National Aeronautics and Space Administration

[redacted]

Paul Hertz

Astronomy and Astrophysics Advisory Committee

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www.nasa.gov

Astrophysics Division at a Glance

Division Director
Deputy Division Director

Program Director
Prog Executive/Prog Scientist

Program Offices at Centers

EXEP JPL	COR GSFC	PCOS GSFC	APEX GSFC
Keck	Herschel	Chandra	Astro-H
Kepler	Hubble	Fermi	GALEX
LBTI	* JWST Ops	Planck	GEMS
NExScI	* SOFIA	ST-7/LPF	NuSTAR
	Spitzer	XMM-Newton	RXTE
			Suzaku
			Swift
			WISE
			WMAP

SOFIA
Program office
DFRC

Aircraft Operations	Science Operations
DFRC	ARC USRA

* Science only as it relates to the overall COR scientific mission

Program Office at Headquarters

Astrophysics Research Program Office

APRA | Theory | Data Analysis

Suborbital payloads (w/ in APRA) | Lab Astro (w/ in APRA) | Archives | Balloon Project

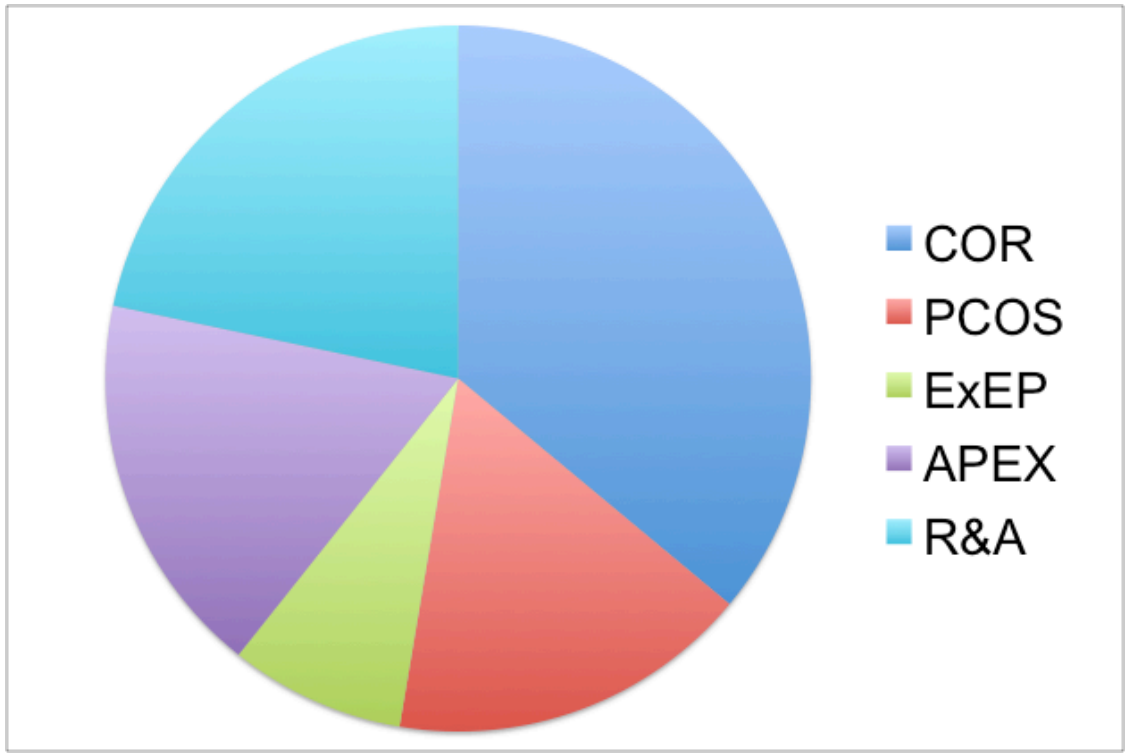
Balloons
Sounding Rockets

Disciplines

Cosmic Ray | Gamma Ray/ X-Ray | IR/Submm/ Radio | Optical/ Ultraviolet

FY2012 NASA Astrophysics Budget

$643.5M Total *



* Does not include SMD budgets that are bookkept in the Astrophysics budget line

SMD FY 2013 Program/Budget Strategy

- Continue to provide the most productive Earth & space science program for the available resources
  - Guided by national priorities
  - Informed by NRC Decadal Surveys recommendations
- Continue to responsibly manage the national investment in robotic space missions
  - Confirm new missions only after sufficient technology maturation and budgets at an appropriate confidence level
  - Closely manage JWST to the new cost and schedule baseline
- Plan and conduct a new Mars program with other NASA organizations to meet both human exploration and science goals
- Adequately budget for launch services acquired for SMD by NASA's Launch Services Program (LSP):
  - Availability and reliability for medium class
  - Encourage cost constraining measures for intermediate/large class

SMD Budget Request Summary

	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Science	**$4,919.7**	**$5,073.7**	**$4,911.2**	**$4,914.4**	**$4,914.4**	**$4,914.4**	**$4,914.4**
Earth Science	$1,721.9	$1,760.5	$1,784.8	$1,775.6	$1,835.5	$1,826.2	$1,772.8
Earth Science Research	$461.1	$440.1	$433.6	$461.7	$485.1	$497.3	$508.1
Earth Systematic Missions	$841.2	$881.1	$886.0	$787.6	$813.2	$835.6	$756.4
Earth System Science Pathfinder	$182.8	$188.3	$219.5	$270.9	$275.6	$224.2	$234.4
Earth Science Multi-Mission Opera	$147.4	$163.4	$161.7	$170.2	$172.9	$176.5	$177.6
Earth Science Technology	$52.8	$51.2	$49.5	$50.1	$52.1	$54.1	$56.1
Applied Sciences	$36.6	$36.4	$34.6	$35.0	$36.7	$38.4	$40.1
Planetary Science	$1,450.8	$1,501.4	$1,192.3	$1,133.7	$1,102.0	$1,119.4	$1,198.8
Planetary Science Research	$158.8	$174.1	$188.5	$222.5	$233.4	$231.7	$230.3
Lunar Quest Program	$130.2	$139.9	$61.5	$6.2			
Discovery	$192.0	$172.6	$189.6	$242.2	$235.6	$193.8	$134.3
New Frontiers	$213.2	$160.7	$175.0	$269.8	$279.6	$259.9	$155.1
Mars Exploration	$547.4	$587.0	$360.8	$227.7	$188.7	$266.9	$503.1
Outer Planets	$91.9	$122.1	$84.0	$80.8	$78.8	$76.2	$76.3
Technology	$117.3	$144.9	$132.9	$84.6	$85.9	$90.9	$99.6
Astrophysics	$631.1	$672.7	$659.4	$703.0	$693.7	$708.9	$710.2
Astrophysics Research	$146.9	$164.1	$176.2	$189.1	$205.1	$211.5	$218.7
Cosmic Origins	$229.1	$237.3	$240.4	$228.5	$215.1	$205.3	$205.7
Physics of the Cosmos	$108.7	$108.3	$111.8	$109.6	$96.3	$92.7	$74.6
Exoplanet Exploration	$46.4	$50.8	$56.0	$41.6	$43.3	$42.4	$45.6
Astrophysics Explorer	$100.0	$112.2	$75.1	$134.3	$133.9	$157.0	$165.6
James Webb Space Telescope	$476.8	$518.6	$627.6	$659.1	$646.6	$621.6	$571.1
Heliophysics	$639.2	$620.5	$647.0	$643.0	$636.7	$638.3	$661.6
Heliophysics Research	$160.8	$175.2	$178.9	$162.6	$168.5	$170.3	$171.6
Living with a Star	$218.4	$196.3	$232.6	$212.2	$286.2	$336.6	$351.7
Solar Terrestrial Probes	$168.3	$188.7	$189.4	$179.8	$64.5	$46.7	$53.4
Heliophysics Explorer Program	$91.7	$60.2	$46.1	$88.4	$117.5	$84.8	$84.8
New Millennium	$0.1						

FY 2014-FY 2017 estimates are notional

Astrophysics Budget Features

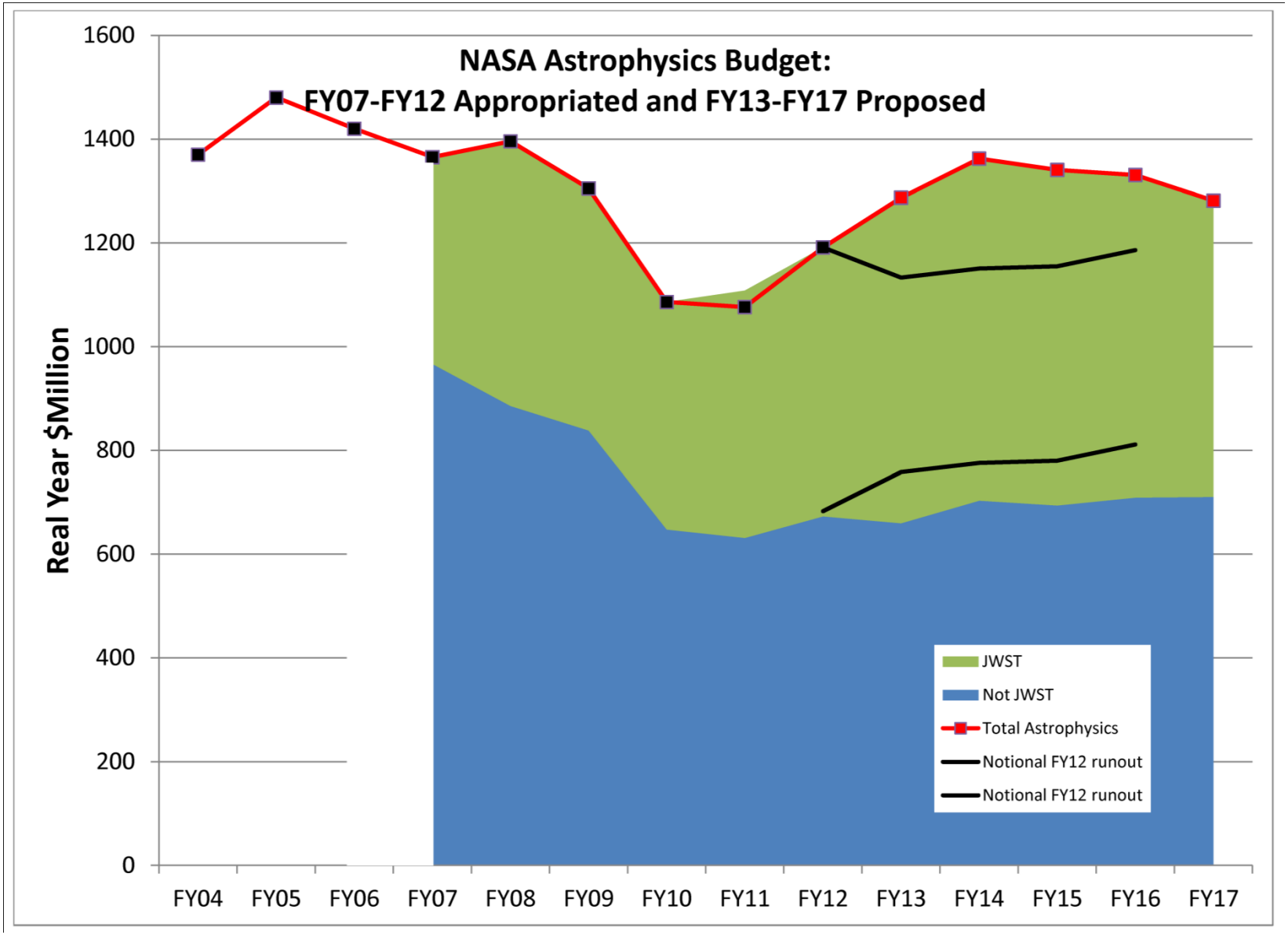
What's changed

- Astro-H and GEMS budgets have been rephased to accommodate programmatic changes
- A partnership is being pursued with ESA's Euclid mission
- Future mission funding within the three strategic programs is sufficient for only mission concept studies; mission-specific technology development will cease
- Balloons and R&A have been held flat to address other priorities
- Launch of next Explorer mission and mission of opportunity (to be downselected in 2013) has been delayed by one year

What's the same

- SOFIA continues development and early science flights
- Hubble, Chandra, Spitzer, Fermi, Kepler, and other operating missions (subject to 2012 Senior Review)
- Keck Interferometer operations will cease in 2012, per plan

President's FY13 Budget Request for Astrophysics



Explorer Options

- FY13 budget request does not support an AO for both missions and missions of opportunity (MOs) in late CY12.
  - First priority in the Explorer program is completion of Explorers in development: NuSTAR, SXS/Astro-H, GEMS.
  - Second priority is to downselect and fund the development of one mission and one MO from the projects currently conducting Phase A studies.

- Astro2010 Decadal Survey
  - "Enable rapid response to science opportunities; augments current plan by 2 MIDEXs, 2 SMEXs, and 4 MoOs."
  - "Annual budget of the astrophysics component of the Explorer program be increased from $40 million to $100 million by 2015."

- Astrophysics Division has planned:
  - An AO for a MO with a $50-60M cost cap in Sep/Oct 2012; followed by
  - An AO for a SMEX and a MO late CY2013 or early CY2014 with the cost caps and actual dates TBD by summer 2012
  - The Astrophysics Explorer budget is $134M in FY15 and $166M in FY17.

WFIRST (Wide-Field Infrared Survey Telescope)

- Science Definition Team has delivered its interim report in July 2011.
  - Copy of the report can be found at: http://wfirst.gsfc.nasa.gov/science/WFIRST_Interim_Report.pdf
  - The Interim Design Reference Mission (IDRM) is a proof of concept that a mission can be constructed that is compliant with the Astro2010 recommendation for groundbreaking observations in Dark Energy, Exoplanet and NIR sky surveys.
- Updated guidance given to Science Definition Team Dec 8, 2011.
  - Accounts for updated events since initial kickoff meeting.
  - Second Design Reference Mission being studied.
  - Second DRM will not duplicate capabilities of Euclid, LSST, and JWST in advancing science objectives of WFIRST.
- Science Definition Team
  - Met Feb 2-3, 2012.
  - Next meeting March 1-2, 2012.
  - Final report due June 2012.

WFIRST

- Astro2010 recommended WFIRST as the highest priority large mission; WFIRST remains NASA's first priority for a large astrophysics mission following JWST.
  - The President's FY13 NASA budget request includes no new large missions; Astrophysics expects none before we successfully complete JWST.
- The FY13 budget request does not fund a start on WFIRST; it would be unrealistic to expect such funding before JWST is launched.
  - WFIRST will not launch in this decade (2018 + 7 yrs = 2025).
  - Astrophysics does not anticipate budget growth in the foreseeable future.
  - FY13 budget request does not support WFIRST technology development as originally planned.
- In the meantime, NASA is proceeding in parallel as follows:
  - Through the Science Definition Team and Design Reference Missions, establish a basis for WFIRST planning.
  - Partner on ESA's Euclid to advance the science of Astro2010 and WFIRST. NASA's contribution to Euclid does not slow WFIRST development: reduced budget flexibility in FY13-FY17 would not allow significant progress on WFIRST.
  - Advance the technology required for WFIRST as the budget allows.

Astrophysics Research Program

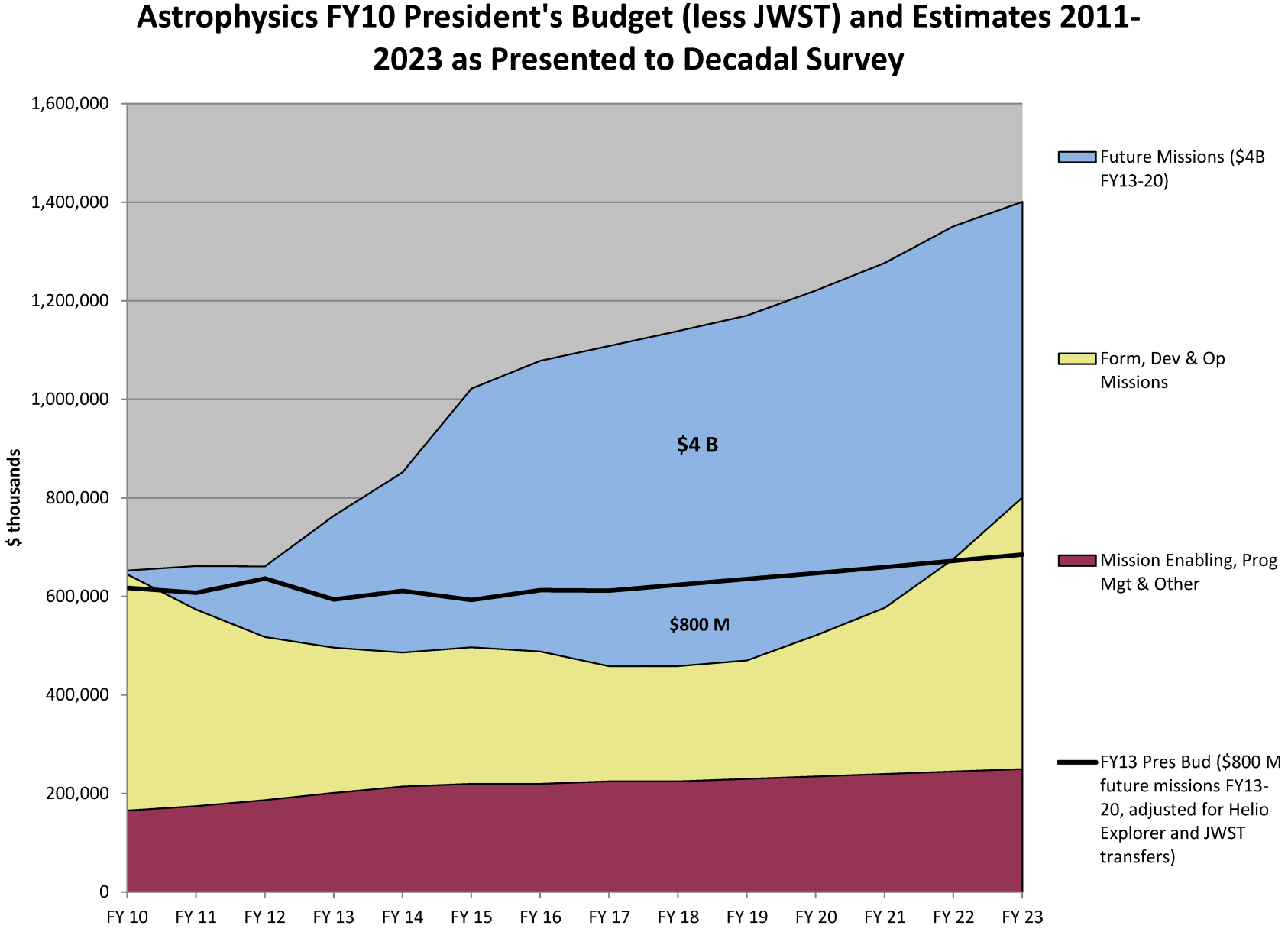
	FY04 Final $k	FY05 Final $k	FY06 Final $k	FY07 Final $k	FY08 Final $k	FY09 Final $k	FY10 Final $k	FY11 Final $k	FY12 Projected
Particle Astro	$ 8,248	$ 7,671	$ 8,544	$ 7,631	$ 6,672	$ 8,201	$ 8,260	$ 8,243	$ 8,585
High Energy	$ 14,548	$ 13,693	$ 14,779	$ 12,782	$ 12,406	$ 13,886	$ 14,110	$ 13,911	$ 14,548
UV/Opt/IR/ Sub-mm	$ 20,409	$ 18,742	$ 21,851	$ 17,442	$ 19,094	$ 22,353	$ 21,534	$ 21,295	$ 23,032
Other	$ 1,019	$ 854	$ 338	$ 394	$ 594	$ 670	$ 673	$ 641	$ 1,627
APRA Total	$ 44,224	$ 40,960	$ 45,511	$ 38,250	$ 38,765	$ 45,110	$ 44,577	$ 44,090	$ 47,791
Orig Solar Systems	$ 4,209	$ 3,872	$ 4,150	$ 3,673	$ 2,965	$ 3,000	$ 2,807	$ 2,944	$ 2,978
Astro Theory Program	$ 7,860	$ 7,363	$ 10,245	$ 10,227	$ 11,696	$ 11,890	$ 12,262	$ 12,577	$ 13,226
R&A (399131)	$ 56,293	$ 52,195	$ 59,906	$ 52,150	$ 53,426	$ 60,000	$ 59,646	$ 59,611	$ 63,995
ADAP/LTSA	$ 16,986	$ 15,700	$ 15,189	$ 12,641	$ 12,013	$ 14,384	$ 13,258	$ 14,132	$ 16,320
Core Research	$ 73,279	$ 67,895	$ 75,095	$ 64,791	$ 65,439	$ 74,384	$ 72,904	$ 73,743	$ 80,315
TPF/FS	$ 2,000	$ 2,000		(Foundation Science; now in ATP)					
Beyond Einstein FS	$ 4,000	$ 3,000	$ 2,000						
ASMCS (399131)	Mission concept studies				$ 3,452	$ 442			
PCOS SR&T				(Fundamental Physics; now in APRA)			$ 968	$ 184	
Technology Fellows									$ 600
TOTAL	$ 79.3M	$ 72.9M	$ 77.1M	$ 64.8M	$ 68.9M	$ 74.8M	$ 73.9M	$ 73.9M	$ 80.9M
		$7M cut	smaller cut	15% cut	partial recovery	more recovery	flat	flat	growth!

In response to the Astro2010 Decadal Survey recommendations
-- the budget for research awards increased by 10% in FY12
-- Theory and Computation Networks: AAAC studying NASA-NSF program

Planning

- The Astro2010 decadal survey prioritized a funding wedge of $3.7B over the decade.
- The “more conservative budget projection” based on the FY11 President’s budget request was $3.0B. Under that more conservative scenario, Astro2010 stated:
  - “In the event that insufficient funds are available to carry out the recommended program, the first priority is to develop, launch, and operate the WFIRST mission, and implement the Explorer program and core research program recommended augmentations. The second priority is to pursue the New Worlds Technology Development Program, as recommended, to mid-decade review by a decadal survey independent advice committee (as discussed in Chapter 3), to start LISA as soon as possible subject to the conditions discussed above, and to invest in IXO technology development as recommended. The third priority is to pursue the CMB Technology Development Program, as recommended, to mid-decade review by a decadal survey implementation advice committee. It is unfortunate that this reduced budget scenario would not permit participation in the JAXA-SPICA mission unless that mission’s development phase is delayed.” (pgs 237-238)
- After removing JWST from the calculation, the runout of the President’s FY13 budget over FY12-FY21 (the decade in Astro2010) has a funding wedge of about $800M ($80M/yr average).
  - Note that JWST is significantly augmented from the planning budget that was presented to the Astro2010 committee.

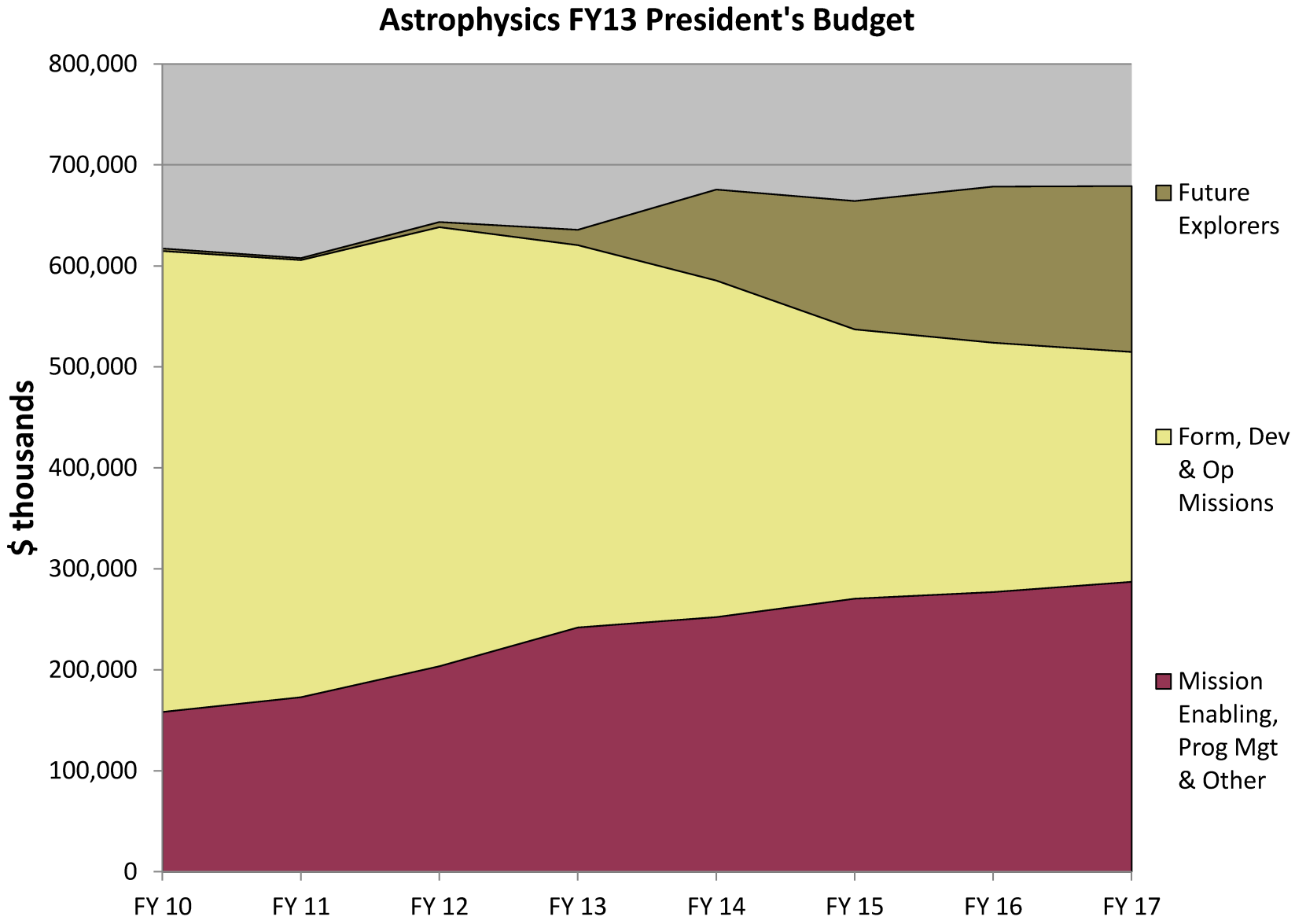
Changes since the Astro2010 Decadal Survey



Planning (continued)

- Astro2010 priorities for a constrained budget:
  - "The first priority is to develop, launch, and operate the WFIRST mission, and implement the Explorer program and core research program recommended augmentations." (pgs 237-238)
- The $800M funding wedge within the runout of the President's FY13 budget request over the decade has been used for:
  - Explorer augmentation: Grows to an augmentation of $70M/yr in FY16
    - Total budget for Future Explorers is $150M/yr
  - SR&T: $15M/yr starting in FY13, growing to $27M/yr in FY17
    - Applied to all three programs.
  - R&A and suborbital: augmentation and reallocation starting in FY12
    - APRA: $1M/yr Suborbital Payloads, $0.5M/yr Lab Astrophysics, $1M/yr Detectors and Supporting Technology
    - $0.3M/yr Astrophysics Theory Program
    - $1.5M/yr Theory and Computation Networks
    - $2M/yr Astrophysics Data Analysis Program
    - $1M/yr Roman Technology Fellows
  - Senior Review: $12M/yr starting in FY15

Balance in President's FY13 Budget



Planning (continued)

- NASA's plans for going forward.
  - Make near term decisions for FY13 including:
    - Fund NASA participation in Euclid
    - Fund GEMS UFE (HQ reserves) and growth (to be confirmed at KDP-C)
    - Respond to 2012 Senior Review
    - Remove some SAT calls from ROSES-11
  - Work with Program Offices to develop a rebalanced plan including technology development, postdoc fellows, and mission concept planning.
    - Priorities include technology development (directed and competed) that may have both near term value (suborbital, Explorers) and lead to advancing decadal priorities with strategic missions, including WFIRST.
  - Work with the advisory structure (APS, PAGs, SAGs) to prioritize the opportunities.
- NRC Mid-Decade Review will comment on NASA's balance between working toward five large missions for the next decadal survey and realizing the science of WFIRST and Astro2010 within the current budget.

Astro2010 Decadal Report Status - Priorities

Program Scale	Recommendation	Science	Total Cost (U.S. share)	Launch Date
Large	**WFIRST** (NASA/DOE collaboration)	Dark energy, exoplanets, and infrared survey-science	$1.6B	2020
Large	**Explorer Program** Augmentation	Enable rapid response to science opportunities; augments current plan by 2 MIDEXs, 2 SMEXs, & 4 MoOs	$463M	Ongoing
Large	**LISA** (requires ESA partnership)	Open low-frequency gravitational-wave window for detection of black-hole mergers and compact binaries and precision tests of general relativity	$2.4B ($1.5B)	2025
Large	**IXO** (partnership with ESA and JAXA)	Black-hole accretion and neutron-star physics, matter/energy life cycles, and stellar astrophysics	$5.0B ($3.1B)	2020s
Medium	**New Worlds Technology Development Program**	Preparation for a planet-imaging mission beyond 2020, including precursor science activities	$100-200M	>2020
Medium	**Inflation Probe Technology Development Program**	CMB/inflation technology development and preparation for a possible mission beyond 2020	$60-200M	>2020
Small	**Astrophysics Theory Program** Augmentation	Broad	$35M additional	
Small	(Definition of) a **future UV-optical space capability**	Technology development benefiting a future UV telescope to study hot gas between galaxies, the interstellar medium, and exoplanets	$40M	
Small	**Intermediate Technology Development** Augmentation	Broad; targeted at advancing the readiness of technologies at TRL 3 to 5	$2M/yr additional, increasing to $15M/yr additional by 2021	
Small	**Laboratory Astrophysics** Augmentation	Basic nuclear, ionic, atomic, and molecular physics to support interpretation of data from JWST and future missions	$2M/yr additional	
Small	**SPICA** mission (U.S. contributions to JAXA-led)	Understanding the birth of galaxies, stars, and planets; cycling of matter through the interstellar medium	$150M	
Small	**Suborbital Program** Augmentation	Broad, but including especially cosmic microwave background and particle astrophysics	$15M/yr additional	
Small	**Theory and Computation Networks** (NASA, NSF, DOE)	Broad; targeted at high-priority science through key projects	$5M/yr NASA	

Astro2010 Decadal Report Status - Response

Program Scale	Recommendation	Recommended Funding	Current Response FY13
Large	**WFIRST**	$1.6B	SDT and DRMs in FY12
Large	**Explorer** Augmentation	$463M	$20M/yr augmentation in FY14 growing to a $70M/yr augmentation in FY16
Large	**LISA**	$852M	$3.4M in FY12; only PCOS SAT in FY13 and beyond
Large	**IXO** Technology	$200M	$6M in FY12 (including PCOS SAT); only PCOS SAT in FY13 and beyond
Medium	**New Worlds Technology**	$100-200M	$9M in FY12 (including EXEP SAT); funding increases by $12M/yr in FY15 growing to an increase of $15M/yr in FY17
Medium	**Inflation Probe Technology**	$60-200M	$0.3M in FY12 (SAT only); only PCOS SAT in FY13 and beyond; several APRA investigations are relevant
Small	**Astrophysics Theory Program** Augmentation	$35M additional	$0.3M/yr augmentation starting in FY12
Small	(Definition of) a **future UV-optical space capability**	$40M	$6M in FY12 (including SAT); included in COR SR&T growing by an additional $6M by FY15
Small	**Intermediate Technology Development** Augmentation	$2M/yr additional, increasing to $15M/yr additional by 2021	Included in 3 Program SAT augmentations toward 5 prioritized areas
Small	**Laboratory Astrophysics** Augmentation	$2M/yr additional	$0.5M/yr augmentation over $3M/yr baseline starting in FY12; includes one large investigation
Small	**SPICA** mission (U.S. contributions to JAXA-led)	$150M	Candidate for Explorer Mission of Opportunity
Small	**Suborbital Program** Augmentation	$15M/yr additional	$1M/yr augmentation for payloads over $22M/yr baseline; zero augmentation for Balloon Project
Small	**Theory and Computation Networks** (NASA, NSF, DOE)	$5M/yr NASA	$1.5M/yr for 3 years; to be reviewed after 3 years
N/A	**Additional core program augmentations**	N/A	Roman Technology fellows: $1M/yr; in FY13 new program; Astrophysics Data Program: $2M/yr augmentation over $14M baseline; APRA SR&T: $1M/yr augmentation over $20M baseline

Backup Slides

Astrophysics Program Content

	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
				(FY14-17 estimates are notional)			
Astrophysics	**631.1**	**672.7**	**659.4**	**703.0**	**693.7**	**708.9**	**710.2**
Astrophysics Research	146.9	164.1	176.2	189.1	205.1	211.5	218.7
Astrophysics Research and Analysis	59.6	64.6	64.2	65.5	66.8	68.2	69.5
Balloon Project	26.8	31.6	31.3	31.2	32.8	34.2	34.3
Other Missions and Data Analysis	60.5	67.9	80.6	92.3	105.4	109.2	114.8
Keck Single Aperture	2.2	2.3	2.4	2.4	2.5	2.5	2.5
Astrophysics Data Analysis Program	14.1	16.3	18.3	18.5	18.5	19.1	19.1
Astrophysics Data Curation and Archival	20.8	20.1	20.0	19.6	21.7	22.1	22.2
Astrophysics Senior Review			16.3	24.5	33.5	35.2	40.0
Education and Public Outreach	13.2	15.4	10.1	10.1	10.1	10.1	10.1
Directorate Support - Space Science	10.1	13.7	13.5	13.9	14.0	14.5	14.5
Directed Research and Technology				3.3	5.2	5.6	6.4
Cosmic Origins	229.1	237.3	240.4	228.5	215.1	205.3	205.7
Hubble Space Telescope (HST)	91.7	95.7	98.3	98.3	94.3	90.2	90.5
SOFIA	79.9	84.2	85.5	88.0	88.0	86.0	85.9
Other Missions And Data Analysis	57.6	57.4	56.6	42.2	32.8	29.1	29.3
Spitzer Space Telescope	22.7	17.8	9.8				
Herschel	24.6	24.0	20.8	15.8	5.8		
Cosmic Origins SR&T	7.9	10.6	19.4	19.5	20.7	21.7	21.8
Cosmic Origins Future Missions	0.7	1.0	1.7	1.7	1.0	2.0	2.0
Cosmic Origins Program Management	1.7	4.0	4.9	5.2	5.3	5.4	5.5

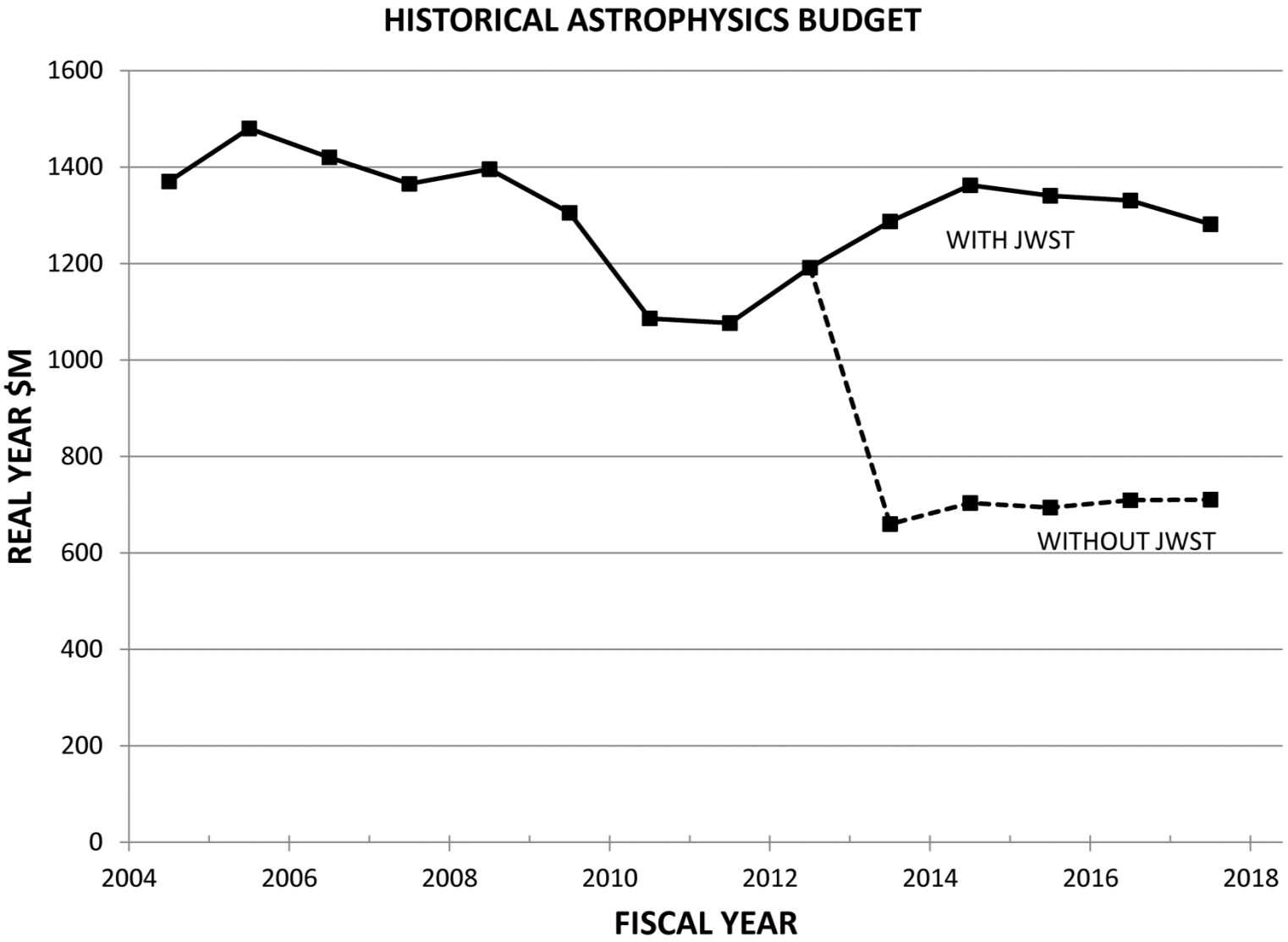
Astrophysics Program Content (cont'd)

	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
				(FY14-17 estimates are notional)			
Physics of the Cosmos	108.7	108.3	111.8	109.6	96.3	92.7	74.6
Chandra X-Ray Observatory	60.6	54.7	56.6	56.6	56.6	56.7	51.2
Fermi Gamma-ray Space Telescope	22.3	25.3	25.0	24.5	17.5	12.9	
Planck	8.1	7.2	6.8	4.6	0.8		
XMM-Newton	1.2	2.1	1.9	1.9			
Physics of the Cosmos SR&T	13.9	15.0	14.9	15.3	15.3	16.0	16.2
Physics of the Cosmos Program Management	2.3	3.1	4.7	5.0	5.1	5.2	5.3
Physics of the Cosmos Future Missions	0.3	1.0	1.8	1.7	1.0	2.0	2.0
Exoplanet Exploration	46.4	50.8	56.0	41.6	43.3	42.4	45.6
Kepler	16.8	19.6	13.6	0.2			
Large Binocular Telescope Interferometer	1.5	2.0	3.8	2.9	2.0	0.5	0.5
Keck Operations	3.6	3.2	3.3	3.4	3.5	3.5	3.5
Keck Interferometer	0.1	0.4					
Wide Field Infrared Space Telescope	3.6						
Exoplanet Exploration SR&T	14.9	18.1	28.0	28.2	30.8	31.1	34.3
Exoplanet Exploration Program Management	4.8	6.0	6.1	5.7	5.9	6.0	6.0
Exoplanet Exploration Future Missions	1.2	1.5	1.2	1.2	1.2	1.2	1.2

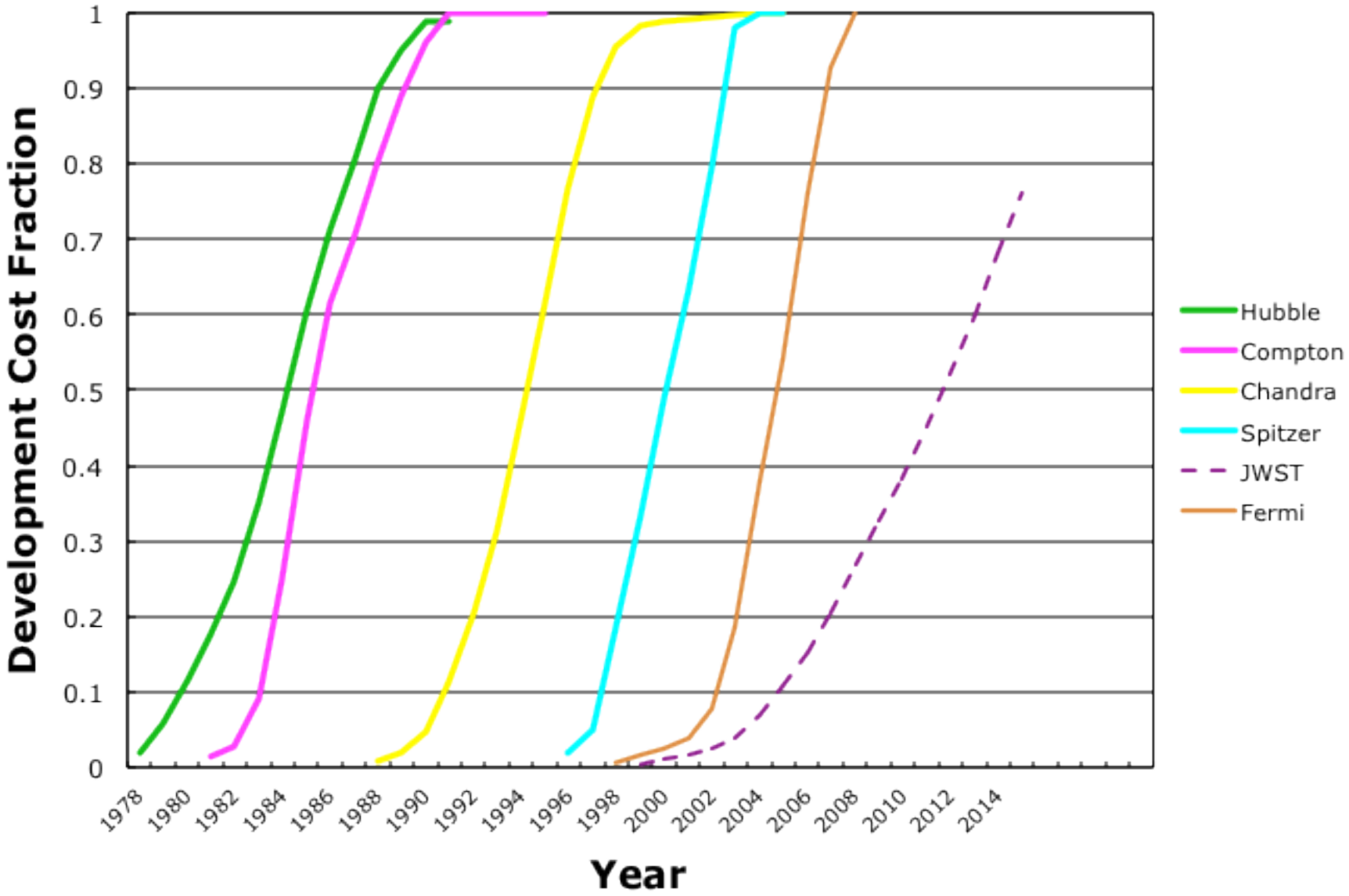
Astrophysics Program Content (cont'd)

	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
				(FY14-17 estimates are notional)			
Astrophysics Explorer	100.0	112.2	75.1	134.3	133.9	157.0	165.6
Nuclear Spectroscopic Telescope Array (NuSTAR)	36.1	11.8	4.7	4.4			
Gravity and Extreme Magnetism	23.0	63.2	46.4	32.9	2.7	0.2	
Other Missions and Data Analysis	41.0	37.2	24.1	97.1	131.2	156.8	165.6
Astro-H (SXS)	16.9	16.2	4.4	1.8	1.0	0.9	
SWIFT	6.3	4.3	4.4	4.4			
Wide-Field Infrared Survey Explorer	7.3	4.5	0.2				
Suzaku (ASTRO-E II)	1.8	0.3	0.3				
GALEX	6.2	0.6					
Wilkinson Microwave Anistropy Pro (WMAP)	1.6	1.0					
Rossi X-Ray Timing Explorer (RXTE)	0.9						
Astrophysics Explorer Future Missions		3.1	10.6	85.6	124.0	149.6	159.3
Astrophysics Explorer Program Management		7.3	4.1	5.3	6.2	6.3	6.4

NASA's Investment in Astrophysics



Missions in Development



Flagship Missions vs Astrophysics Budget