations plus strategic astrophysics technology (SAT) investments.
Small-scale. Research Program Augmentations	Increased annual R&A budget from \$74M (FY10) to \$82M (FY12 and beyond). Within R&A: established Theoretical and Computational Astrophysics Networks (TCAN) program with NSF; funding available for astrophysics theory; funding available for lab astrophysics; funding available for suborbital payloads.
Small-scale. Intermediate Technology development Augmentation	Established competed Strategic Astrophysics Technology (SAT) program element; directed technology funding for WFIRST and other large-scale decadal priorities.
Small-scale. Future Ultraviolet- Visible Space Capability	Strategic Astrophysics Technology (SAT) investments.
Small-scale. SPICA (U.S. contribution to JAXA-led)	Not supported as a strategic contribution; candidate for Explorer Mission of Opportunity.

JWST Progress

- ISIM completed very successful 116 day cryovacuum test #2.
- First of 5 flight sunshields completed, two others being manufactured, 5 engineering sunshields successfully completed deployment testing.
- Spacecraft bus under construction.
- Pathfinder backplane has optics installed undergoing final assembly before 2015 testing at JSC.
- Program remains on track and within budget for October 2018 launch.



ISIM with all instruments



Flight telescope backplane & with one wing installed



5 engineering sunshields deployed



http://jwst.nasa.gov/

Pathfinder (backplane center section with secondary mirror structure) 16

JWST Flight Sunshield Layer 3





NASA

Astrophysics Timeline



Dates beyond 2016 are contingent upon the results of the 2016 Senior Review





FY15 Planned Accomplishments

- The TESS Explorer Mission will be confirmed to begin implementation (KDP-C) in FY15.
- The **ISS-CREAM** experiment will be launched to the International Space Station (KDP-E) in FY15.
- The Step 1 selection (KDP-A) will be made for the next Small Astrophysics
 Explorer and Explorer Mission of Opportunity in FY15.
- ESA's LISA Pathfinder with NASA's ST-7 experiment will launch (KDP-E) in FY15.
- The WFIRST/AFTA science definition team report will be completed in FY15.
- Manufacture, assembly, and test of the Euclid flight detectors will continue in FY15.
- JAXA's **ASTRO-H** mission spacecraft system level test will take place in FY15.
- The Astrophysics **Archives Senior Review** will be held in FY15.
- **Hubble** will achieve 25 years of operation in FY15.
- The NRC **Mid-Decade Review** will begin in FY15.
- Four **Balloon** campaigns will be conducted in FY15.
- Five **Sounding Rockets** with Astrophysics payloads will launch in FY15.