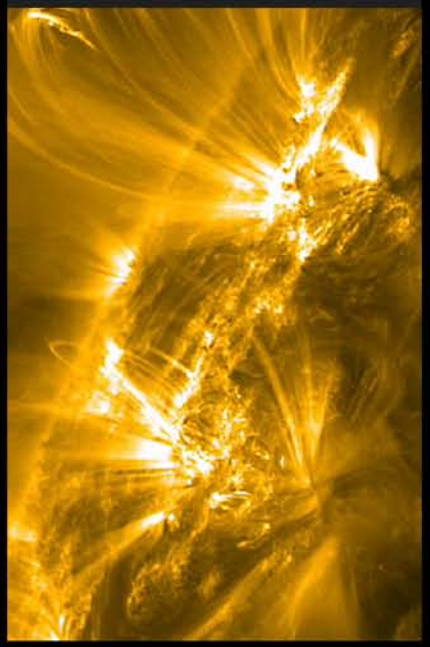
National Aeronautics and Space Administration

EARTH SCIENCE



HELIOPHYSICS

PLANETARY SCIENCE

ASTROPHYSICS

SCIENCE MISSION DIRECTORATE

Board on Physics and Astronomy

Dr. Paul Hertz,
Astrophysics Division Director

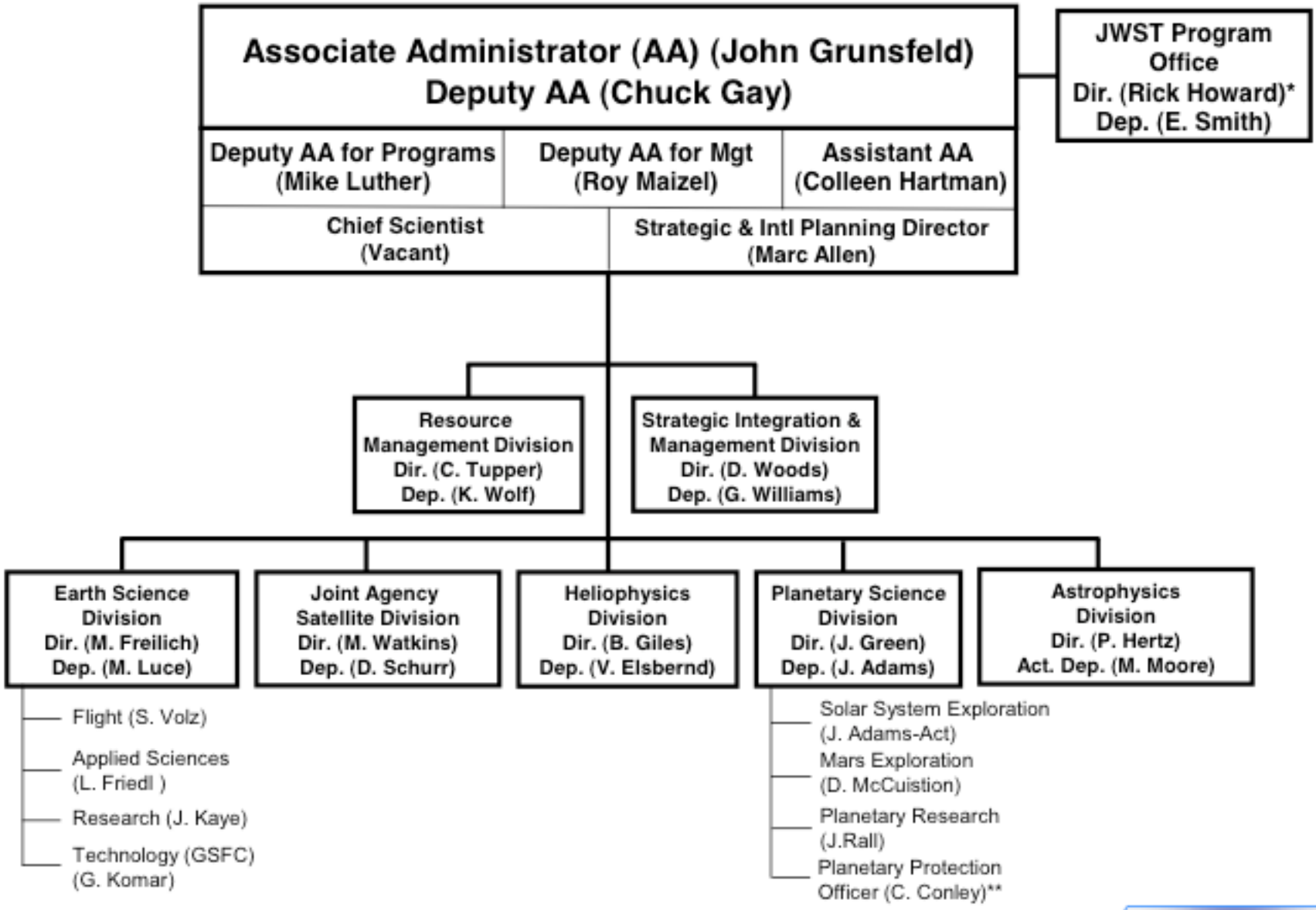
April 27, 2012

www.nasa.gov

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 Organization Chart



* Direct report to NASA Associate Administrator
** Co-located from the Front Office

March 2012

Science 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


Formulation
Implementation
Primary Ops
Extended Ops
GPM
LDCM
OCO-2
GRACE-FO (2)
SMAP
SAGE III (on ISS)
ICESat-2
TRMM
EO-1
Landsat-7
(USGS)
ACRIMSAT
Terra
SORCE
QuikSCAT*
Aqua
CloudSat
CALIPSO
Aquarius
Aura
GRACE (2)
Jason
OSTM/Jason 2
(NOAA)
Suomi-NPP

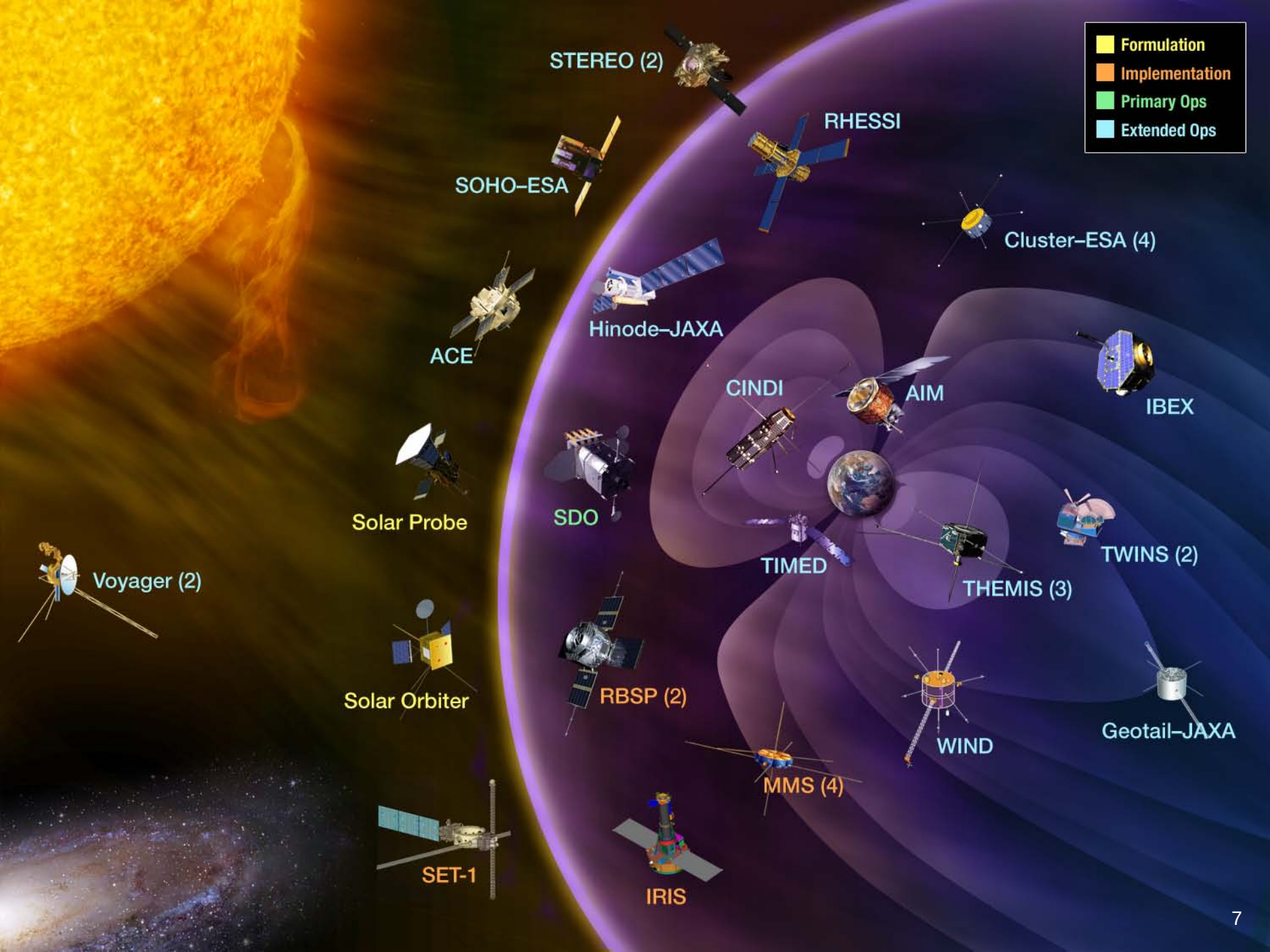
Earth Science Budget Features

What changed:

- Budgeted for increased-cost, lower-risk launch vehicles for OCO-2, SMAP.
- GMP LRD delayed owing to development issues (both U.S. and JAXA) - on track for June 2014 LRD.
- OCO-2, OCO-3 LRD changes owing to LV issues for OCO-2.
- Multi-Mission Ops line accommodates Sr. Review, continuation of ACRIMSAT, and planned new missions.

What is the same:

- Tier-1 Decadal missions SMAP and ICESat-2 are progressing toward launch in 2014 and 2016, respectively.
- EV-2 (Small-sat) and EV-Instrument AOs released for selections in FY2012.
- Continues focused pre-formulation activities for GRACE-FO for launch in 2017.
- DESDynl Radar continues in pre-formulation study, launch NET 2021.
- Maintains support for foundational and decadal missions in formulation and development.
- Maintains support for operating missions.
- Maintains support for USGCRP activities.


Formulation
Implementation
Primary Ops
Extended Ops
STEREO (2)
RHESSI
SOHO–ESA
Cluster–ESA (4)
Hinode–JAXA
ACE
CINDI
AIM
IBEX
SDO
Solar Probe
TIMED
TWINS (2)
THEMIS (3)
Voyager (2)
Solar Orbiter
RBSP (2)
WIND
Geotail–JAXA
MMS (4)
SET-1
IRIS

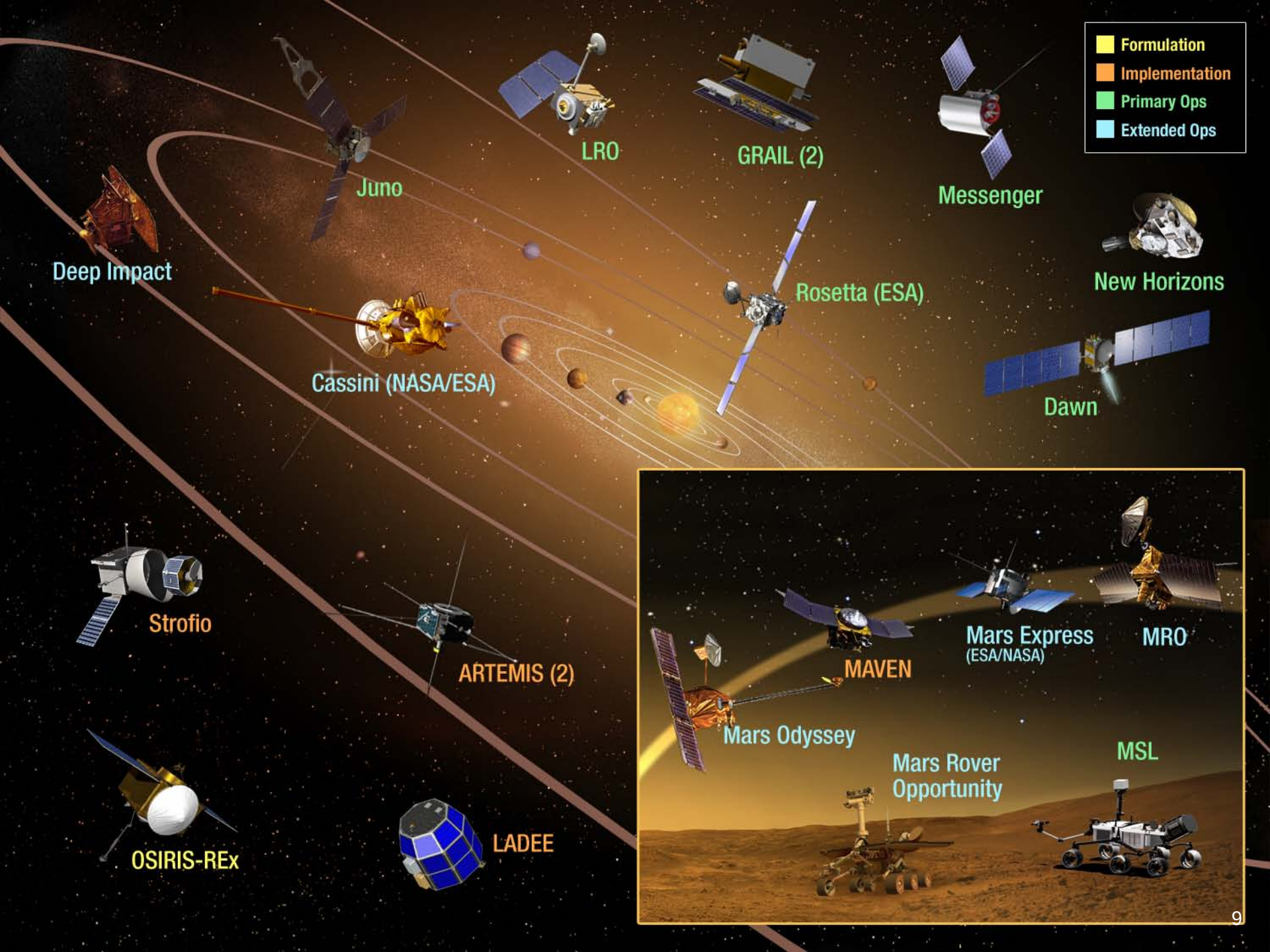
Heliophysics Budget Features

What Changed:

- Covers increased launch vehicle costs.
- Modest investment in Sounding Rocket Sustainer Motor design activity.

What is the Same:

- Fully funds missions in formulation/development: RBSP/BARREL, IRIS, MMS, SOC, SPP.
- Continues support for 16 operating missions (Voyager, Wind, ACE, TIMED, RHESSI, STEREO, THEMIS/ARTEMIS, AIM, IBEX, SDO; *Partnerships*: Geotail, SOHO, Cluster, Hinode; *MO*: TWINS, CINDI).
- Maintains Supporting Research and Suborbital Program.


Formulation
Implementation
Primary Ops
Extended Ops
LRO
GRAIL (2)
Messenger
Juno
Deep Impact
New Horizons
Rosetta (ESA)
Cassini (NASA/ESA)
Dawn
Strofio
ARTEMIS (2)
OSIRIS-REx
LADEE
Mars Express
(ESA/NASA)
MRO
MAVEN
Mars Odyssey
MSL
Mars Rover
Opportunity

Planetary Science Budget Features

What Changed:

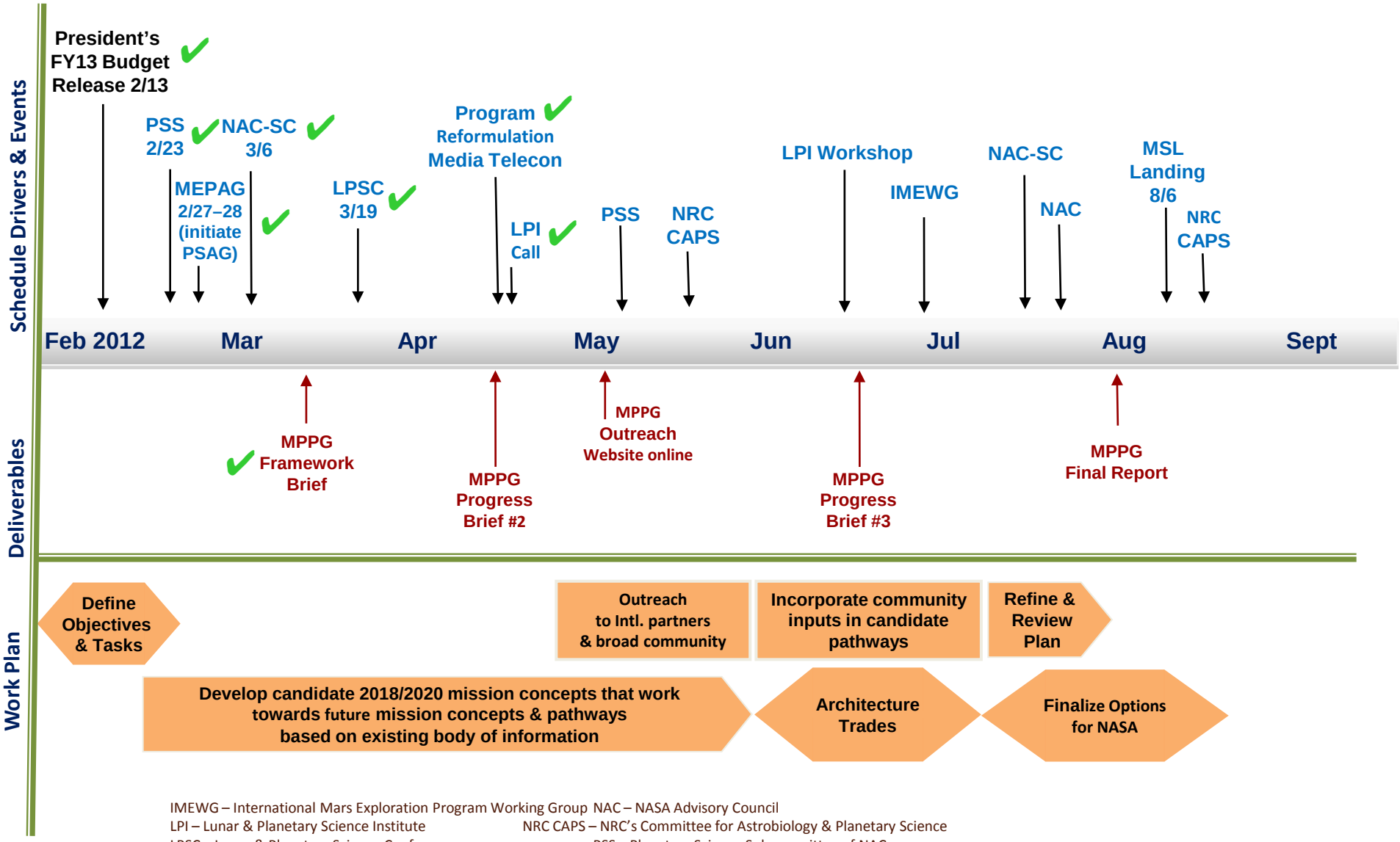
- Initiate a new Mars exploration strategy as an integrated approach by partnering with Human Exploration and the Office of the Chief Technologist.
  - Ending work on 2016 ExoMars Trace Gas Orbiter and Mars 2018 ExoMars rover.
  - Looking at a robotic exploration mission.
- Reduced Discovery flight rate with Discovery 13 AO release moved to FY15.
- Lunar Quest Program phased out after LADEE with remaining activities absorbed into Research Programs and Discovery.
- NEO program expanded to improve and increase its detection efforts.

What is the Same:

- Continuing 14 operating science missions:
  - MESSENGER, GRAIL, LRO, Deep Impact, MRO, Odyssey, Opportunity, Dawn, Juno, Cassini, New Horizons.
  - ESA partnered missions: Venus Express, Mars Express, Rosetta.
- LADEE and MAVEN launches in 2013.
- Technology and Data Programs: Develop Radioisotope Power Systems (RPS); Planetary instruments; continue to support Planetary missions with navigation and sample curation.
- Continue with Research and Analysis selections and awards.

Mars Exploration Program Reformulation

FY12 Timeline & Milestones (dates are approximate; as of 4/16/12)



IMEWG – International Mars Exploration Program Working Group
LPI – Lunar & Planetary Science Institute
LPSC – Lunar & Planetary Science Conference
MEPAG – Mars Exploration Program Analysis Group
NAC – NASA Advisory Council
NRC CAPS – NRC's Committee for Astrobiology & Planetary Science
PSS – Planetary Science Subcommittee of NAC
NRC – National Research Council


Formulation
Implementation
Primary Ops
Extended Ops
XMM-Newton (ESA)
Swift
Suzaku (JAXA)
Fermi
INTEGRAL (ESA)
Planck (ESA)
Hubble
Kepler
GALEX
Spitzer
JWST
Chandra
Herschel (ESA)
Astro Ex-1
NuSTAR
GEMS
ST-7
Astro H
SOFIA

2012 Senior Review Results

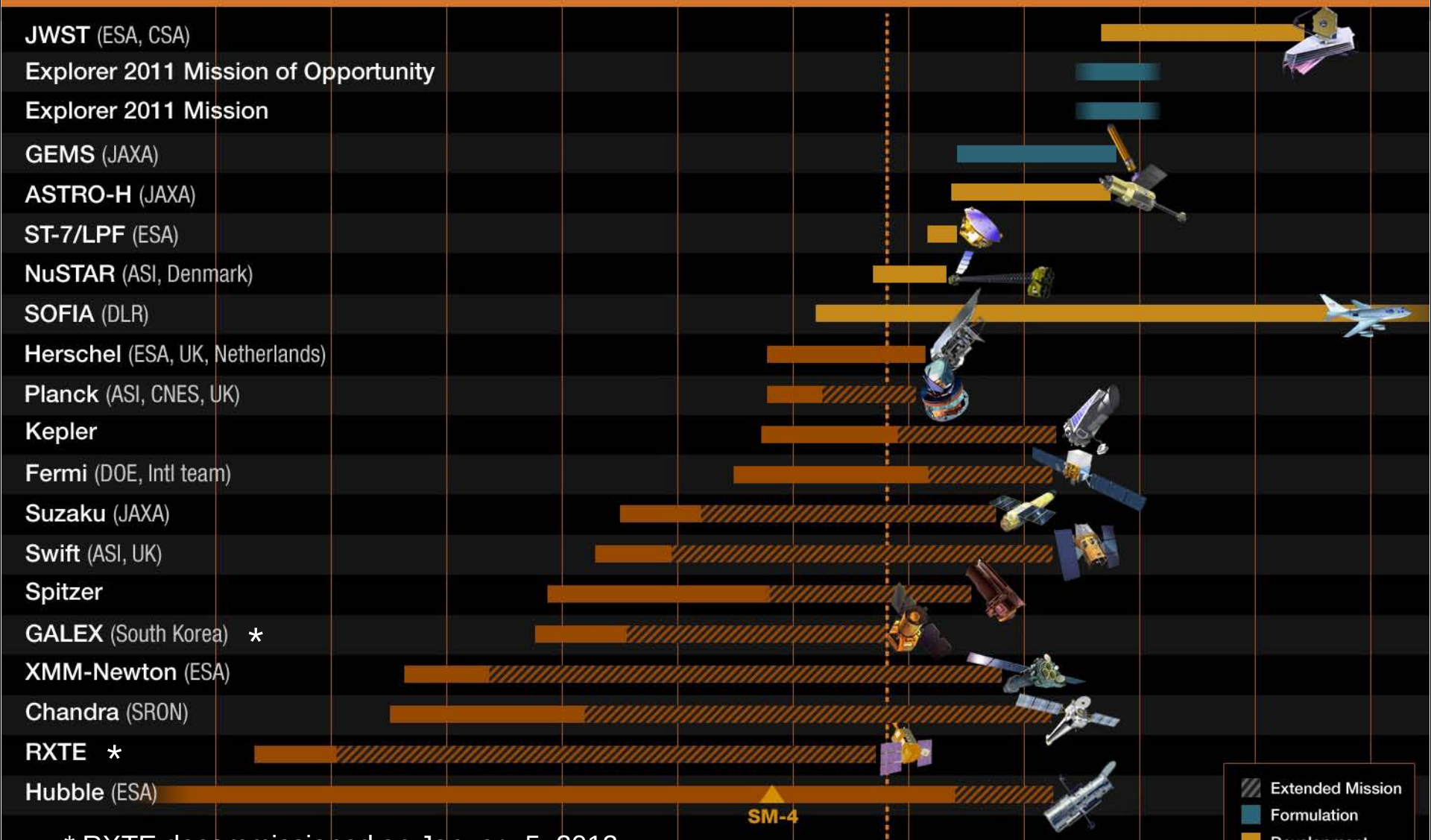
Mission	Result
Chandra	- Fully fund as budgeted - Augment Guest Observer Program at ½ Project request
Fermi	- Mission extension thru 2016 - Reduced budget starting in FY 14
Hubble	- Fully fund as budgeted
Kepler	- Extend mission operations thru FY 16 - Augment Guest Observer and Participating Science Program at 1/2 Project request
Planck	- Fund US Support of 1-year extension of Low Frequency Instrument operations
Spitzer	- Extend ops thru FY 14 - Closeout in FY 15
Suzaku	- Extend US Science support through March 2015 (Astro-H launch +1 year)
Swift	- Extend mission operations thru FY 16 - Augment Guest Observer Program per Project request
XMM-Newton	- Extend US support through March 2015

Note: All FY15 and FY16 decisions will be revisited in the 2014 Senior Review.

13

Astrophysics Missions timeline

Last updated: April 24, 2012

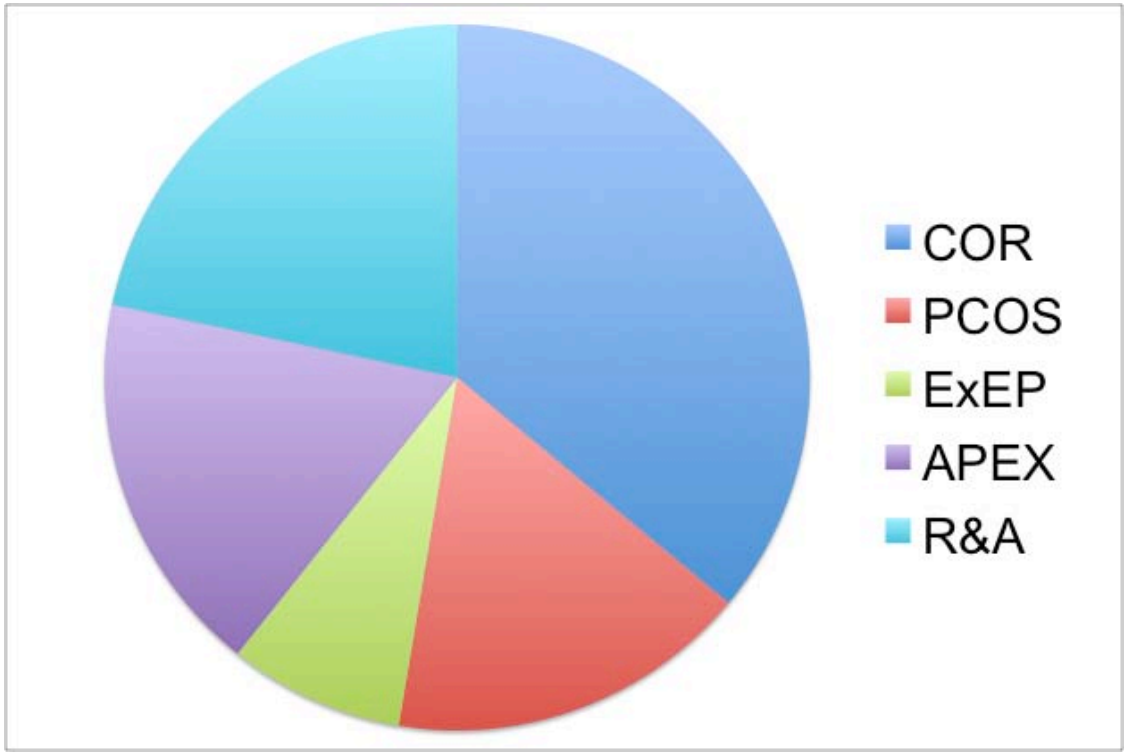


* RXTE decommissioned on January 5, 2012.
GALEX NASA science data acquisition ended on February 7, 2012.

JWST on track for 2018

FY2012 NASA Astrophysics Budget

$643.5M Total *



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

Astrophysics Budget Features

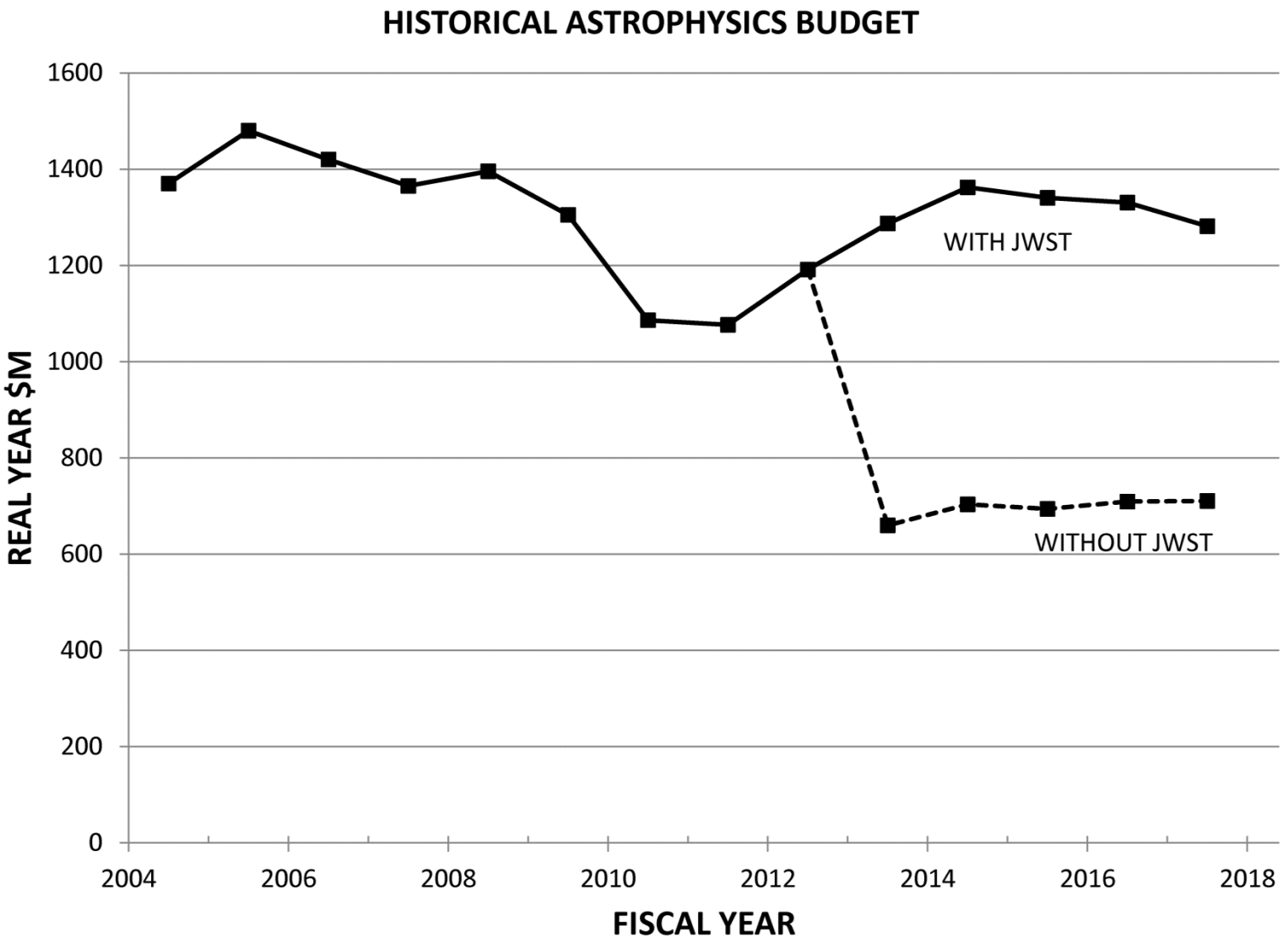
What changed:

- 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.

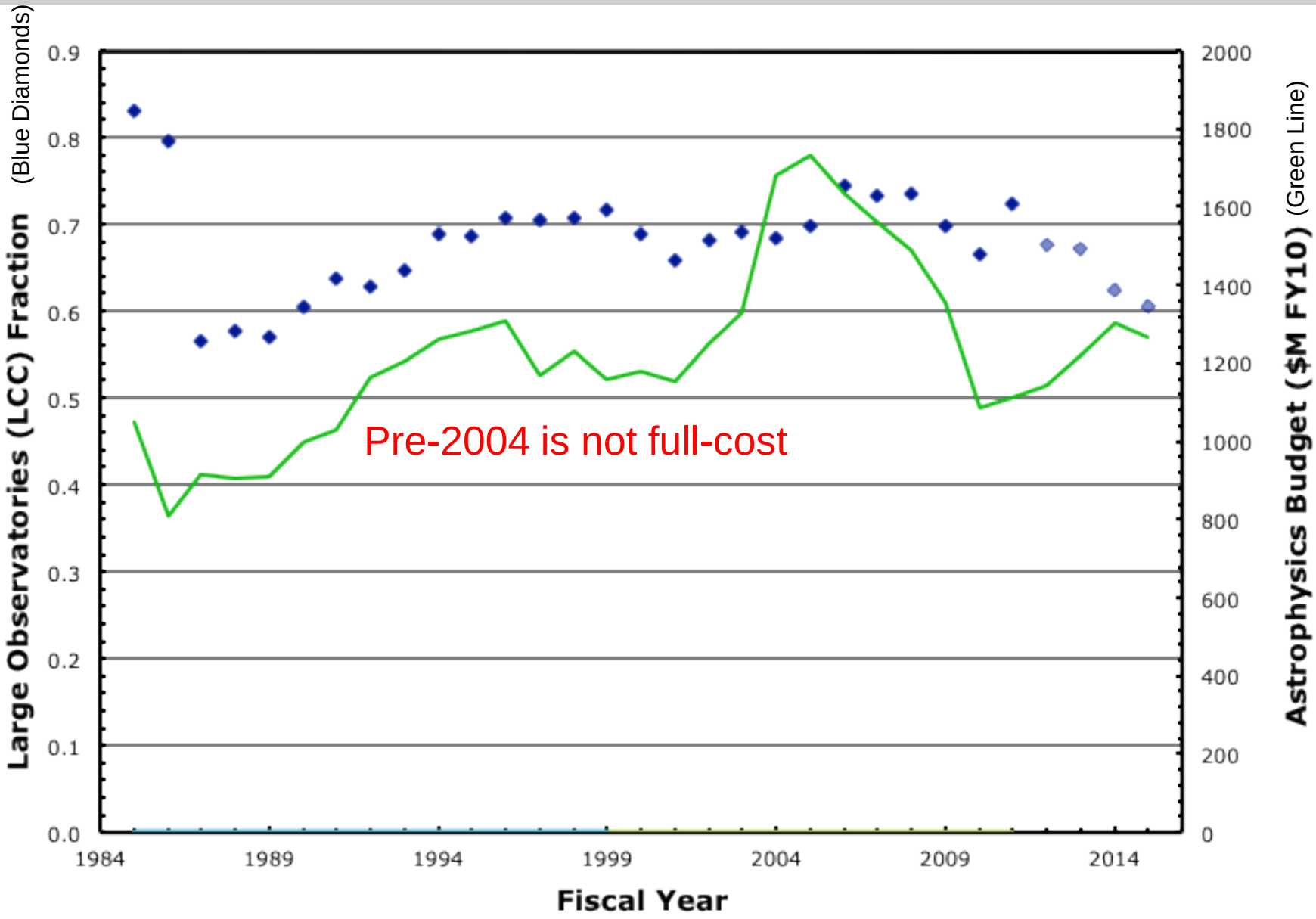
What is the same:

- SOFIA continues development and early science flights. Selected upgrades to HAWC far infrared camera as SOFIA's first second-generation instrument.
- Hubble, Chandra, Spitzer, Fermi, Kepler, and other operating missions (subject to 2012 Senior Review).
- Keck Interferometer operations will cease in 2012, per plan.

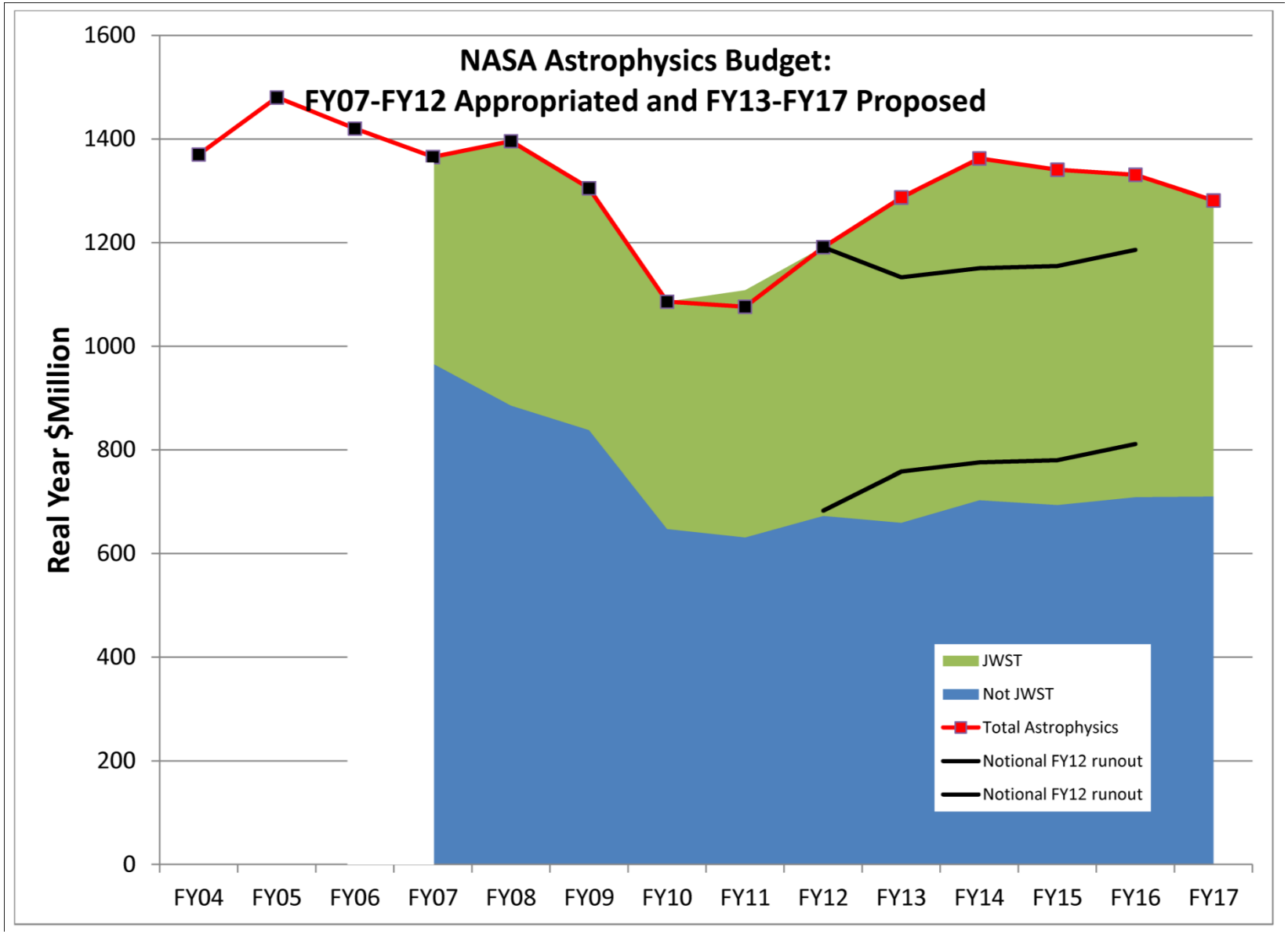
NASA's Investment in Astrophysics



Flagship Missions vs Astrophysics Budget



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 to complete 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.
  - Third priority is to issue new AOs leading to the development of new missions.
- Identifying Explorer AO options is straightforward: (i) identify total mission budget (including Launch Vehicle and required HQ reserves, neither of which is included in the PI cost cap); (ii) see when Phase B and a reasonable profile can be accommodated within the future mission line; (iii) back up 2 years from Phase B start for a 2-step AO release date (a little less for a 1-step AO for MOs).
- The Astro2010 Decadal Survey said to “Enable rapid response to science opportunities; augments current plan by 2 MIDEXs, 2 SMEXs, and 4 MoOs.”
  - “This survey recommends that the annual budget of the astrophysics component of the Explorer program be increased from $40 million to $100 million by 2015.”
  - The Astrophysics Explorer budget is $134M in FY15 and $166M in FY17.
- Astrophysics Division has proposed to SMD a series of AOs:
  - An AO for a MO with a $50-60M cost cap in Sep/Oct 2012.
  - An AO for a SMEX and a MO late CY2013 or early CY2014 with the cost caps and actual dates TBD by summer 2012.

WFIRST (Wide-Field Infrared Survey Telescope)

- Science Definition Team delivered its interim report in July 2011.
  - The report is 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.
  - Second DRM will not duplicate capabilities of Euclid, LSST, and JWST in advancing science objectives of WFIRST. Hope for cost savings.
  - Final report due June 2012.
- Astro2010 recommended WFIRST as the highest priority large mission.
  - The President's FY13 NASA budget request includes no new large missions; Astrophysics expects none before we successfully complete JWST.
  - 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 originally planned WFIRST technology development.
- NASA is proceeding as follows:
  - Through the Science Definition Team and Design Reference Missions, establish a basis for WFIRST planning.
  - Partner on ESA's Euclid to advance some of the science of Astro2010 and 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

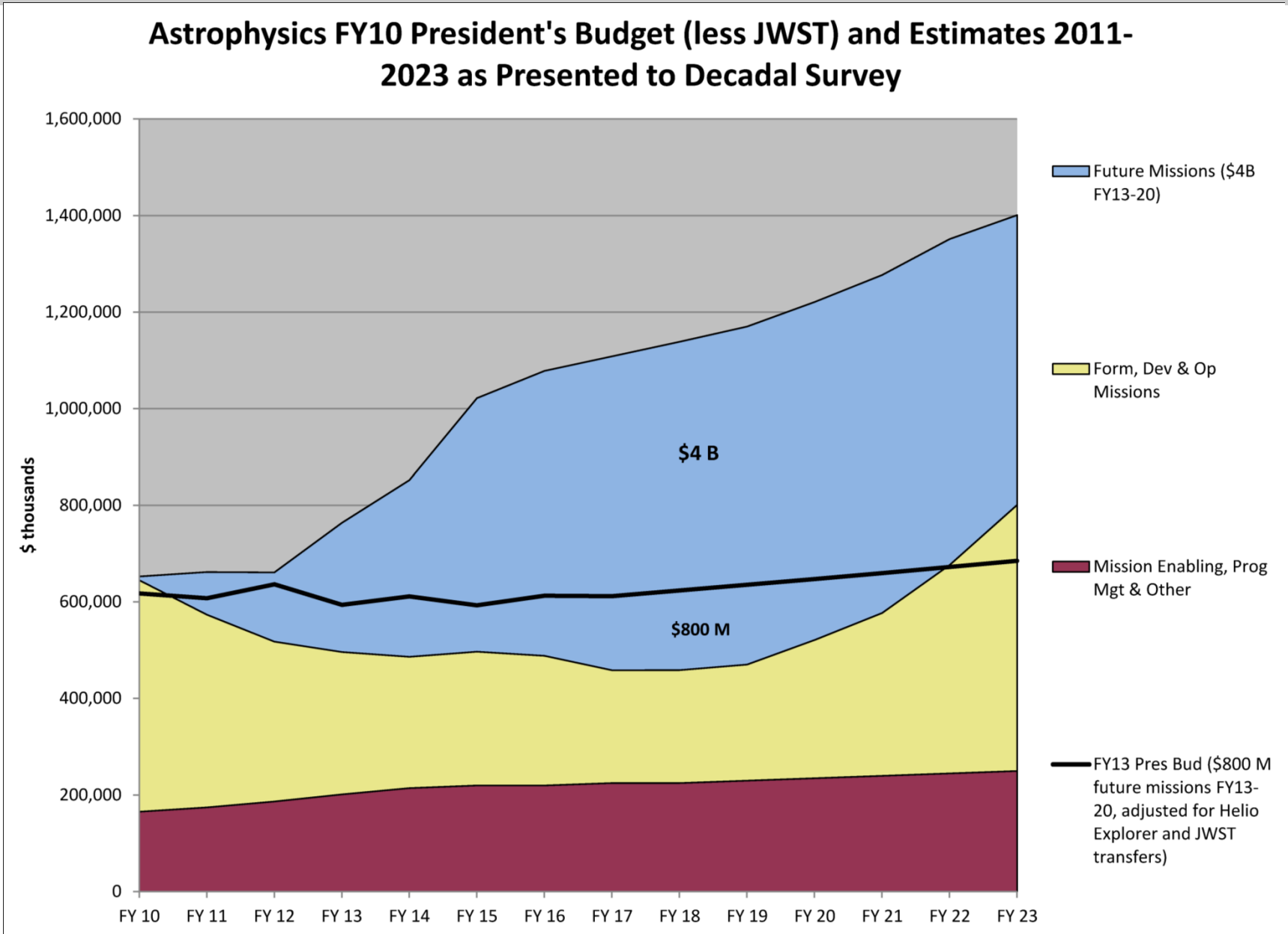
-- Theory and Computation Networks: AAAC studying NASA-NSF program

-- Suborbital program (payloads, balloons) growth deferred

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).

Changes since the Astro2010 Decadal Survey



Planning (continued)

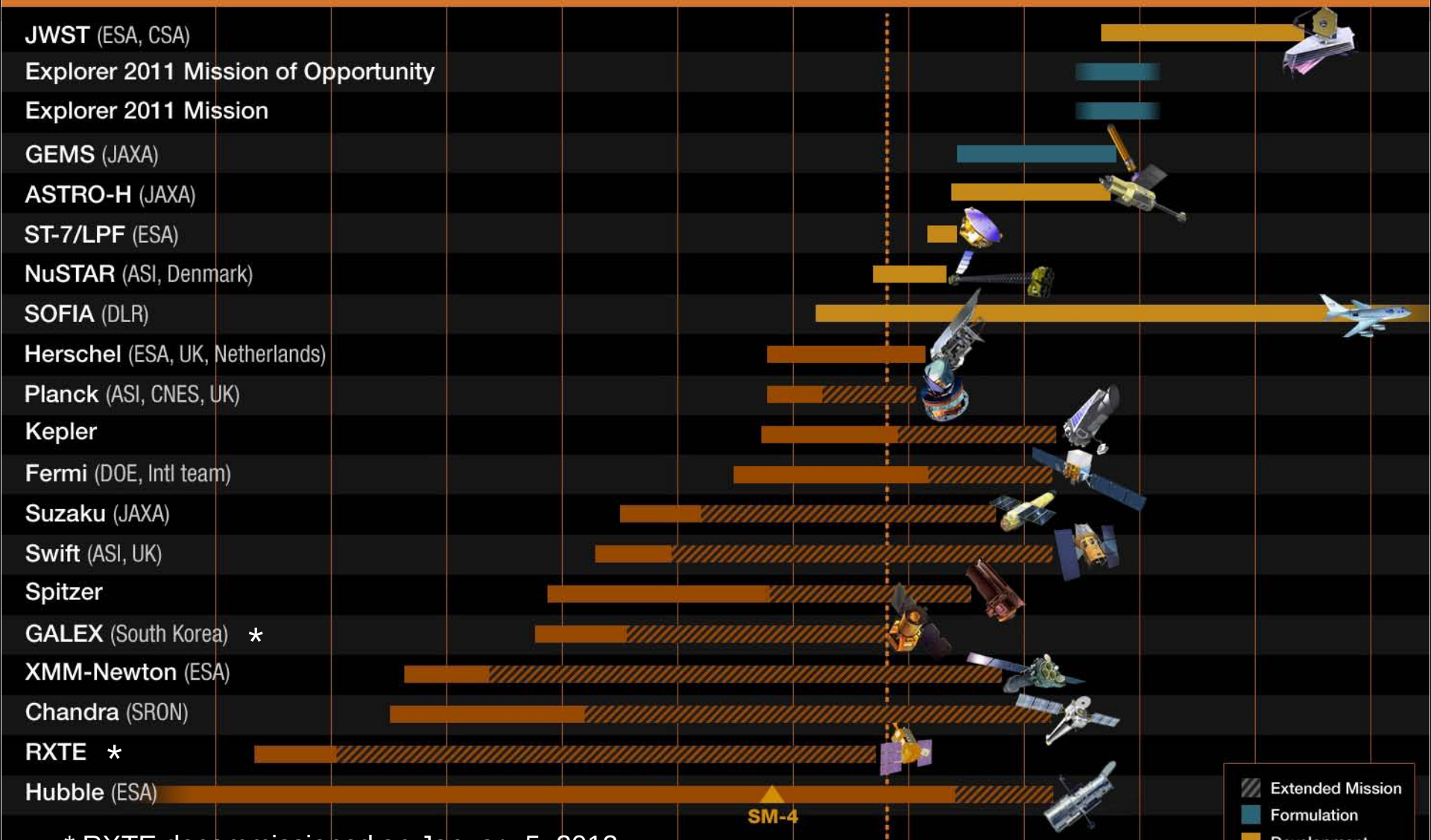
- Astro2010 priorities for a constrained budget:
  - "The first priority is to develop, launch, and operate the WFIRST mission, and implement the Explorer program and core research program recommended augmentations." (pgs 237-238)
- The $800M funding wedge within the runout of the President's FY13 budget 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.

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.
    - Look for opportunitie sto realize decadal priorities with moderate missions.
  - Work with the advisory structure (APS, PAGs, SAGs) and NRC (SSB, BPA, CAA) 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 earlier within the current budget.

Astrophysics Missions timeline

Last updated: April 24, 2012



* RXTE decommissioned on January 5, 2012.
GALEX NASA science data acquisition ended on February 7, 2012.