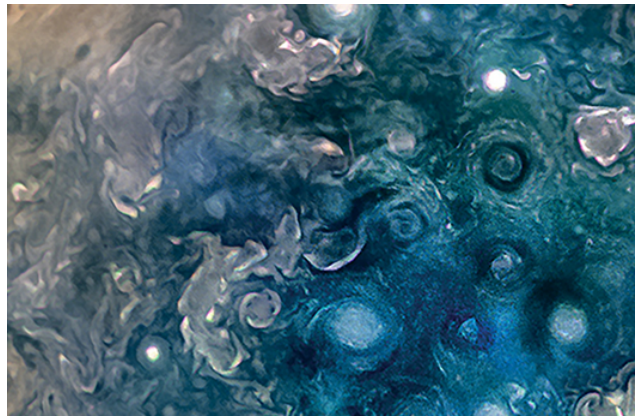
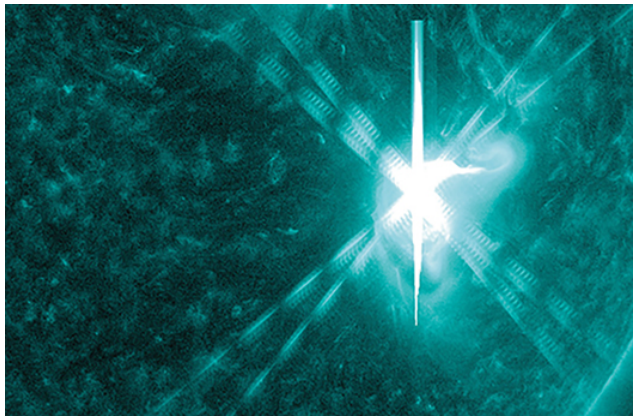
SCIENCE

National Aeronautics and Space Administration



SCIENCE MISSION DIRECTORATE

FY 2019 BUDGET ESTIMATES

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Associate Administrator
Science Mission Directorate
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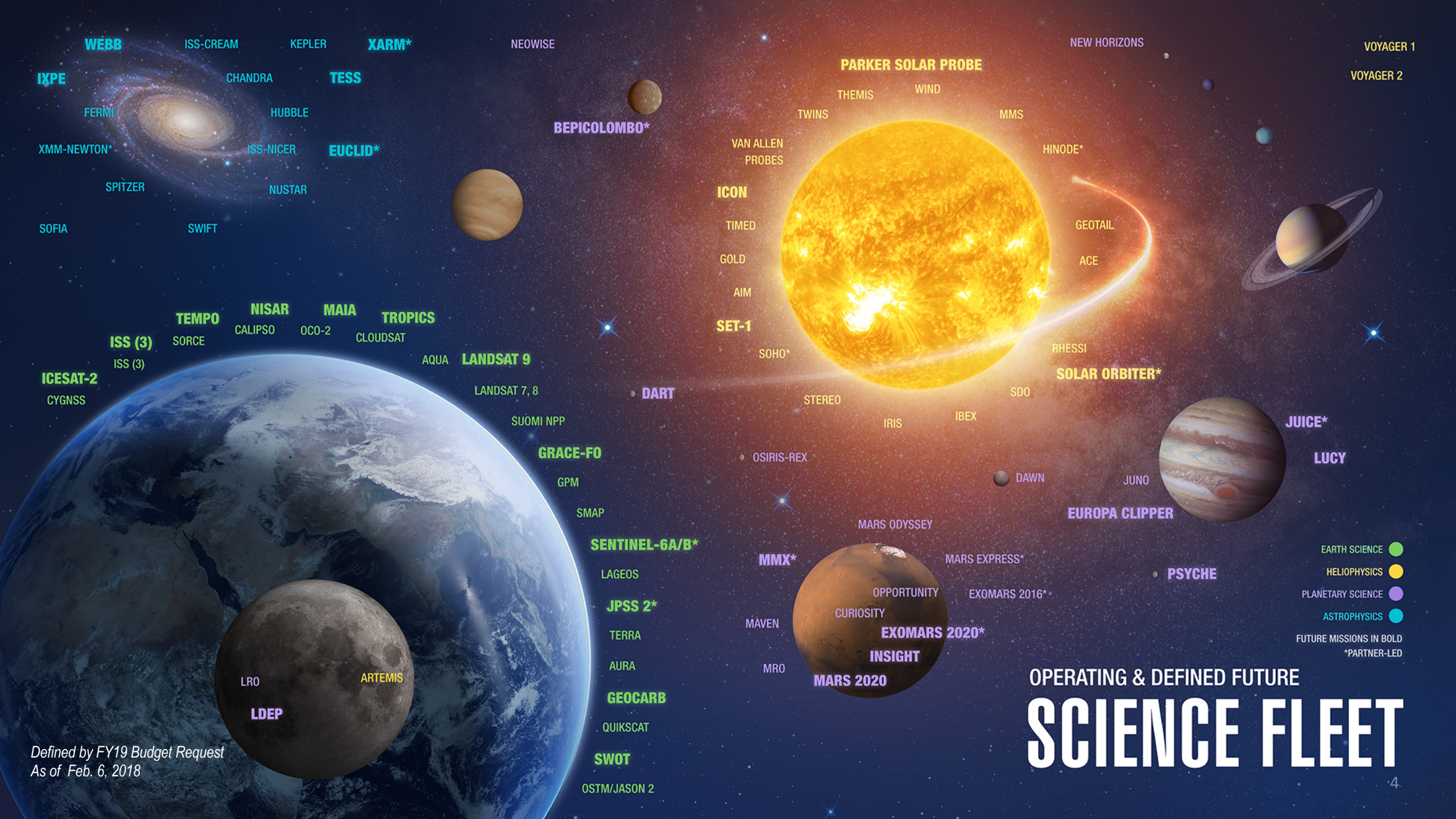
FEBRUARY 2018

Agenda

- SMD Overview
- Budget Highlights
- Planetary Science
- Astrophysics
- Heliophysics
- Earth Science
- Joint Agency Satellite Division
- Science Activation

NASA Science Mission Directorate

An Integrated Program
Enabling Great Science



Defined by FY19 Budget Request
As of Feb. 6, 2018

OPERATING & DEFINED FUTURE

SCIENCE FLEET

FY 2019 Budget Highlights

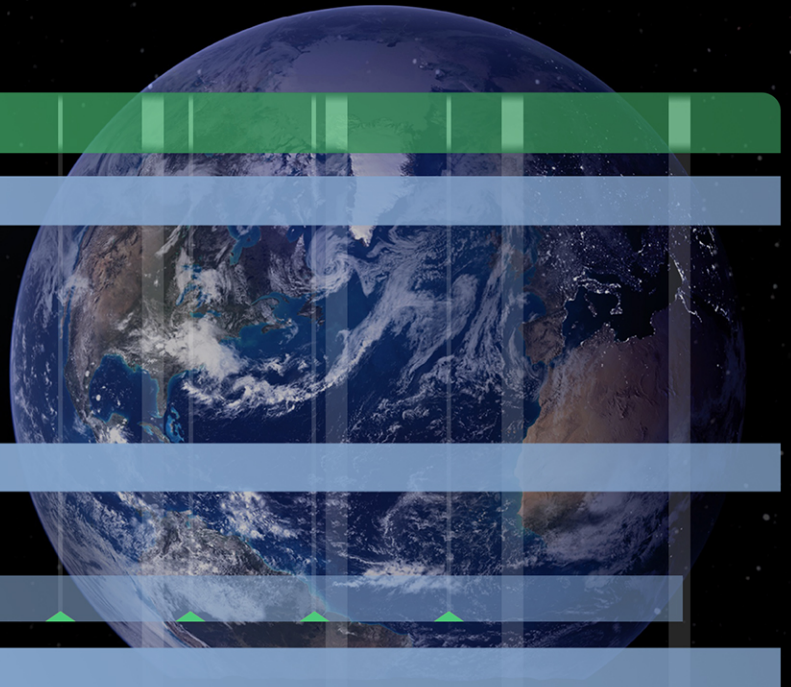
- Advance National Science and Exploration Goals
- Safeguard and Improve Life
- Execute a Balanced and Integrated Science Program

FY 2019 Budget Highlights

Advance National Science and Exploration Goals

- Execute a new **Lunar Discovery and Exploration** program to leverage commercial partnerships and innovative approaches to achieve human and science exploration goals
- Build on extensive past **Lunar** exploration and science experience
- Plan a potential **Mars Sample Return** mission, a decadal survey priority, leveraging international and commercial partnerships

NASA Lunar Exploration Campaign



NOTIONAL LAUNCHES

EARLY SCIENCE & TECHNOLOGY INITIATIVE

- **SMD**–Pristine Apollo Sample, Virtual Institute
- **HEO/SMD**–Lunar CubeSats
- **SMD**/HEO–Science & Technology Payloads

SMALL COMMERCIAL LANDER INITIATIVE

- **HEO**–Lunar Catalyst & Tipping Point
- **SMD**/HEO–Small Commercial Landers/Payloads

MID TO LARGE COMMERCIAL LANDER INITIATIVE TOWARD HUMAN-RATED LANDER

- **HEO**/SMD–Mid Commercial Landers (~500kg–1000kg)
- **HEO**/SMD–Human Descent Module Lander (5-6000kg)
- **SMD**/HEO–Payloads & Technology/Mobility & Sample Return

LUNAR ORBITAL PLATFORM—GATEWAY

- **HEO**/SMD–Power & Propulsion Element/Communication Relay
- **HEO**/SMD–Crew Support of Lunar Missions
- **HEO**/SMD–Lunar Sample Return Support

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

Timelines are tentative and will be developed further in FY 2019

FY 2019 Budget Highlights

Safeguard and Improve Life

- Execute **Planetary Defense** program for near-Earth object detection and mitigation, developing **DART** and studying a low-cost space-based near-Earth object detection mission
- Provide additional funding for **Space Weather** research to improve forecasting and prediction, and strengthen cross-agency collaboration on Research-to-Operations / Operations-to-Research
- Execute a robust **Earth Science** program consistent with the 2017 Decadal Survey
- Support **interagency partners** to achieve missions and leverage data obtained from partners (e.g., NOAA, USGS) to further science research

FY 2019 Budget Highlights

Execute a Balanced and Integrated Science Program

- Execute program informed by National Academy of Sciences **Decadal Surveys**
- Support for **Europa Clipper** mission, no funding for Europa lander
- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, **WFIRST** terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
- Continue leveraging innovation and partnerships, including **SmallSats/CubeSats** and commercial efforts
- Invest in innovative early-stage research and technology to promote **economic growth**

FY 2019 Budget

Program Highlights

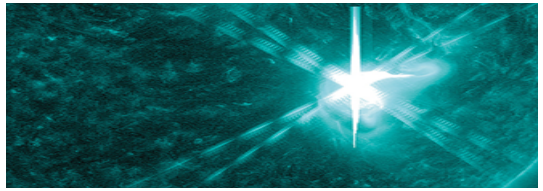
Planetary Science

- New Lunar Discovery and Exploration program supports commercial partnerships and innovative approaches to achieving human & science exploration goals
- New Planetary Defense program includes DART development
- Europa Clipper launch as early as FY25
- Plan a potential Mars Sample Return mission

Astrophysics

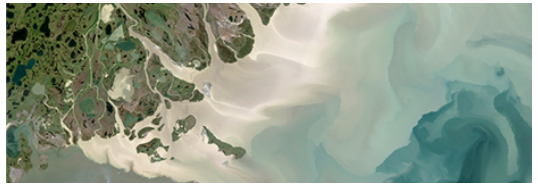
- Webb remains on track for 2019 launch
- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research

Heliophysics



- Space Weather increase will strengthen cross-agency collaboration on Research-to-Operations/Operations-to-Research
- Provides for a balanced Heliophysics portfolio, including enhanced emphasis on small missions, technology development and expanded opportunities for R&A

Earth Science



- Continues focused, balanced Earth science portfolio
- Maintains regular cadence of Venture Class missions and instruments solicitations
- Healthy research and applied science programs, and SmallSat/CubeSat investments

Science budget ~2% above the FY17 appropriated level

Science Budget Request Summary ($M)

	Actual	Enacted	Request	Notional			
	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23
Science	5,762.2		5,895.0	5,859.9	5,841.1	5,822.4	5,803.6
Earth Science	1,907.7		1,784.2	1,784.2	1,784.2	1,784.2	1,784.2
Earth Science Research	462.0		451.4	457.4	483.8	507.7	537.8
Earth Systematic Missions	929.7		788.1	729.5	689.1	646.5	595.0
Earth System Science Pathfinder	208.8		235.0	273.7	268.2	274.3	287.7
Earth Science Multi-Mission Operations	204.9		196.9	208.7	225.0	231.6	237.1
Earth Science Technology	62.9		59.7	61.6	64.2	67.8	69.6
Applied Sciences	39.4		53.1	53.3	53.9	56.3	57.0
Planetary Science	1,827.5		2,234.7	2,199.6	2,180.8	2,162.1	2,143.3
Planetary Science Research	230.1		258.0	247.6	247.6	247.6	247.6
Planetary Defense	60.0		150.0	150.0	150.0	150.0	150.0
Lunar Discovery and Exploration	19.0		218.0	218.0	218.0	218.0	218.0
Discovery	194.6		381.2	476.6	375.0	355.6	348.5
New Frontiers	134.0		130.2	163.7	245.0	327.6	388.4
Mars Exploration	647.0		601.5	529.7	371.9	290.8	215.3
Outer Planets and Ocean Worlds	359.5		285.6	213.8	373.3	372.5	375.5
Technology	183.3		210.2	200.2	200.0	200.0	200.0
Astrophysics	1,352.3		1,185.4	1,185.4	1,185.4	1,185.4	1,185.4
Astrophysics Research	190.1		259.2	280.8	321.5	318.4	310.0
Cosmic Origins	779.4		491.4	354.5	311.9	312.7	312.7
Physics of the Cosmos	106.2		136.8	139.1	113.3	108.3	105.0
Exoplanet Exploration	152.6		52.4	44.5	44.6	44.4	44.9
Astrophysics Explorer	124.1		245.6	366.5	394.0	401.6	412.8
Heliophysics	674.7		690.7	690.7	690.7	690.7	690.7
Heliophysics Research	180.8		242.7	234.3	226.7	217.9	220.6
Living with a Star	368.4		247.8	103.4	83.5	93.2	127.8
Solar Terrestrial Probes	38.8		91.0	89.9	177.7	175.6	247.9
Heliophysics Explorer Program	86.7		109.2	263.1	202.9	204.1	94.4

Science Mission Directorate

Planetary Science

Planetary Science Budget Features

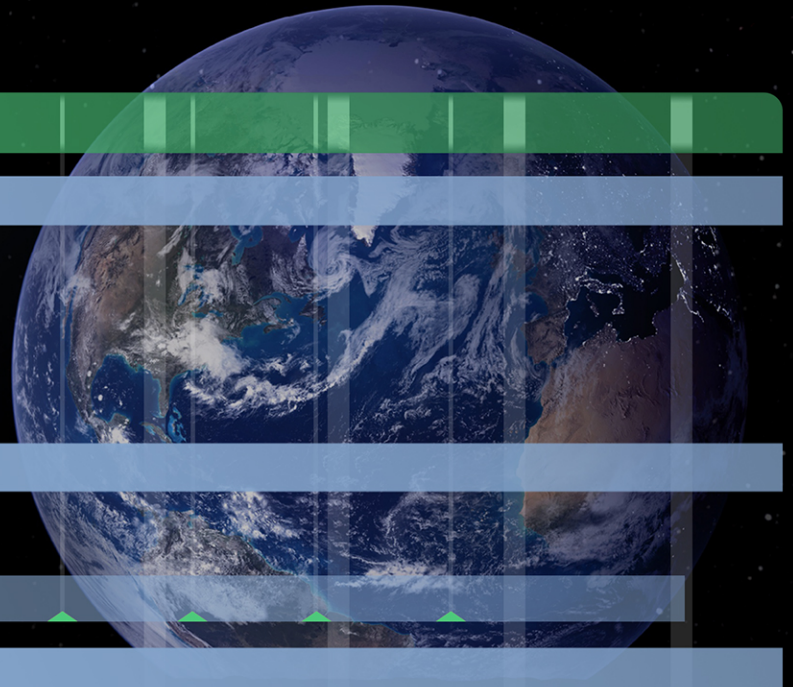
What's Changed

- New Lunar Discovery and Exploration Program supports public-private partnerships and innovative approaches to achieving science and human exploration goals
- New Planetary Defense Program for near-Earth object detection and mitigation includes development of DART and studies a low-cost, space-based near-Earth object detection mission
- Supports trade studies and technology development for returning Mars samples cached by Mars 2020 rover
- Europa Clipper as early as FY25; proposes to fly Clipper on a commercial launch vehicle given cost savings

What's the Same

- Supports InSight, Psyche, Lucy, and next New Frontiers selection in FY19
- Funds all operating missions, and completes development of Mars 2020
- DoE production of radioisotope power generators and Pu-238 to fuel missions
- Healthy research program and SmallSat/CubeSat investments

NASA Lunar Exploration Campaign



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ASSESS
[CENTER FOR NEAR EARTH OBJECT STUDIES]
IAU
Minor Planet Center
SEARCH, DETECT & TRACK
[SPACE-BASED & GROUND-BASED OBSERVATIONS, IAWN]
PLANETARY
DEFENSE
MITIGATE
[DART, FEMA EXERCISES]
CHARACTERIZE
[NEOWISE, GOLDSTONE, ARECIBO, IRTF]
PLAN & COORDINATE
[SMPAG, PIERWG, DAMIEN IWG]

Planned Accomplishments FY18-19

- First commercial opportunities as part of the Lunar Discovery and Exploration Program in 2019
- Explore options for an affordable space-based NEO search capability
- InSight will launch May 2018 and land on Mars November 2018
  - Will peer beneath surface of Mars, providing insight into processes that shaped rocky planets of inner solar system
- OSIRIS-REx will arrive at asteroid Bennu August 2018
  - Investigation of asteroid will provide information about early history of Solar System and help scientists develop future missions to mitigate asteroid impacts at Earth
- New Horizons will flyby MU69 on January 1, 2019; first ever flyby of a Kuiper Belt object beyond Pluto system
- Next New Frontiers mission (CAESAR or Dragonfly) will be announced in 2019

Science Mission Directorate

Astrophysics

Astrophysics Budget Features

What's Changed

- Webb included as project within Astrophysics budget, remains on track and within budget for 2019 launch
- Given its significant cost within a proposed lower budget for Astrophysics and competing priorities within NASA, WFIRST terminated with remaining WFIRST funding redirected towards competed astrophysics missions and research
- Euclid budget increased to recover from failed sensor electronics design
- XARM begun within Explorers program
- Spitzer ops extended until Webb is operational, consistent with 2016 Senior Review

What's the Same

- TESS, IXPE, and GUSTO remain on track and within budget
- All 11 operating missions continue; next Senior Review in 2019
- CubeSat initiative and four balloon campaigns within healthy research program

Planned Accomplishments FY18-19

- TESS will launch March 2018
- IXPE will complete preliminary design review and enter Phase C Fall 2018
- Next MIDEX and Mission of Opportunity missions will be downselected by January 2019
- Decadal Survey will begin January 2019
- Webb will complete observatory integration and will launch in 2019
- Senior Review will be conducted Spring 2019
- If Congress adopts the Administration's request to terminate WFIRST, the funds made available would enable a competed probe-class mission AO in FY19

Science Mission Directorate

Heliophysics

Heliophysics Budget Features

What's Changed

- Space Weather increase will strengthen cross-agency collaboration on Research-to-Operations/Operations-to-Research, a priority of National Space Weather Action Plan
- Increased investments in CubeSats and Technology Development
- ESA delayed Solar Orbiter launch beyond February 2019
- ICON delayed from October 2017 to 2018 to address launch vehicle separation system issue

What's the Same

- GOLD launched as planned in January 2018
- Parker Solar Probe on track for launch by August 2018
- ICON observatory I&T completed; Solar Orbiter instruments delivered to ESA for spacecraft integration
- Operating missions funded according to senior review guidance

Planned Accomplishments FY18-19

- Parker Solar Probe, scheduled for launch July 2018, will be first spacecraft to fly into Sun's atmosphere
- Ionospheric Connection Explorer (ICON) launches in 2018
- Space Environment Testbed 1 (SET-1) scheduled to launch June 2018
- Interstellar Mapping and Acceleration Probe (IMAP) Step 1 selections in 2018
- Six CubeSats expected to launch in FY18-19
  - CeREs will study what energizes electrons and causes escape from radiation belts
  - MinXSS-2 will measure solar soft X-rays to study processes from quiet sun to solar flares
  - CuSP will study the sources and acceleration mechanisms of solar and interplanetary particles
  - CuPID will image solar wind around Earth, planets and the moon
  - SORTIE will study space weather sources of wave-like plasma perturbations in ionosphere
  - ELFIN will study dominant wave-loss mechanism of relativistic electrons
- Increased funding for competed research programs to meet or exceed Decadal Survey recommendation (DRIVE initiative)

Science Mission Directorate

Earth Science

Earth Science Budget Features

What's Changed

- Executes data buy pilot – purchase and evaluation of Earth observations data from private sector small satellite constellations
- Radiation Budget Instrument (RBI), previously planned for flight on JPSS-2, terminated due to technical and programmatic reasons

What's the Same

- GRACE Follow-On, ECOSTRESS, ICESat-2, and GEDI slated for launch on time FY18-19; SWOT, NISAR, Sentinel-6, Landsat 9, TEMPO, GeoCarb, TROPICS and MAIA remain on schedule for launch in budget window
- Six INVEST CubeSats remain on schedule for launch in budget window
- Maintains regular cadence of Venture Class missions and instruments solicitations
- Healthy research and applied science programs, and SmallSat/CubeSat investments
- As in FY18 Presidential Budget Request, assumes termination of PACE, OCO-3, CLARREO Pathfinder, DSCOVR Earth-viewing instruments, and Carbon Monitoring System

Planned Accomplishments FY18-19

- GRACE-FO scheduled April 2018 launch, continuing mission of recently completed GRACE mission (after 15 years in operations), to support drought prediction, global aquifer monitoring and global ice mass balance research and modelling
- ECOSTRESS scheduled June 2018 launch to ISS to monitor vegetation health and improved drought forecasting
- ICESat-2 scheduled September 2018 launch to measure polar ice sheet elevation, sea ice thickness, land topography and global vegetation canopy height characteristics in unprecedented detail
- TEMPO instrument, designed to provide hourly measurements of North American air quality, expected completed and manifested for flight on commercial geo satellite as hosted payload
- Conduct 14 oceanic and terrestrial airborne field campaigns in four continents
- Launch six CubeSats: 4 from InVEST, 1 Venture Tech, 1 Flight Demo (CSIM FD)
- NASA and USAID to select and award a new SERVIR Amazonia hub serving South America

Science Mission Directorate

Joint Agency Satellite Division

Planned Accomplishments FY18-19

- Complete NOAA-20 product validation and transition to operations February 2018
- Launch GOES-S March 2018
- Complete GOES-S product validation and transition to operations
- Initiate and complete GOES-T integration and test and store spacecraft
- Complete build of JPSS-2 instruments (ATMS, CrIS, VIIRS, and OMPS) and spacecraft
- Launch MetOp-C by EUMETSAT October 2018

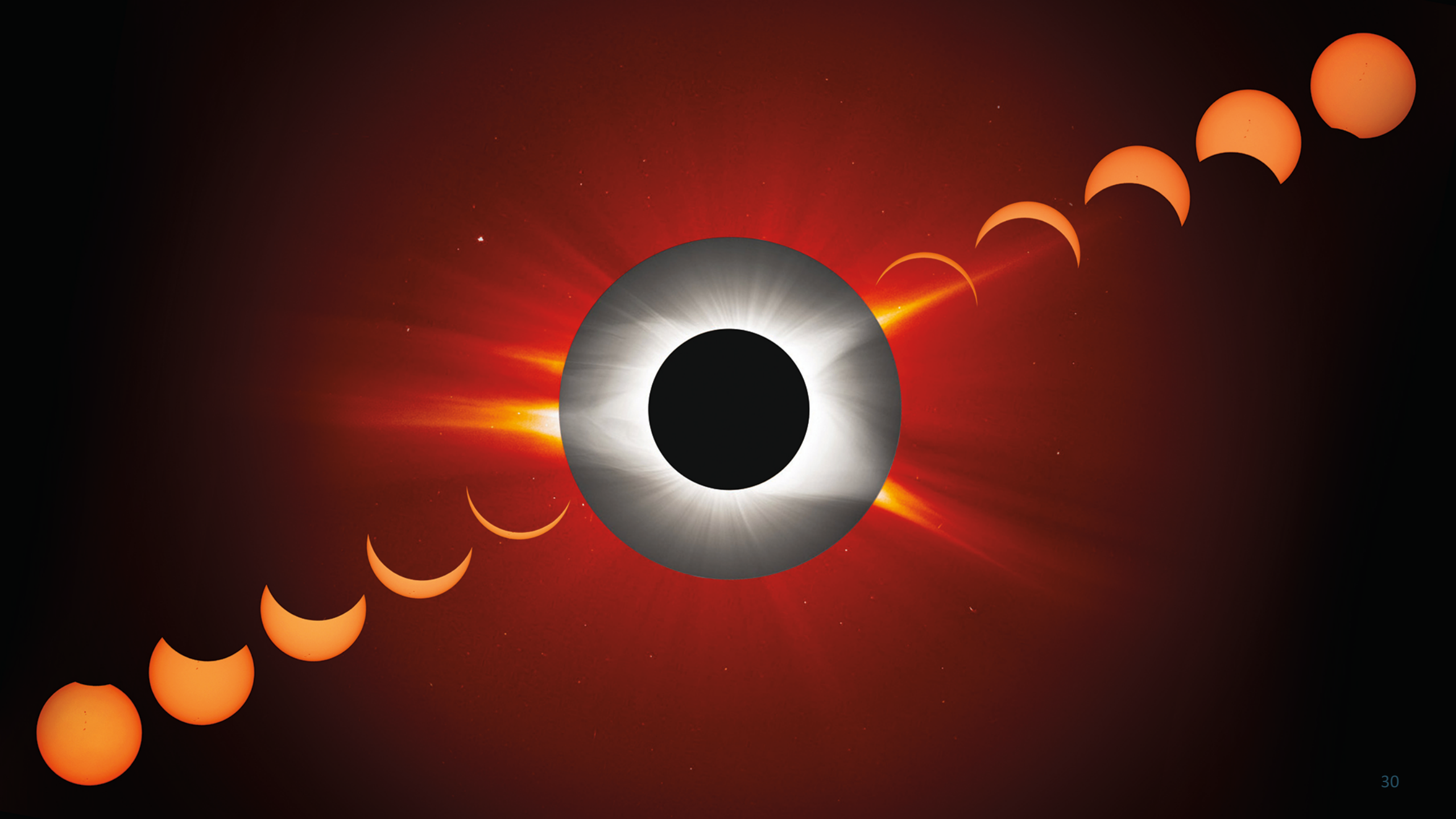
Note: Budget information and justification provided in NOAA budget documentation

Science Mission Directorate

Science Activation

Science Activation "Reach" Extends Across U.S.

For details visit: science.nasa.gov/learners



Conclusion

FY 2019 Budget

Program Highlights

Planetary Science

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- New Planetary Defense program includes DART development
- Europa Clipper launch as early as FY25
- Plan a potential Mars Sample Return mission

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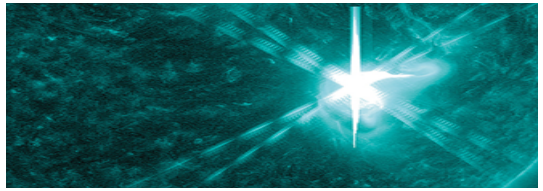

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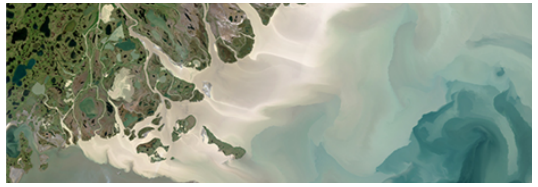
- Provides for a balanced Heliophysics portfolio, including enhanced emphasis on small missions, technology development and expanded opportunities for R&A

Earth Science



- Continues focused, balanced Earth science portfolio
- Maintains regular cadence of Venture Class missions and instruments solicitations
- Healthy research and applied science programs, and SmallSat/CubeSat investments

Science budget ~2% above the FY17 appropriated level


EXPLORE AS
ONE
EXPLORER 1
INSIGHT
PARKER
ICESAT-2
WEBB

Back-Up

Upcoming SMD Mission Solicitations and Selections

- FY18 Announcements of Opportunity
  - Heliophysics Medium Explorer mission and Mission of Opportunity
  - SOFIA Next Generation Instrumentation
  - Earth Venture Instruments-5 (EVI-5)
- FY19 Announcements of Opportunity
  - Discovery mission
  - Astrophysics Small Explorer and Mission of Opportunity
  - Lunar instrument(s) for Missions of Opportunity
  - Earth Venture Mission (EVM)-3, and Earth Venture Instrument (EVI)-6
- FY19 Selections
  - New Frontiers 4
  - Heliophysics Small Explorer and Mission of Opportunity missions
  - Astrophysics Medium Explorer and Mission of Opportunity missions
  - Earth Venture Suborbital-3 investigations from the AOs released in 2016 and 2017

Major Project Status - Science

- Explanatory Statement for FY 2016 Appropriation directs NASA to provide semiannual briefings to Committees on missions listed in Cost and Schedule Performance Summary in NASA's budget submission
- The following slides represent the fifth required response for Science
  - Cover Science missions in FY 2018 Cost and Schedule Performance Summary

- GRACE-FO
- ICESat-2
- ICON
- InSight
- Mars 2020
- NISAR
- Parker
- Sentinel-6
- SOC
- SWOT
- TESS
- Webb

Major Project Status - Overview

- In the last year, missions in report continued to do well with changes to
  - Lower cost estimates for GRACE-FO, TESS, SOC, and NISAR (total $45M)
  - $13M Mars 2020 increase related to HEOMD/STMD contributions
  - Launch delays for ICON, GRACE-FO, SOC and Webb with no budget growth
- Status since confirmation

	Original Baseline			Revised Baseline			Q1 FY18 Actual/Current		Change From Original Baseline	
	Estab.	Sched	Dev $M	Estab.	Sched	Dev $M	Sched	Dev $M	Sched	Dev Cost
ICON	Oct-14	Oct-17	196				TBD	196	+4 mos	
GRACE-FO	Feb-14	Feb-18	264				Apr-18	248	+4 mos	-6%
InSight	Dec-13	Mar-16	542				May-18	673	+26 mos	24%
TESS	Oct-14	Jun-18	323				Jun-18	281		-13%
PSP	Mar-14	Aug-18	1056				Aug-18	1050		-1%
ICESat-2	Dec-12	May-17	559	May-14	Jun-18	764	Oct-18	765	+17 mos	37%
SOC	Mar-13	Oct-18	377				TBD	310	+4 mos	-18%
Webb	Aug-09	Jun-14	2581	Sep-11	Oct-18	6198	TBD	6189	+57 mos	140%
Mars 2020	Jun-16	Jul-20	1677				Jul-20	1688		1%
Sentinel-6	Apr-17	Nov-21	466				Nov-21	466		
SWOT	May-16	Apr-22	571				Apr-22	571		
NISAR	Aug-16	Sep-22	661				Sep-22	656		-1%

GRACE Follow-On

- Purpose: The GRACE-FO mission will allow scientists to gain new insights into the dynamic processes in Earth's interior, currents in the oceans, and variations in the extent of ice coverage. Data from the mission will support drought prediction, global aquifer monitoring and global ice mass balance research and modelling.
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - NASA expects GFZ (Germany) to launch GRACE-FO on a Falcon-9 as commercial IRIDIUM rideshare by April 2018, later than the KDP-C estimate of February 2018
  - Development costs are currently estimated to be $248M, 6% under the Agency commitment of $264M
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

ICESat-2

- Purpose: ICESat-2 will measure polar ice sheet elevation, sea ice thickness, land topography and global vegetation canopy height characteristics in unprecedented detail. It will extend the measurements from ICESat.
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - NASA expects to launch ICESat-2 by October 2018, 17 months after the original Agency commitment date of May 2017, and four months later than the May 2014 rebaseline commitment of June 2018
  - Development costs are currently estimated to be $765M, 37% over the original Agency commitment of $559M, and unchanged from the May 2014 rebaseline
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Ionospheric Connection Explorer (ICON)

- Purpose: ICON is dedicated to understanding neutral-ion coupling in the Earth's upper atmosphere, also known as the thermosphere. It will resolve both long-standing and newly emerging questions about the mechanisms that control the daily development of plasma in Earth's space environment
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - NASA confirmed ICON to proceed into implementation phase (Phase C/D) on October 29, 2014
  - NASA hopes to launch ICON in 2018, later than our original commitment of October 2017
  - Development costs are currently estimated to be $196M, the same as the Agency commitment
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

InSight

- Purpose: InSight is a Mars lander mission to investigate fundamental issues of terrestrial planet formation and evolution with a study of the deep interior of Mars. InSight will also investigate the dynamics of any Martian tectonic activity and meteorite impacts and compare this with similar phenomena on Earth
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - The primary instrument, SEIS, provided by CNES was unable to make delivery for the 2016 launch opportunity due to technical problems, causing a delay until May 2018
  - NASA and CNES continue to make good progress toward the May 2018 launch
  - Development costs are currently estimated to be $673M, unchanged since NASA and CNES decided to continue the project in September 2016
- Programmatic Analysis
  - The InSight lander, EDL system and other instruments are complete, and ready to support launch
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Mars 2020

- Purpose: NASA's Mars 2020 mission will take the next key steps in our understanding of Mars' potential as a habitat for past or present life. The mission will seek signs of past life on Mars, collect and store a set of samples for potential return to Earth in the future, and test new technology to benefit future robotic and human exploration of Mars
  - Major partners with SMD include NASA's Space Technology Mission Directorate, Human Exploration and Operations Mission Directorate, and international partners
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, project risks, etc.
- Status
  - In FY 2018 the mission will complete the System Integration Review and begin Assembly, Test, and Launch Operations
  - NASA expects to launch Mars 2020 by the Agency commitment date of July 2020
  - Estimated development costs have increased by $13M related to HEOMD/STMD contributions
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

NASA-ISRO Synthetic Aperture Radar (NISAR)

- Purpose: NISAR, a joint mission between NASA and the Indian Space Research Organization, will observe and take measurements of some of the planet's most complex processes, including ecosystem disturbances; ice sheet collapse; and natural hazards, such as earthquakes, tsunamis, volcanoes, and landslides. Data collected by the NISAR satellite will reveal information about the evolution and state of Earth's crust and aid future resource and hazard management.
  - NASA provides the L-band radar, the engineering payload, the payload integration, and payload operations. ISRO provides the S-band radar, the spacecraft bus, the launch vehicle, observatory integration and testing, and spacecraft operations
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, project risks, etc.
- Status
  - In FY 2018, the NISAR project will complete all planned engineering models and begin to build flight hardware. The project will start to build the reflector and boom, and will mature the mission operations concept jointly with ISRO
  - NASA and ISRO expect to launch NISAR by the Agency commitment date of September 2022
  - Development costs are estimated to be $656M, $5M less than the Agency commitment
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Parker Solar Probe

- Purpose: Parker will explore the Sun's outer atmosphere, or corona, as it extends out into space. Parker will orbit at a distance from the Sun of less than five times the Sun's diameter, closer than any other spacecraft. Parker's findings could revolutionize our knowledge and understanding of coronal heating and of the origin and evolution of the solar wind
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - NASA expects to launch Parker by the Agency commitment date of August 2018. The primary launch window of 20 days opens on July 31, 2018
  - Development costs are currently estimated to be $1050M, 0.5% under the original Agency commitment of $1056M. The difference is due to the consolidation and restructuring of Science Education activities
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Sentinel-6

- Purpose: The Sentinel-6 mission will provide continuity of ocean topography measurements beyond the Topography Experiment (TOPEX)/Poseidon (launched in 1992), Jason-1 (2001), OSTM/Jason-2 (2008), and Jason-3 (2016) missions. The Sentinel-6 mission consists of two satellites, Sentinel-6A and -6B, that will launch approximately five years apart to extend measurement continuity for at least another decade.
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status:
  - The mission passed its Key Decision Point-C review in April 2017. In FY 2018 NASA made the launch vehicle selection, will complete CDR and initiate the build of the NASA payload instruments
  - NASA expects to launch Sentinel-6 by the Agency commitment date of November 2021
  - Development costs are estimated to be $466M, the same as the Agency commitment
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Solar Orbiter Collaboration

- Purpose: The NASA and ESA SOC mission will explore the near-Sun environment to improve our understanding of the origins of the solar wind streams and the heliospheric magnetic field; the sources, acceleration mechanisms, and transport processes of solar energetic particles; and the evolution of CMEs in the inner heliosphere
  - NASA provides the launch vehicle and two science investigations/instruments
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - The Project delivered the two U.S. science instruments in FY 2017
  - ESA has announced that they cannot make launch in February 2019, and they are examining a potential February 2020 launch. This compares to NASA's original commitment date of October 2018
  - Development costs are currently estimated to be $310M, 18% under the original Agency commitment of $377M. The difference is attributable to the selection of a less expensive launch vehicle than was budgeted at KDP-C, as well as good cost performance on the U.S. instruments
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Surface Water and Ocean Topography (SWOT)

- Purpose: The SWOT mission will improve ocean circulation models, leading to better prediction of weather and climate. The mission will also revolutionize knowledge of the surface water inventory on the continents by precise measurement of water levels in millions of lakes and water bodies and the discharge of all major rivers, allowing for deeper understanding of the natural water cycle and the informed control of this resource
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - In FY 2018, the project will complete the mission Critical Design Review
  - NASA expects to launch SWOT by the Agency commitment date of April 2022
  - Development costs are estimated to be $571M, the same as the Agency commitment
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

Transiting Exoplanet Survey Satellite (TESS)

- Purpose: TESS will carry out the first space-borne, all-sky exoplanet transit survey, covering 400 times as much sky as any previous mission, including Kepler. It may discover approximately 30 Earth sized planets, 200 Super-Earth sized planets, and 400 sub-Neptune sized planets around other stars in the solar neighborhood
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status
  - NASA expects to launch TESS by the Agency commitment date of June 2018
  - Development costs are currently estimated to be $281M, 13% under the original Agency commitment of $323M. The difference is attributable to the selection of a less expensive launch vehicle than was budgeted at KDP-C, and good cost performance
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks

James Webb Space Telescope

- Purpose: Webb is in many ways a successor to the Hubble Space Telescope, extending Hubble's discoveries by looking into the infrared spectrum. Webb will observe the highly red-shifted early universe and study relatively cool objects like protostars and protoplanetary disks, which emit infrared light strongly where dust obscures shorter wavelengths. With more light-collecting area than Hubble and with near- to mid-infrared-optimized instruments, Webb will observe objects farther away and further back in time
  - Refer to NASA's FY 2019 CJ for technical details, key milestones, major partners, project risks, etc.
- Status:
  - NASA expects to launch Webb in 2019, later than the September 2011 rebaseline commitment of October 2018
  - Development costs are currently estimated to be $6189M, unchanged from last year and slightly less than the September 2011 rebaseline of $6198M
- Programmatic Analysis
  - The technical, cost, and schedule risks of the program are clearly identified and the program has developed a plan to manage those risks
- The FY 2017 appropriation law specifies that formulation and development of Webb shall not exceed $8B.

General Acronym List

AO	Announcement of Opportunity
AMSU	Advanced microwave sounding unit
ARIA	Advanced Rapid Imaging and Analysis
ATMS	Advanced Technology Microwave Sounder
AVHRR	Advanced Very High Resolution Radiometer
CATE	Continental-America Telescopic Eclipse
CDR	Critical Design Review
CH4	Methane
CO	Carbon Monoxide
CO2	Carbon Dioxide
CGS	Common Ground System
CJ	Congressional Justification
CME	Coronal Mass Ejection
CNES	French Space Agency
CrIS	Cross-track Infrared Sounder
CRS	Cargo Resupply Services
CSA	Canadian Space Agency
DAMIEN IWG	Detecting And Mitigating the Impacts of Earthbound Near-Earth Objects Interagency Working Group
DLR	German Space Agency
DOE	Department of Energy
EDL	Entry, Descent, Landing
ESA	European Space Agency
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FY	Fiscal Year
GLOBE	Global Learning and Observations to Benefit the Environment
GOLD	Global-scale Observations of the Limb and Disk
GPS	Global Positioning System
HASP	High Altitude Student Platform
HECC	High-End Computing Capability
HEOMD	Human Exploration and Operations Mission Directorate
IAWN	International Asteroid Warning Network
IAU	International Astronomical Union
I&T	Integration and Testing
InVEST	In-Space Validation of Earth Science Technologies
IRTF	NASA Infrared Telescope Facility
ISS	International Space Station
JAXA	Japanese Space Agency
KDP	Key Decision Point
LDEP	Lunar Discovery and Exploration Program
LRD	Launch Readiness Date
MCR	Mission Concept Review
MIDEX	Medium-class Explorer
MOO	Mission of Opportunity
NOAA	National Oceanic and Atmospheric Administration
NRA	NASA Research Announcement
NSF	National Science Foundation
PBS	Public Broadcasting Service
PDCO	Planetary Defense Coordination Office
PDR	Preliminary Design Review
PI	Principal Investigator
PIERWG	Planetary Impact Emergency Response Working Group
PSD	Planetary Science Division
POES	Polar Operational Environmental Satellite
R&A	Research and Analysis
R&D	Research and Development
R&T	Research and Technology
RFI	Request for Information
RFP	Request for Proposals
ROM	Rough Order of Magnitude
ROSES	Research Opportunities in Space and Earth Science
SALMON	Stand Alone Mission of Opportunity
SAR	Synthetic Aperture Radar
SEM	Space Environment Monitor
SLS	Space Launch System
SMD	Science Mission Directorate
SMEX	Small Explorer
SMPAG	Space Missions Planning Advisory Group
SR&T	Supporting Research and Technology
STEM	Science, Technology, Engineering, and Math
STDT	Science and Technology Definition Team
STMD	Science and Technology Mission Directorate
STScI	Space Telescope Science Institute
TIROS	Television Infrared Observation Satellite
TRAPPIST	Transiting Planets and Planetessimals Small Telescope
TRL	Technology Readiness Level
USGCRP	U.S. Global Change Research Program
USGEO	U.S. Group on Earth Observations
USGS	U.S. Geological Survey
VIIRS	Visible Infrared Imaging Radiometer Suite
WIETR	WFIRST Independent External Technical/Management/Cost Review

Acronyms by Division

Planetary Science Acronyms

BepiColombo	Joint ESA/JAXA mission to Mercury; NASA is contributing the Strofio instrument
Cassini	Flagship mission to Saturn and its moons
DART	Double Asteroid Redirection Test
Dawn	Discovery mission to visit asteroids Vesta and Ceres
Europa Clipper	Mission to Jupiter's moon
ExoMars 2020 (ESA)	Mars rover mission. NASA is contributing the MOMA instrument
InSight	Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport
INSPIRE	Interplanetary NanoSpacecraft Pathfinder In Relevant Environment
JUICE (ESA)	Jupiter Icy Moons Explorer
Juno	New Frontiers mission to Jupiter
LADEE	Lunar Atmosphere Dust and Environment Explorer
LRO	Lunar Reconnaissance Orbiter
Lucy	Discovery mission to six Jovian Trojan asteroids
MarCO	Mars Cube One
Mars Express (ESA)	Mars orbiter lander mission
Mars Odyssey	Mars orbiter
Mars Rover 2020	Next robotic science rover of Mars Exploration Program
MAVEN	Mars Atmosphere and Volatile Evolution
MER	Mars Exploration Rover (Opportunity)
MOMA	Mars Organic Molecule Analyzer
MRO	Mars Reconnaissance Orbiter
MSL	Mars Science Laboratory (Curiosity)
NEOWISE	Near Earth Object Wide-Field Infrared Survey Explorer
New Horizons	New Frontiers mission to fly by Pluto and into the Kuiper Belt
OSIRIS-REx	Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer
Psyche	Discovery mission to asteroid 16-Psyche
Strofio	Mass spectrometer instrument for ESA's BepiColombo mission

Astrophysics Acronyms

ASTRO-H (JAXA)	Facility-class X-ray mission
Chandra	Chandra X-ray Observatory
CREAM (ISS)	Cosmic Ray Energetics and Mass experiment on ISS
Euclid (ESA)	ESA visible/near infrared survey mission
Fermi	Fermi Gamma-ray Large Area Space Telescope
GUSTO	Galactic/Extragalactic Ultralong-Duration Balloon Spectroscopic Terahertz Observatory
HST	Hubble Space Telescope
IXPE	Imaging X-Ray Polarimetry Explorer
JWST	James Webb Space Telescope
Kepler	Kepler Space Telescope to detect extrasolar planets
LISA Pathfinder (ESA)	Laser Interferometer Space Antenna Pathfinder
NICER (ISS)	Neutron-star Interior Composition Explorer experiment on ISS
NuSTAR	Nuclear Spectroscopic Telescope Array
SOFIA	Stratospheric Observatory For Infrared Astronomy
Spitzer	Spitzer Infrared Space Telescope
Swift	Gehrels Swift Gamma-ray Burst Explorer
TESS	Transiting Exoplanet Survey Satellite
WFIRST	Wide-Field Infrared Survey Telescope
XARM	JAXA's X-Ray Astronomy Recovery Mission
XMM-Newton (ESA)	X-ray Multi-mirror Mission

Acronyms by Division (continued)

Heliophysics Acronyms

ACE	Advanced Composition Explorer
AIM	Aeronomy of Ice in the Mesosphere
BARREL	Balloon Array for Radiation-belt Relativistic Electron Losses
CeRE	Compact Radiation Belt Explorer
CuPID	Cusp Plasma Imaging Detector
CuSP	CubeSat to study Solar Particles
DRIVE	Diversify, Realize, Integrate, Venture and Educate Initiative
ELFIN	Electron Losses and Fields Investigation
GEOTAIL	Japan/NASA mission to study Earth's magnetotail
GDC	Geospace Dynamic Constellation
GOLD	Global-scale Observations of the Limb and Disk
HaloSat	SmallSat Mission to map distribution of hot gases associated with the Milky Way galaxy
Hinode (JAXA)	Mission to study energy transport and release in the solar atmosphere
HIS	Heavy Ion Sensor for Solar Orbiter
IBEX	Interstellar Boundary Explorer
ICON	Ionospheric Connection Explorer
IMAP	Interstellar Mapping and Acceleration Probe
IRIS	Interface Region Imaging Spectrograph
IS⊙IS	Integrated Science Investigation of the Sun
LWS	Living With a Star Program
MMS	Magnetospheric Multiscale
MinXSS	Miniature X-Ray Solar Spectrometer
RHESSI	Reuven Ramaty High Energy Solar Spectroscope Imager
SDO	Solar Dynamics Observatory
SET-1 (ISS)	Space Environment Testbed
SOC	Solar Orbiter Collaboration, with ESA
SOHO	Solar and Heliospheric Observatory
SPP	Solar Probe Plus (now Parker Solar Probe)
SORTIE	Scintillation Observations and Response of The Ionosphere to Electrodynamics
STEREO	Solar Terrestrial Relations Observatory
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIMED	Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics
TWINS A&B	Two Wide-Angle Imaging Neutral-Atom Spectrometers
Van Allen Probes	Formerly Radiation Belt Storm Probes
Voyager	Missions to the outer planets
Wind	Mission to measure energetics of the solar wind
WISPR	Wide-field Imager for Solar Probe

NOAA Reimbursable Acronyms

DSCOVR	Deep Space Climate Observatory
GOES series	Geostationary Operational Environmental Satellites
Jason-3	Ocean surface topography satellite
JPSS	Joint Polar-orbiting Satellite System
MetOp-C	Polar orbiting meteorological satellite

Acronyms by Division (continued)

Earth Science Acronyms

Aqua	Earth Observing Satellite mission for atmospheric dynamics
ATLAS	Advanced Topographic Laser Altimeter System
Aura	Earth Observing Satellite for atmospheric chemistry
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CATS (ISS)	Cloud-Aerosol Transport System
CLARREO-PF (ISS)	Climate Absolute Radiance and Refractivity Observatory – Pathfinder
Cloudsat	Studies the role of clouds and aerosols regulating Earth's weather, climate and air quality
CSIM FD	Compact Spectral Irradiance Monitor Flight Demonstration
CubeRRT	CubeSat Radiometer RFI Technology
CYGNSS	Cyclone Global Navigation Satellite System
ECOSTRESS (ISS)	ECOsystem Spaceborne Thermal Radiometer Experiment
EMIT	Earth Surface Mineral Dust Source Investigation
EVS	Earth Venture Sub-orbital missions
GEDI (ISS)	Global Ecosystem Dynamics Investigation
GeoCARB	Geostationary Carbon Cycle Observatory
GMAO	Global Modeling and Assimilation Office
GPM	Global Precipitation Measurement
GRACE	Gravity Recovery and Climate Experiment
GRACE- FO	Gravity Recovery and Climate Experiment – Follow On
HARP	Hyper-Angular Rainbow Polarimeter
IceCube	Mission to map of the global distribution of atmospheric ice in the 883-Gigahertz band
ICESat-2	Ice, Clouds and land Elevation Satellite-2
IMERG	Integrated Multi-satellite Retrievals for GPM
Jason-CS/Sentinal-6A	Radar altimeter on Jason Continuity of Service mission
LAGEOS	Laser Geodynamics Satellite
Landsat	Land imaging satellite
LIS (ISS)	Lightning Imaging Sensor
MAIA	Multi-Angle Imager for Aerosols
MiRaTA	Microwave Radiometer Technology Acceleration
MODIS	Moderate Resolution Imaging Spectroradiometer
NISAR	NASA-ISRO Synthetic Aperture Radar Satellite
OCO-2	Orbiting Carbon Observatory-2
OCO-3 (ISS)	Orbiting Carbon Observatory-3
OMPS-Limb	Ozone Mapping and Profiler Suite-Limb
OSTM/Jason-2	Ocean Surface Topography Mission with France
PACE	Pre-Aerosol, Clouds, and ocean Ecosystem
PREFIRE	Polar Radiant Energy in the Far Infrared Experiment
Q-PACE	CubeSat Particle Aggregation and Collision Experiment
QuikSCAT	Quick Scatterometer for ocean winds measurement
RainCube	Radar in a CubeSat
RBI	Radiation Balance Instrument
SAGE III (ISS)	Stratospheric Aerosols and Gas Experiment III
SORCE	Solar Radiation and Climate Experiment
SLI	Sustainable Land Imaging
SMAP	Soil Moisture Active/Passive
Suomi NPP	Suomi National Polar-orbiting Partnership
SWOT	Surface Water Topography
TEMPEST-D	Temporal Experiment for Storms and Tropical Systems - Demonstrator
TEMPO	Tropospheric Emissions: Monitoring of Pollution
Terra	Earth Observing System mission for land, ocean, and clouds
TROPICS	Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats
TSIS (ISS)	Total Solar Irradiance Spectrometer