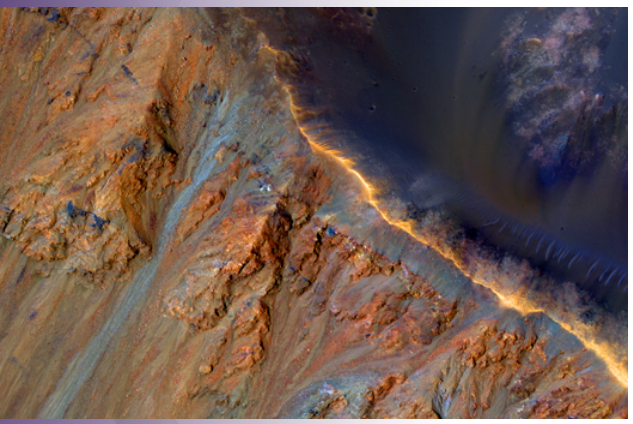
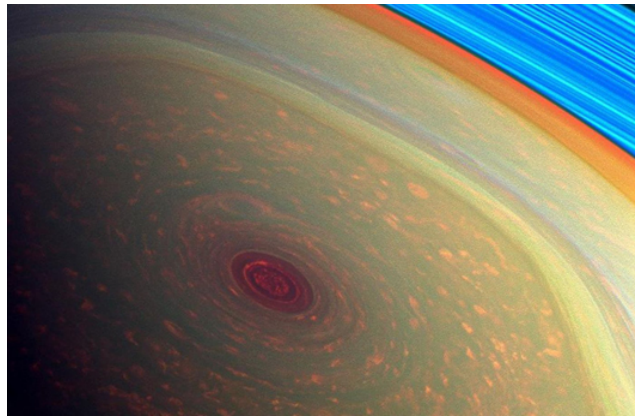
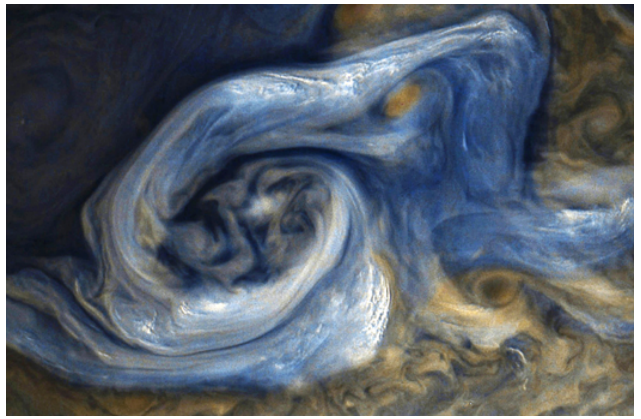
SCIENCE

National Aeronautics and Space Administration


Committee on Astrobiology and Planetary Sciences (CAPS)

PLANETARY SCIENCE DIVISION

Lori S. Glaze
Planetary Science Division Director (Acting)
Science Mission Directorate, NASA

September 11, 2018

Planetary Science Missions: Events

2017

*Completed

January 4 – Discovery Mission selection announced

February 9-20 – OSIRIS-REx conducted Earth-Trojan search

April 22 – Cassini began plane change maneuver for the “Grand Finale”

August 21 – Solar Eclipse across America

September 15 – Cassini end of mission at Saturn

September 22 – OSIRIS-REx Earth flyby

October 28 – International Observe the Moon night (1st quarter)

2018

May 5 – Launch of InSight mission to Mars

August – OSIRIS-REx begins observing Bennu

August – New Horizons begins observing Ultima Thuli

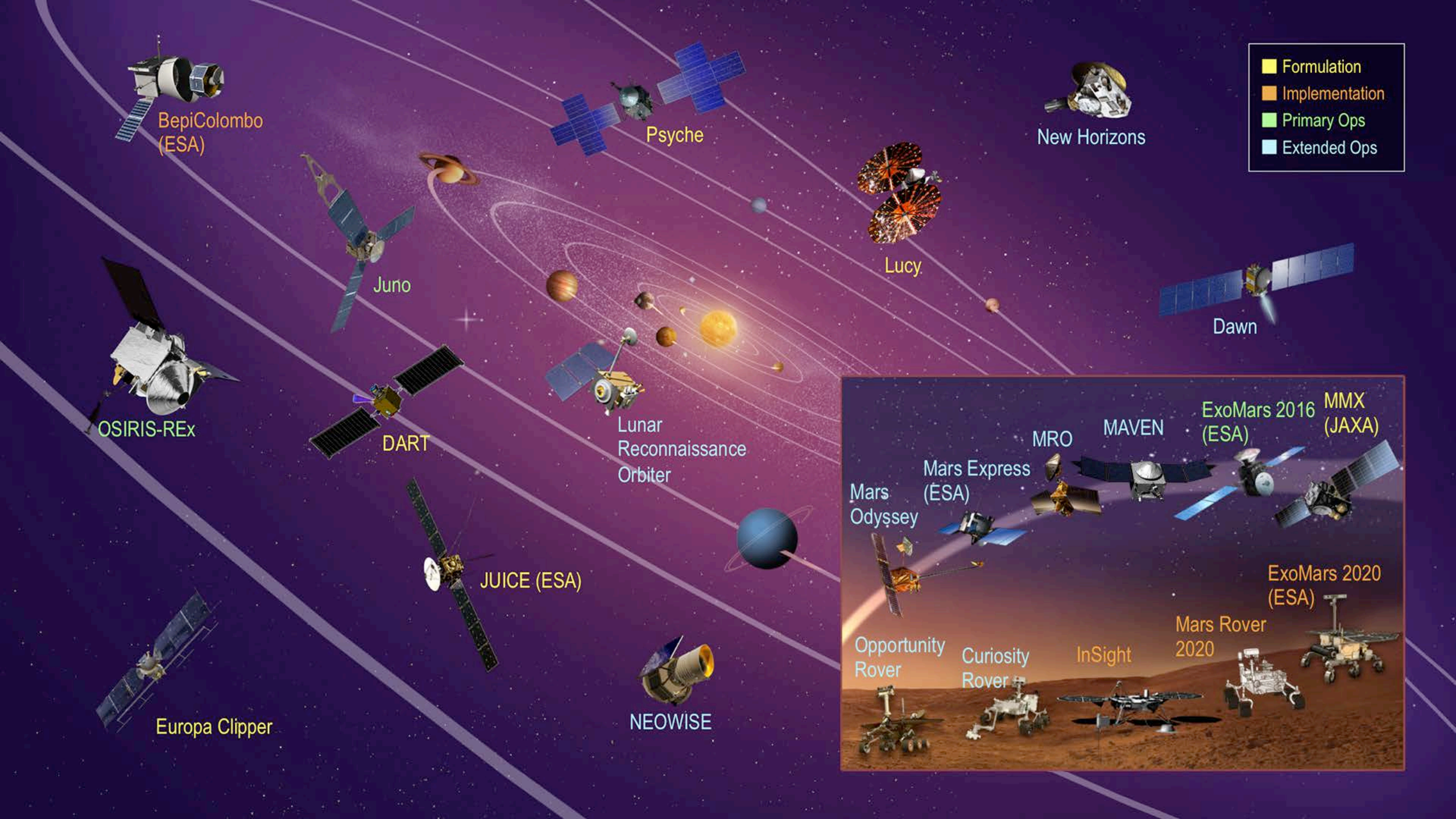
October – Launch of ESA’s BepiColombo to Mercury

November 26 – InSight landing on Mars

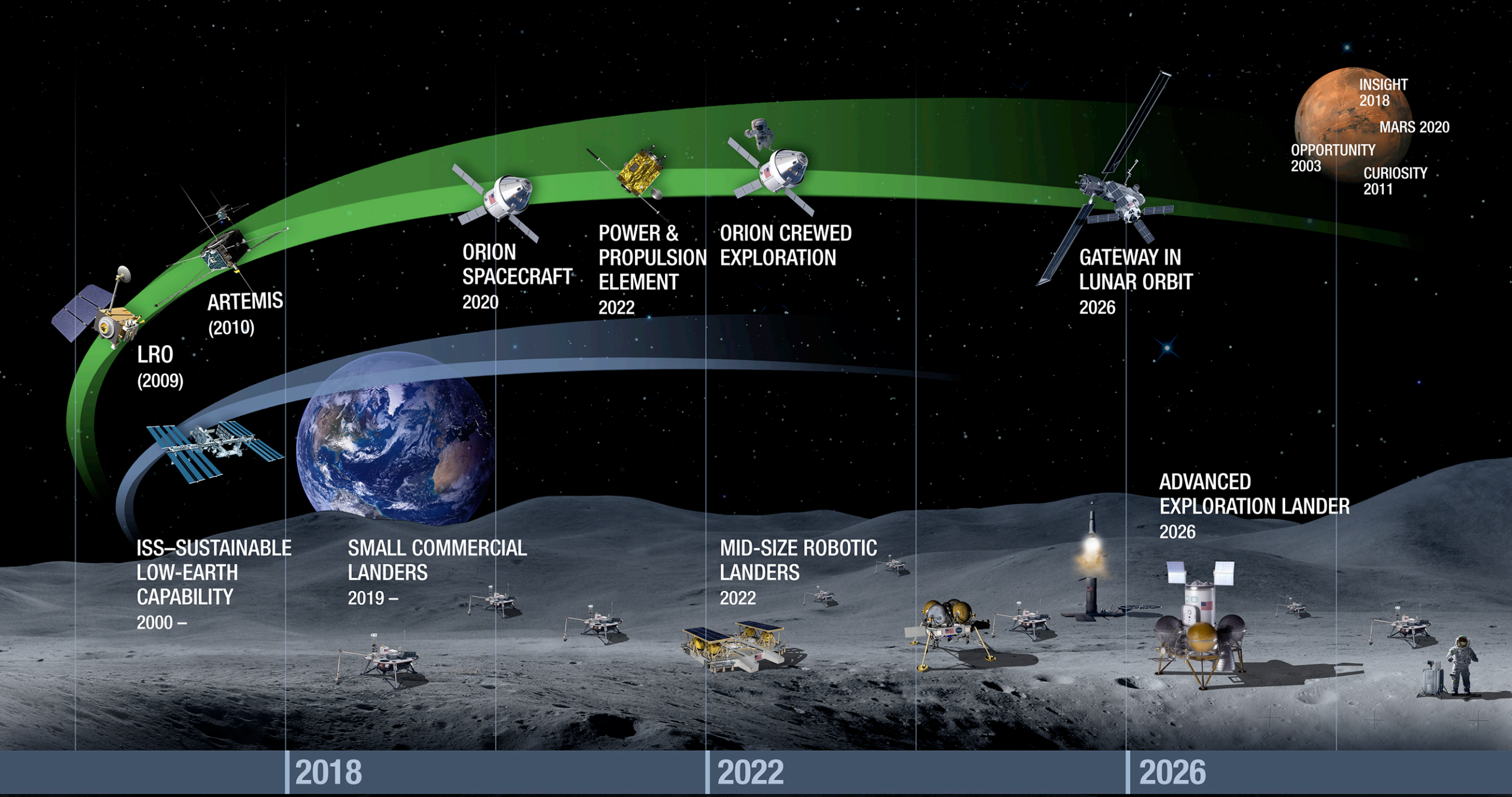
December 03 – OSIRIS-REx rendezvous with Bennu

2019

January 1 – New Horizons flyby of Kuiper Belt object Ultima Thule


Formulation
Implementation
Primary Ops
Extended Ops
BepiColombo (ESA)
Psyche
New Horizons
Juno
Lucy
Dawn
OSIRIS-REx
DART
Lunar Reconnaissance Orbiter
JUICE (ESA)
Europa Clipper
NEOWISE
MRO
MAVEN
ExoMars 2016 (ESA)
MMX (JAXA)
Mars Express (ESA)
Mars Odyssey
ExoMars 2020 (ESA)
Mars Rover 2020
Opportunity Rover
Curiosity Rover
InSight

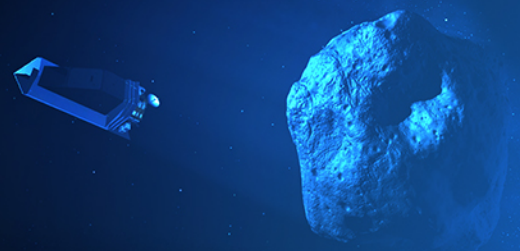
NASA Exploration Campaign
Steven Clarke


LRO
(2009)
ARTEMIS
(2010)
ORION
SPACECRAFT
2020
POWER &
PROPULSION
ELEMENT
2022
ORION CREWED
EXPLORATION
GATEWAY IN
LUNAR ORBIT
2026
INSIGHT
2018
MARS 2020
OPPORTUNITY
2003
CURIOSITY
2011
ISS–SUSTAINABLE
LOW-EARTH
CAPABILITY
2000 –
SMALL COMMERCIAL
LANDERS
2019 –
MID-SIZE ROBOTIC
LANDERS
2022
ADVANCED
EXPLORATION LANDER
2026
2018
2022
2026

Planetary Defense

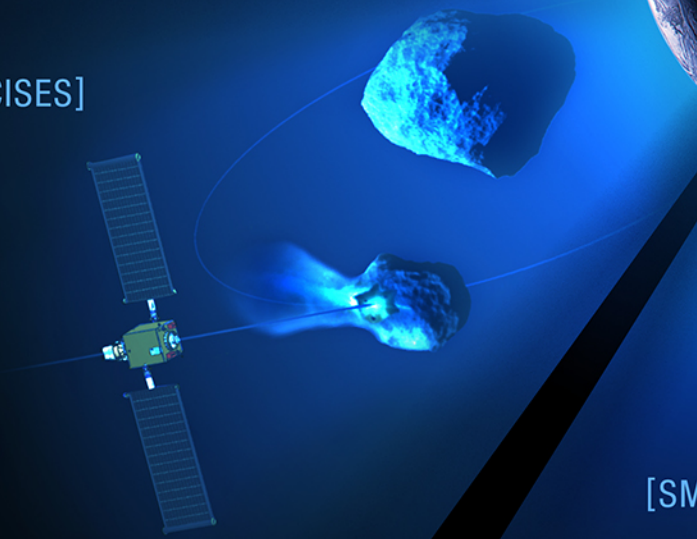
PLANETARY DEFENSE

ASSESS
[CENTER FOR NEAR EARTH OBJECT STUDIES]

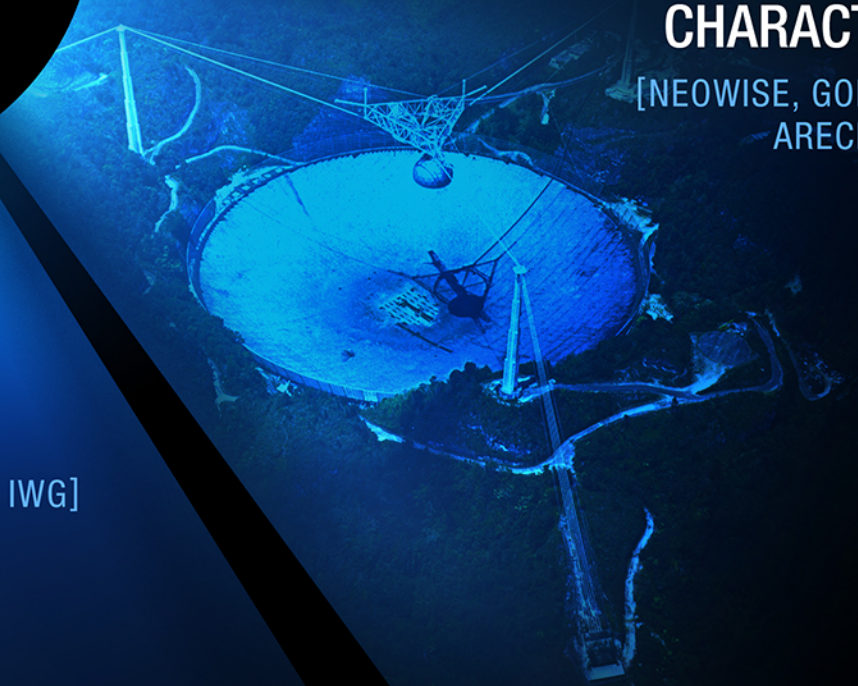


SEARCH, DETECT & TRACK
[GROUND-BASED & SPACE-BASED OBSERVATIONS, IAWN]

MITIGATE
[DART, FEMA EXERCISES]



CHARACTERIZE
[NEOWISE, GOLDSTONE, ARECIBO, IRTF]



PLAN & COORDINATE
[SMPAG, PIERWG, DAMIEN IWG]

Enhanced Planetary Defense

- FY19 budget request proposes an enhanced Planetary Defense program for near-Earth object detection, characterization and mitigation
- This is a significant ramping up of our NEO-related activities!
- DART, is an innovative way to test deflection capability
  - Joint study with ASI for potential CubeSat addition
- Currently studying cost-effective space-based near-Earth object detection mission

Planetary Defense Coordination Office Status

- 18,569 (September 2018) near-Earth objects (NEOs) discovered and confirmed to date (versus 17,741 as of February 1, 2018)
  - Over 8,286 NEOs greater than 140 meters in size
  - Over 1,927 NEOs are Potentially Hazardous Asteroids
- White House National Near-Earth Object Preparedness Action Plan was released on June 20, 2018, by the Detecting and Mitigating the Impact of Earth-Bound Near-Earth Objects (DAMIEN) Interagency Working Group

- 2017 NEO Science Definition Team reassessed NEO search and characterization given current technology and understanding of the NEO population. Of the estimated 25,000 NEOs 140 meters or larger in size (that can cause regional damage), 1/3 have been found. Study determined that a space-based asset will be needed to complete the 140 meter survey in less than several decades.

PSD R&A Update

General R&A Updates

- ROSES 2018 released on February 14, 2018
- ECF – Still developing framework but plan to amend new program into ROSES 2018
- Facilities Update – New Cooperative Agreements Notice (CAN) for Facilities on hold:
  - NASA has requested a National Academies study; *ad hoc* committee is working: Sample Analysis Future Investment Strategy
- National Academies Study on R&A Restructuring
  - Report completed https://www.nap.edu/catalog/24759/review-of-the-restructured-research-and-analysis-programs-of-nasas-planetary-science-division
- Archiving manuscripts – new policy for all NASA funded work to be put into PubSpace (part of PubMed)

  https://www.nasa.gov/open/researchaccess/pubspace

General R&A Update

- Language added to many ROSES 2018 calls to emphasize the Moon
  - DALI, SIMPLEx, SSERVI
- New Scientific Exploration Subsurface Access Mechanism for Europa (SESAME) technology development program element released in ROSES 2018
- NASA encourages experts in all fields to commit to supporting our peer-review process either as panelists or external reviewers
  - Volunteer at: https://science.nasa.gov/researchers/volunteer-review-panels
  - Or, when contacted by a program officer, consider joining the team

C.17 Planetary Major Equipment and Facilities (PMEF)

- Replaces the former Planetary Major Equipment (PME) program element
- PMEF requests may still be APPENDED to full research proposals in the same program elements as before
  - But, only for Investigator Instruments, not Facility Instruments
- STAND-ALONE proposals may still be made for both Investigator and (all) Facility Instruments
  - But, there is now a single deadline for all such proposals (Step 1: July 17; Step 2: Sept. 17)
  - Step 1s will either be invited to submit Step 2 or declined
  - PI does not have to be current PI
  - Open to same programs as before, plus ISFM and XRP
- Minimum budget raised from $40k to $50k

ROSES 18 Due Dates

Program Name	Step-1 Due Date	Step-2 Due Date
Juno PSP	***03/01/2018***	***04/26/2018***
Exobiology (EXOB)	***04/16/2018****	***05/24/2018***
Exoplanets (XRP)	***03/29/2018***	***05/30/2018***
Emerging Worlds (EW)	***04/12/2018***	***06/01/2018***
Development & Advance of Lunar Instruments (DALI)	***04/03/2018***	***06/05/2018***
Solar System Obs. (SSO)	***04/05/2018***	***06/07/2018***
MatISSE	***04/18/2018***	***06/20/2018***
Laboratory Analysis of Returned Sample (LARS)	***04/26/2018***	***06/28/2018***
Planetary Data Archiving, Restoration, Tools (PDART)	***05/10/2018***	***07/12/2018***
Cassini Data Analysis (CDAP)	***06/01/2018***	***08/14/2018***
New Frontiers Data Analysis Program (NFDAP)	***06/12/2018***	***08/23/2018***
Instrument Concepts for Europa Exploration 2	***06/22/2018***	**09/07/2018**
Planetary Major Equipment/Facilities (PMEF)	***07/17/2018***	09/17/2018
Discovery Data Analysis (DDAP)	***08/30/2018***	11/01/2018
Rosetta Data Analysis Program (RDAP)	***08/30/2018***	11/01/2018
CDAP Data Release 54	09/18/2018	12/7/2018
PICASSO	09/20/2018	11/20/2018
Habitable Worlds (HW)	11/15/2018	01/17/2019
Solar System Workings (SSW)	11/15/2018*	01/31/2019
Lunar Data Analysis (LDAP)	11/29/2018	02/28/2019

Missions Participating Scientist Programs (PSP)

- The InSight PSP program has completed its review and selected Participating Scientists were notified in August
- Korean Pathfinder Lunar Orbiter (KPLO) PSP Call waiting for reference documents. Otherwise, it is ready to be released
- BepiColombo will also have an opportunity for scientists to participate, most likely via a Guest Investigator Program or an InterDisciplinary Scientist program
- Akatsuki mission has been extended; PSP will be re-competed

Internal Scientist Funding Model (ISFM) – NASA Centers

Number of Work Packages	Support Received to Date
5 GSFC	$7.5 M
6 ARC	$4.6 M
5 JSC	$6.6
1 Combined between LaRC & MSFC	$0.5

High Risk/High Impact Research at NASA

NAS Recommendation

- “NASA needs to investigate appropriate mechanisms to ensure that high-risk/high-payoff fundamental research and advanced technology-development activities receive appropriate consideration during the review process.” *Review of the Restructured Research and Analysis Programs of NASA’s Planetary Science Division, 2017, p. 31.*

- There is also the wide spread perception that NASA peer review, and possibly all peer review, is hostile to truly innovative, high-risk research and technology development proposals.

Data on High Risk/High Impact Proposals

- For one year, asked our peer reviewers to answer the following questions:
- IMPACT: How large an effect on current thinking, methods, or practice would this project have, if successful?
  - Three choices: high (H), medium (M), low (L)
- RISK: To what extent would this proposal test novel and significant hypotheses, for which there is scant precedent or preliminary data or which run counter to the existing scientific consensus.
  - Three choices: A great extent (G), to some extent (S), little or none (L)
- Looked at the results for 1,577 proposals submitted to ROSES-2017.

Results

- 10% of proposals in examined set were judged to be high-impact/high-risk
- 24% of all proposals (regardless of risk or impact) were selected for funding
- 35% of high-risk/high-impact proposals were selected for funding
- Merit score driven by perceived impact regardless of perceived risk
- Panel process seems agnostic to risk level for proposals judged to have high-to-moderate impact.

Small Innovative Missions For Planetary Exploration (SIMPLEx)

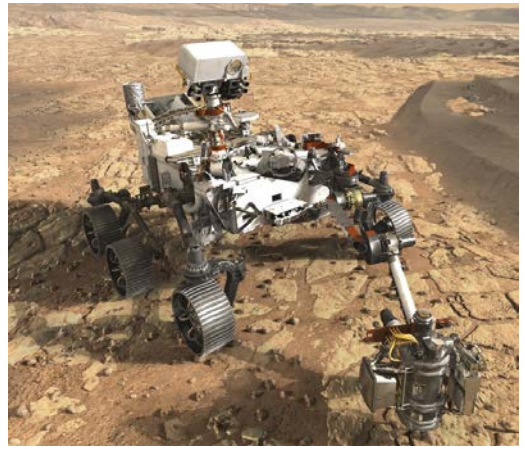
SIMPLEx Selection Schedule

- July 24, 2018
  - Proposal due date for first round of evaluation/selections
  - Final Proposal due date for Lucy and Psyche
  - 12 Proposals Received
- Proposal due date for CYCLE-2 round of evaluations/selections will be announced well in advance of that deadline. This due date is likely to be no earlier than July 2019.
- August - September 2018
  - Science Review Panels
- August 2018 – December 2018
  - Technical Management Cost Review Panels
- ~February 2019 – Selection Announcements
- ~May – ~August 2019 – Contract Awards
  - Contract award time based on dollar value of contract

Mars Exploration Program

MEP News & Status

- All Operating Missions are doing well
  - Opportunity status pending outcome after dust storm subsides
  - MRO battery charging issue resolved
  - MAVEN orbit adjustment (in 2019) to facilitate improved communications relay for Mars 2020
    Apoapsis change from 6200 km to 4000/4500 km



- All Development Missions and systems are doing well
  - Successful Mars 2020 Systems Integration Review (SIR) and Agency KDP-D
    - Excellent technical progress
    - Healthy schedule & budget reserves
  - MOMA instrument delivered for ExoMars Rover integration

- Progressing in our technology maturation program for key technologies that would support a potential future Mars Sample Return (MSR) mission

- Beginning preparations for the next Decadal; considering studies and roadmap activities

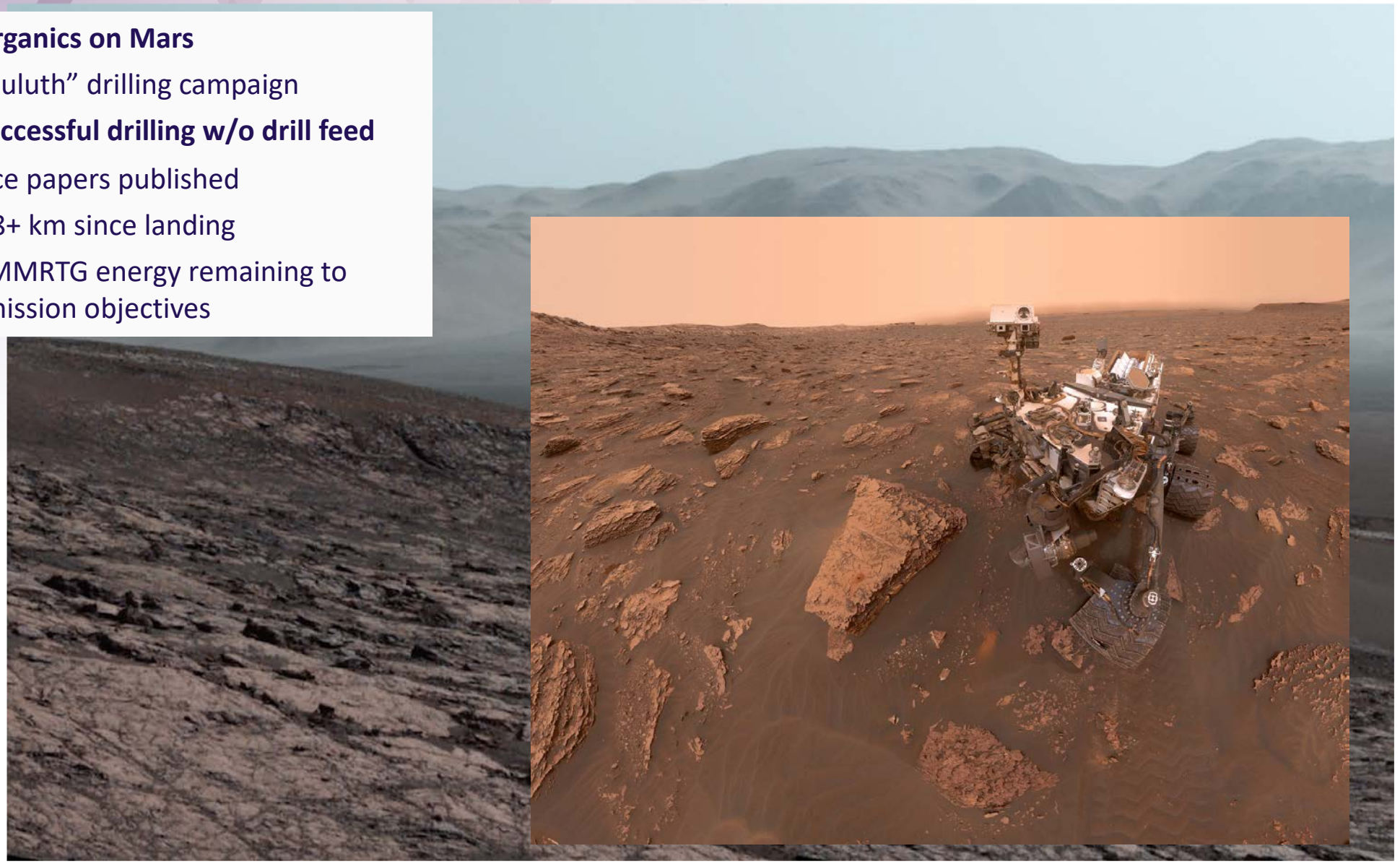
MEP Budget News

- FY18 Budget Appropriation included ~$75M increase over President's request
  - Maintain the high pace of development on Mars 2020, preserving maximum schedule reserves for ATLO
  - Continue all our operating missions
  - Continue our technology maturation activities
  - Fully fund R&A

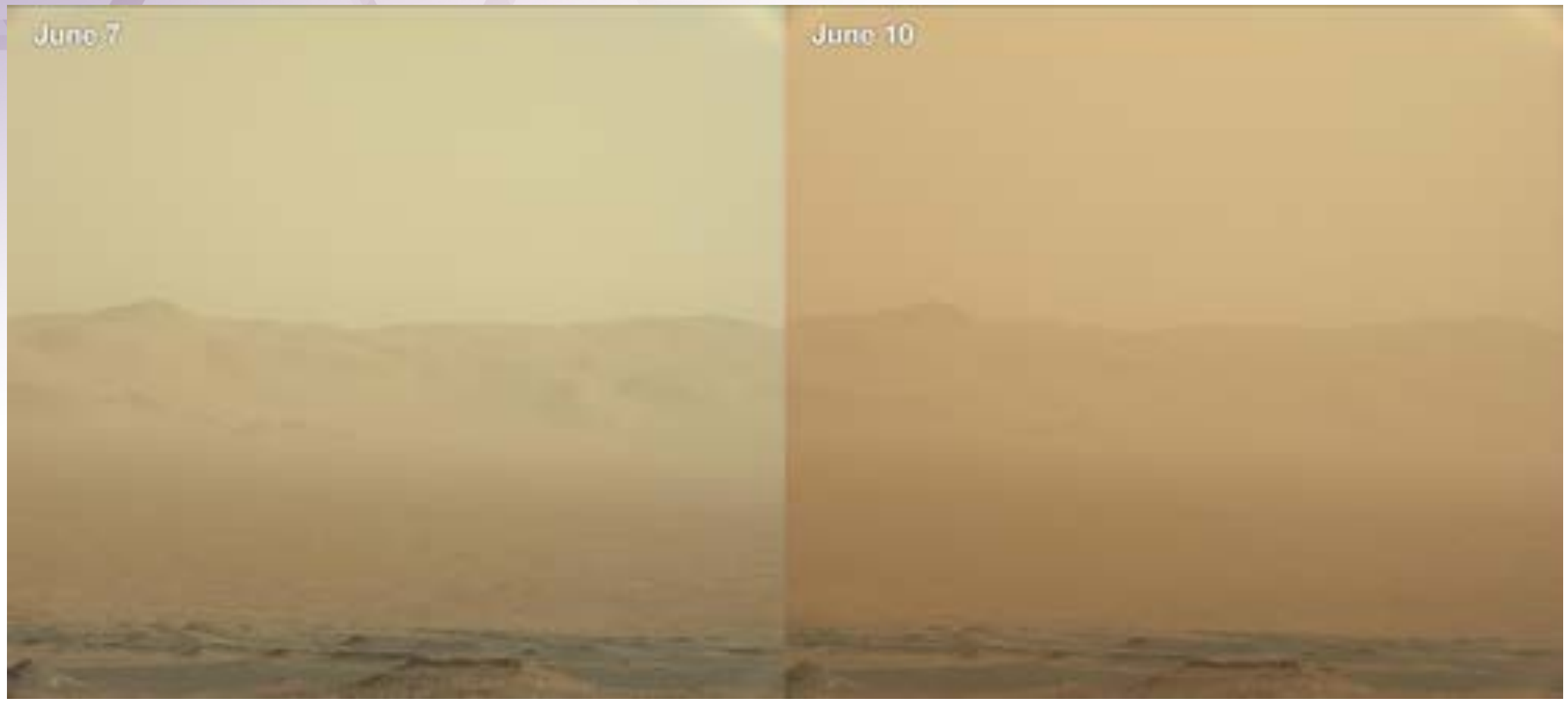
- FY19 President's Budget Request, requesting $50M for planning Mars Sample Return

Curiosity Exploration of GALE Crater

- **Complex organics on Mars**
- Finished “Duluth” drilling campaign
  - **First successful drilling w/o drill feed**
- 400+ science papers published
- Explored 18+ km since landing
- Adequate MMRTG energy remaining to complete mission objectives

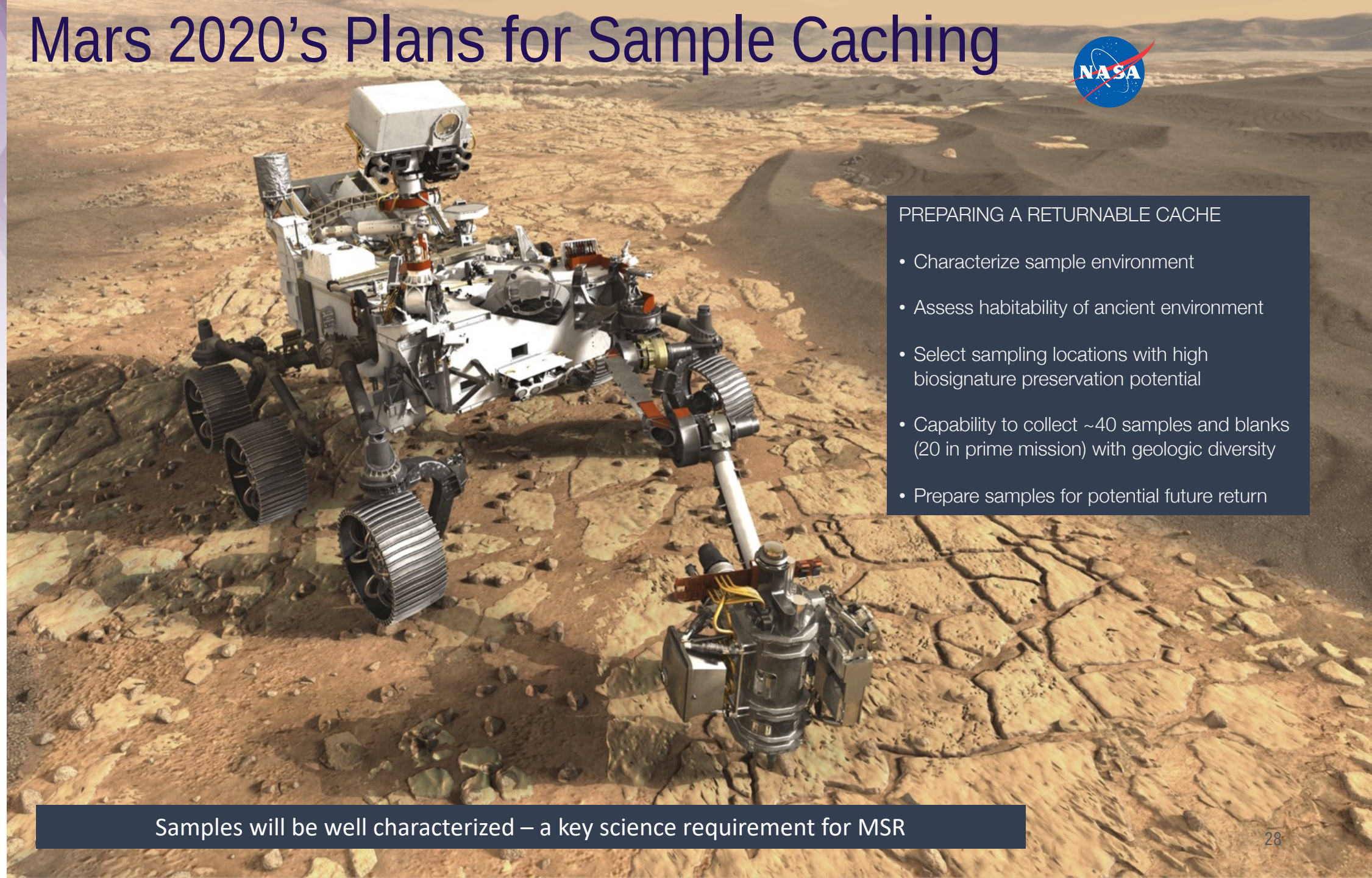


2018 Dust Storm



Curiosity looking at Crater Wall

Mars 2020's Plans for Sample Caching



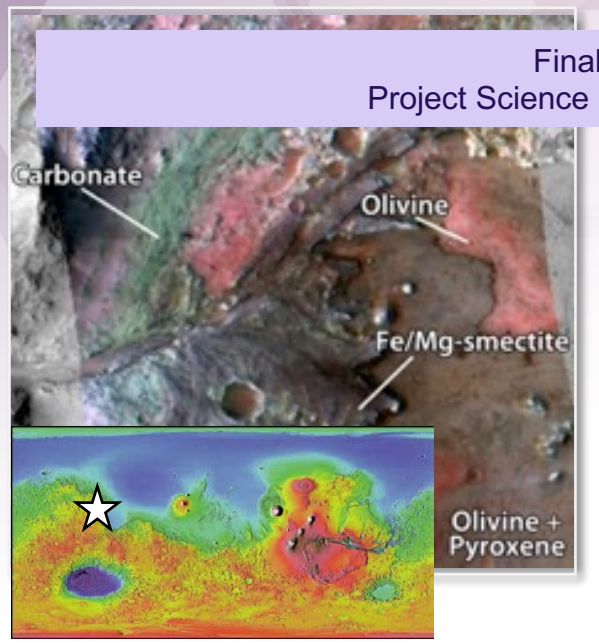
PREPARING A RETURNABLE CACHE

- Characterize sample environment
- Assess habitability of ancient environment
- Select sampling locations with high biosignature preservation potential
- Capability to collect ~40 samples and blanks (20 in prime mission) with geologic diversity
- Prepare samples for potential future return

Samples will be well characterized – a key science requirement for MSR

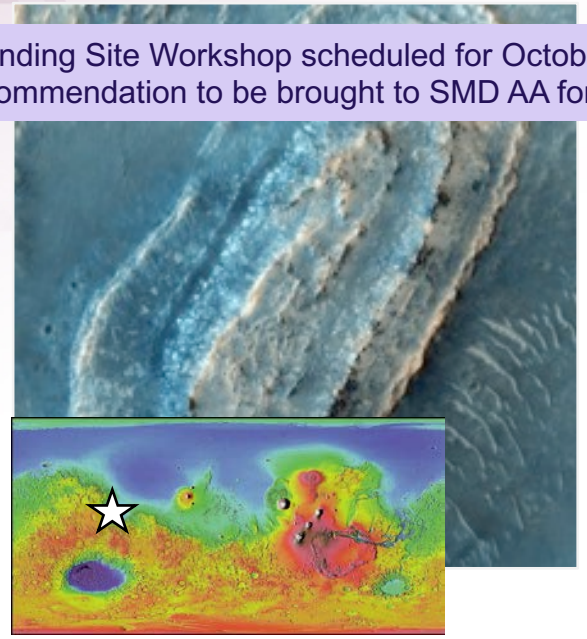
Candidate Mars 2020 Landing Sites

Final Landing Site Workshop scheduled for October 2018.
Project Science recommendation to be brought to SMD AA for decision late 2018.



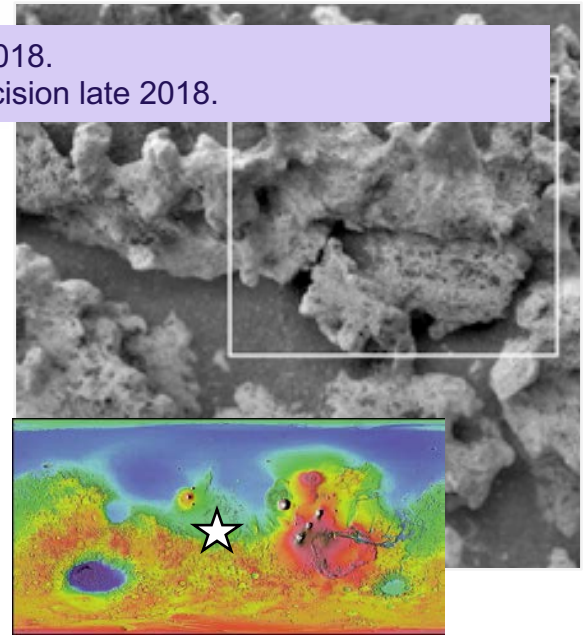
JEZERO

- Deltaic/lacustrine deposition with Hesperian lava flow and hydrous alteration
- Mineralogic diversity including clays and carbonates
- Evidence for hydrous minerals from CRISM, including carbonates



NE SYRTIS

- Extremely ancient igneous, hydrothermal, and sedimentary environments
- High mineralogic diversity with phyllosilicates, sulfates, carbonates, olivine
- Serpentinization and subsurface habitability?



COLUMBIA HILLS

- Carbonate, sulfate, and silica-rich outcrops of possible hydrothermal origin and Hesperian lava flow
- Potential bio-signatures identified
- Previously explored by MER

Discovery Program

Discovery Long-Range Planning

- Cost Cap $495M Phase A-D (FY19) excluding LV
- ~~May not propose the use of radio-isotope power systems (RPS)~~ – UPDATED
- May include radioisotope heater units (RHUs)

Release of draft AO ..... September 2018 (target)

Release of final AO ..... February 2019 (target)

Pre-proposal conference ..... ~3 weeks after final AO release

Proposals due ..... 90 days after AO release

Selection for competitive Phase A studies ..... December 2019 (target)

Concept study reports due ..... November 2020 (target)

Down-selection ..... June 2021 (target)

Launch readiness date ..... NLT December 31, 2026

New Frontiers Program

New Frontiers 4 AO

Investigations (listed without priority)

- Comet Surface Sample Return
- Lunar South Pole-Aitken Basin Sample Return
- Ocean Worlds (Titan, Enceladus)
- Saturn Probe
- Trojan Tour and Rendezvous
- Venus In Situ Explorer

12 Proposals received on ..... April 28, 2017

Step-1 Selections Announced ..... December 2017

Phase A Concept Study Reports due..... December 2018

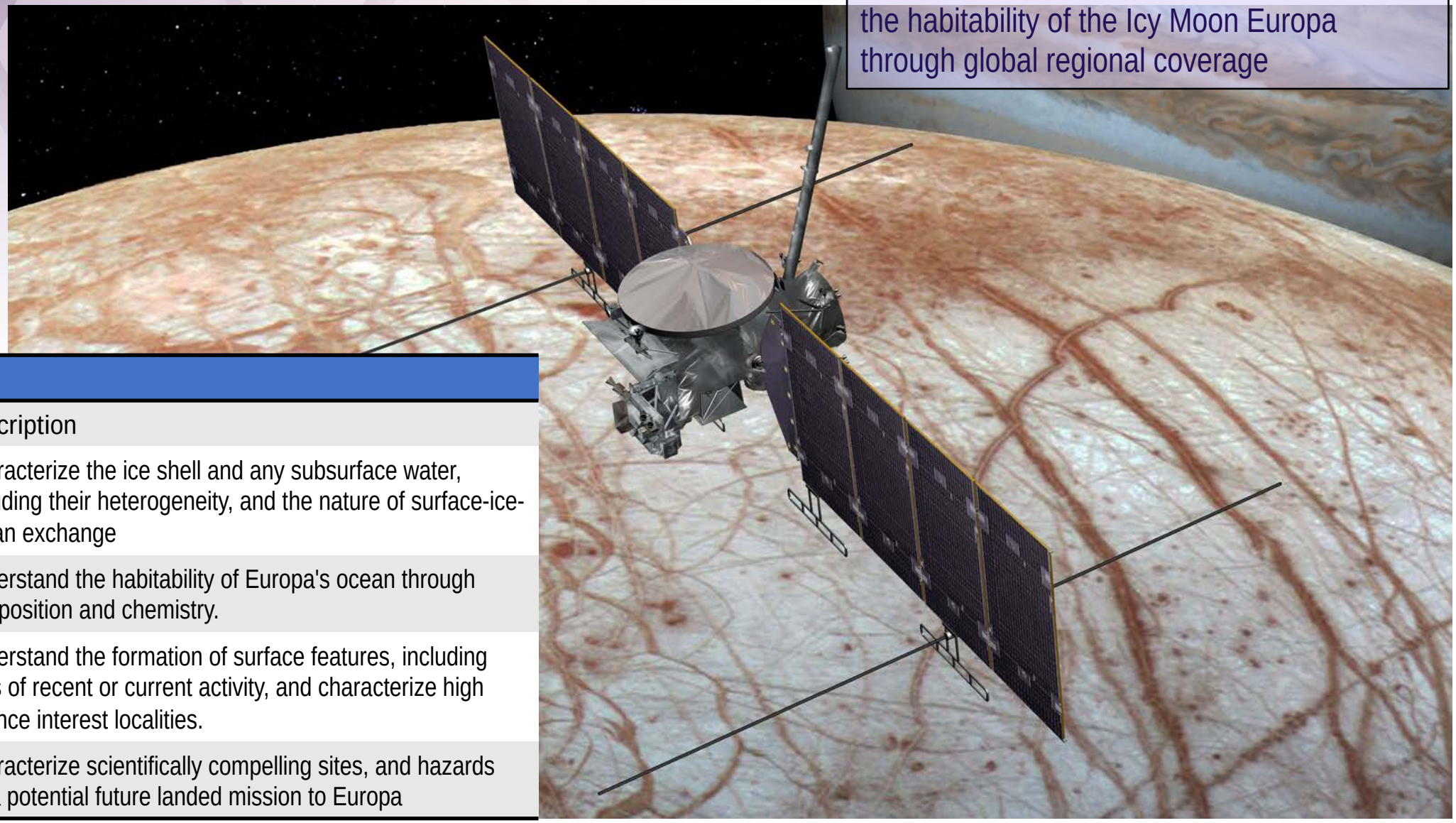
Down selection for Flight (target)..... July 2019

Launch Readiness Date..... NLT December 31, 2025

Oceans Worlds

Europa Clipper Overview

Will conduct approximately 45 low altitude flybys (25 – 100 km altitude) to characterize the habitability of the Icy Moon Europa through global regional coverage



Science	
Objective	Description
Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange
Composition	Understand the habitability of Europa's ocean through composition and chemistry.
Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.
Recon	Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

Europa Clipper

- Preliminary Design Review conducted August 20 – 24
- The Standing Review Board Highlighted:
  - The Europa Clipper Team is exceptional
  - The payload complement is very robust with margin against the Level 1 requirements
  - The system approach and design is sound
  - Most areas met requirements for a PDR, with the exception of the Solar Array design which has not yet passed it's PDR, and the associated accommodation of radar on the solar array
  - This mission is as complex as it is exciting
- Programmatic analysis continues with multiple independent cost and schedule estimates in development
- At this time we expect the Mission to come forward for a Confirmation Review in spring, 2019.

NASA Astrobiology Institute

Building a Research Collaboration Network

NASA SMD is committed to interdisciplinary and interdivisional research:

- There are numerous ways to stimulate and support this type of research
- NAI is one, another is NExSS which is based on a Research Collaboration Network (RCN) model

NAI cutting-edge nature and the collaborations it fostered play a critical role in:

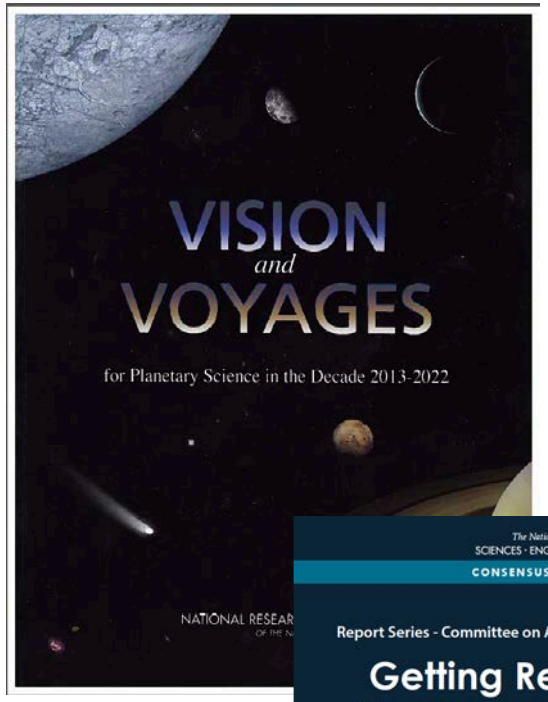
- Growing the astrobiology discipline and community
- Leading the international astrobiology community for much of its 20 years of existence

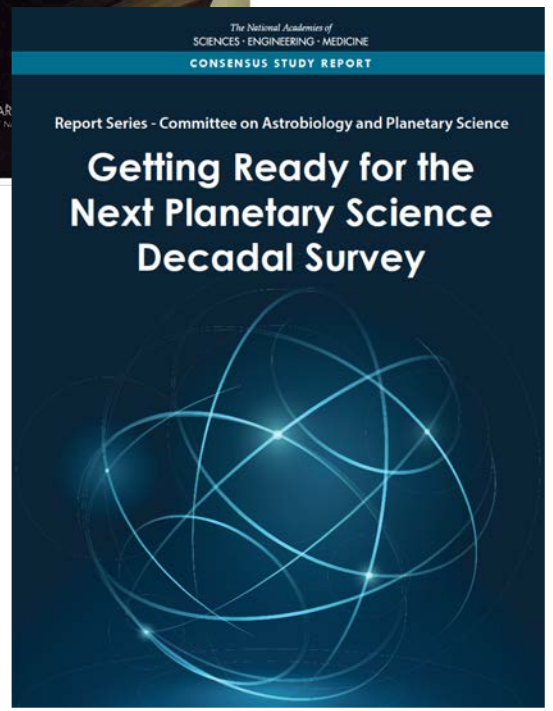
NExSS experiment has proven itself and a key reason is that it is run by the community itself

NASA Planetary Science Studies

Timeline of Studies

- 1st Planetary decadal: 2002-2012
- 2nd Planetary decadal: 2013-2022
- CubeSat Review: Completed June 2016
- Extended Missions Review: Completed Sept 2016
- R&A Restructuring Review: Completed June 2017
- Searching For Life : Completed Sept 2017
- Large Strategic Science Missions: Completed Aug 2017
- Midterm evaluation:
  - Tasked August 26, 2016
  - Above NAS studies were input
  - Report to NASA released in August 2018
- Sample Analysis Investment Strategy
  - Started November 2017
- 3rd Planetary Decadal: 2023-2032
  - To be tasked *before* October 2019
  - Expect report to NASA due 1st quarter 2022
- CAPS reviewed completed studies and recommended several more to be completed





Mission Studies Completed Thus Far

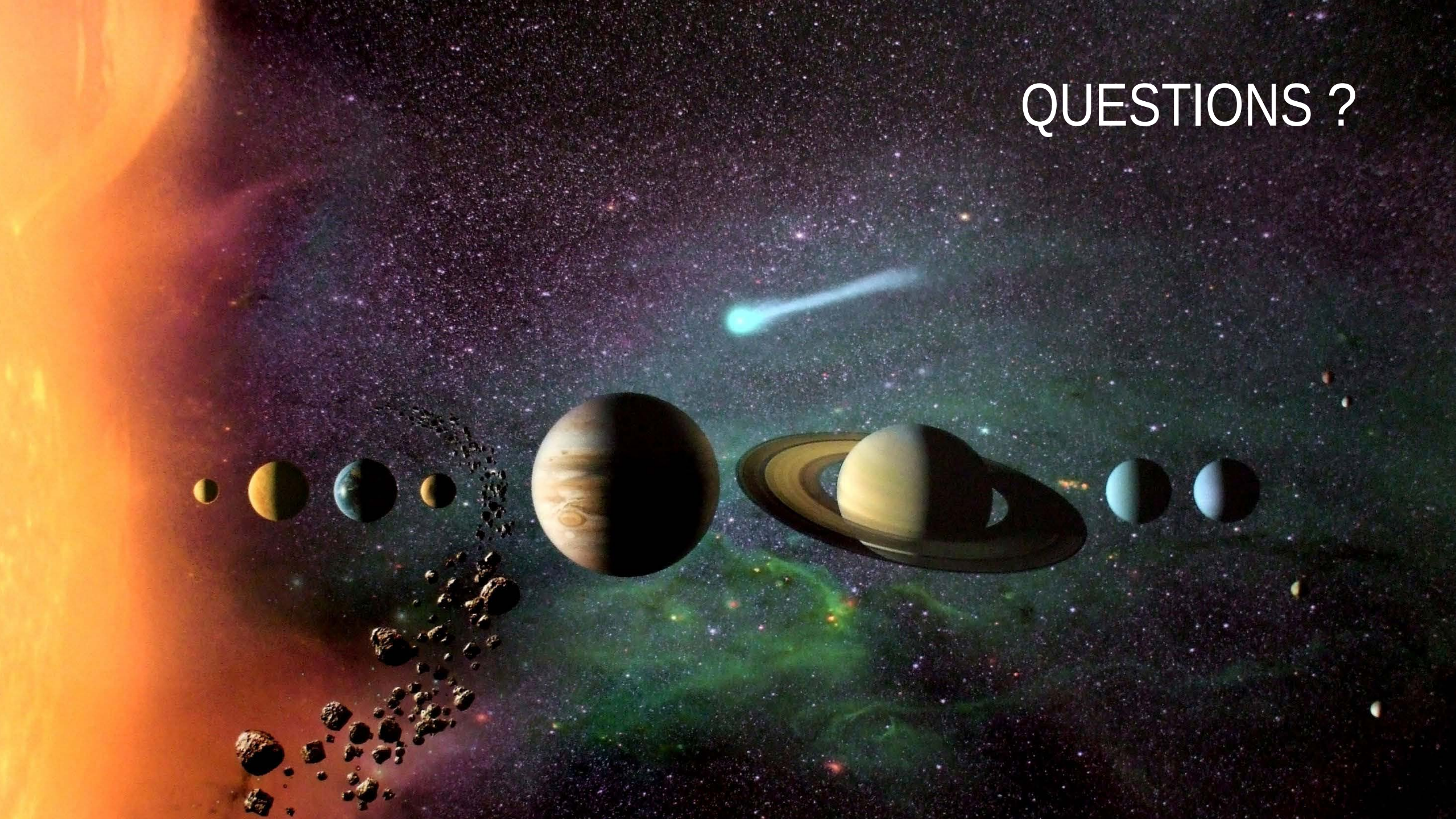
- Mars orbiter
  - 2015 MEPAG's Next Orbiter Science Analysis Group
- Uranus and Neptune (Ice Giants) system missions
  - 2017 NASA science definition team report
- Europa lander
  - 2017 NASA science definition team report
- Venus orbiter and lander (Venera-D)
  - 2017 joint U.S.-Russian science definition team report
- NEO Search and Characterization
  - 2017 NEO science definition team updated report

CAPS Priority Areas Candidates for Large or Medium Class Mission Studies (Unprioritized)

Venus exploration missions (assigned to GSFC but team has not formed yet)	Additional concepts beyond the Venera-D orbiter and lander
Lunar science missions	Understanding interior processes and polar volatiles (Volatiles SAT Team-2)
Mars sample-return next-step missions	Mission elements beyond Mars 2020 necessary for second and third phases of a Mars sample-return campaign
Mars medium-class missions	Multiple mobile explorers, polar explorers, & life-detection. Investigations responsive to new discoveries
Dwarf planet missions (starting to move forward JPL)	Large- & medium-class mission concepts to Ceres, Pluto, Triton
Io science (NEW FRONTIERS FIVE)	Reexamine mission to Io
Saturn system missions	Affordable, large strategic missions that visit multiple targets
Dedicated space telescope for solar system science	Dynamic phenomena on planetary bodies

Plan for Conducting Pre-Decadal Mission Concept Studies

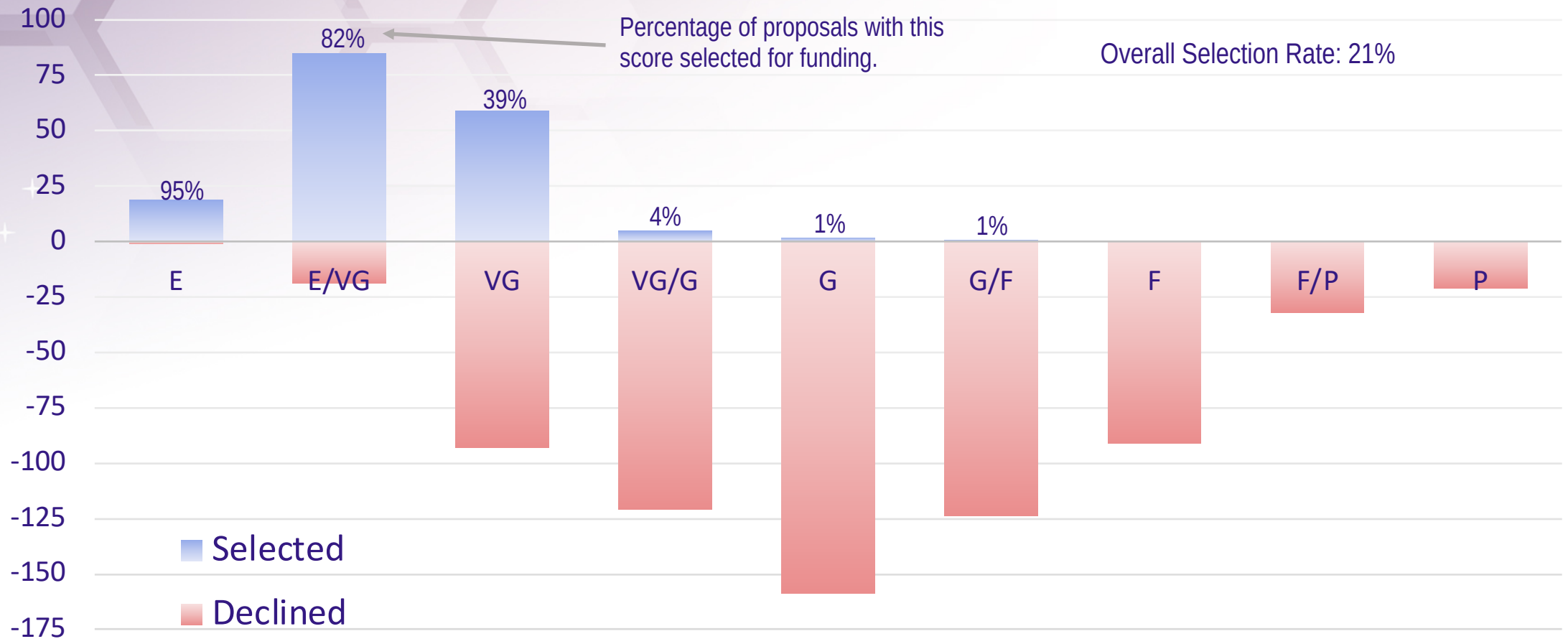
- Ceres study has been initiated at JPL
  - SDT members are being vetted per FACA requirements
- Mars Sample Return architecture studies are underway
- Propose to conduct remaining studies through a competed ROSES opportunity for science teams
  - Approximately 1 year duration studies, staggered over ~2 years
  - Support for 2 – 3 face-to-face meetings and ~2 Team X/MDL/ACE runs
  - Requirement for community updates at Analysis Group meetings and/or town halls as well as at a final Findings Workshop
  - Final reports, including advocacy cost estimates, to be provided to the Decadal Survey as input


QUESTIONS ?

NESSF Changes

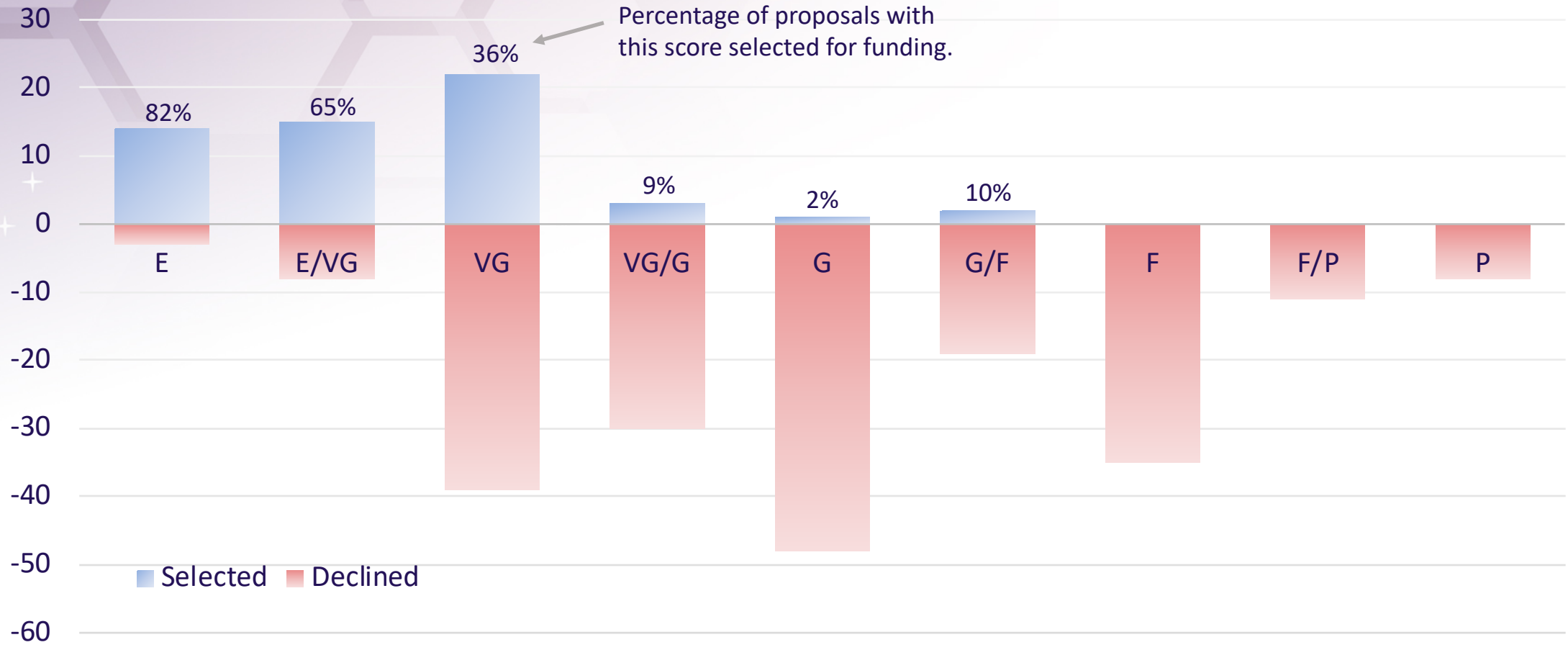
- Award amount increased to $45K. ($35K stipend + $10K for travel to conferences and seminars, health insurance policy, books, tuition and fees, etc.)
- New award amount more in line with other graduate research fellowships, NASA will be able to compete for the best students
- Change went into effect for ROSES17, and impacts existing renewal NESSF awards
- Overall budgets did not change

PSD R&A Selections – ROSES 2016



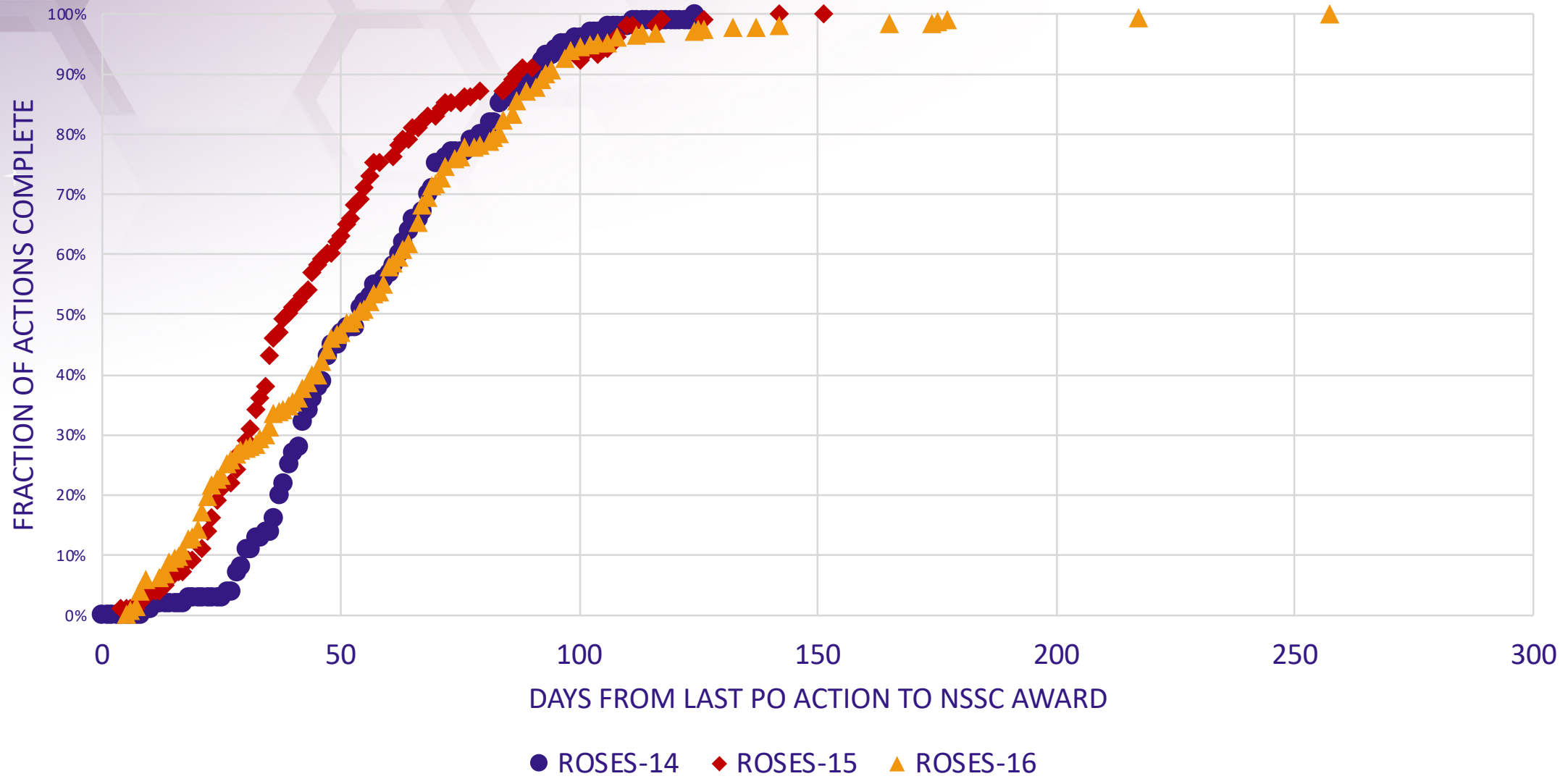
For proposals submitted to ROSES 2016, including all core programs (EW, SSW, HW, SSO, EXO) and all DAPs (MDAP, DDAP, LDAP, CDAPS).

PSD R&A Technology Selections – ROSES 2016



For technology proposals submitted to ROSES 2016, including MatISSE, PICASSO, COLDTech, HOTTech. The awards below VG/G reflect descopes/proof of concept studies that were not re-voted, hence scores remain low

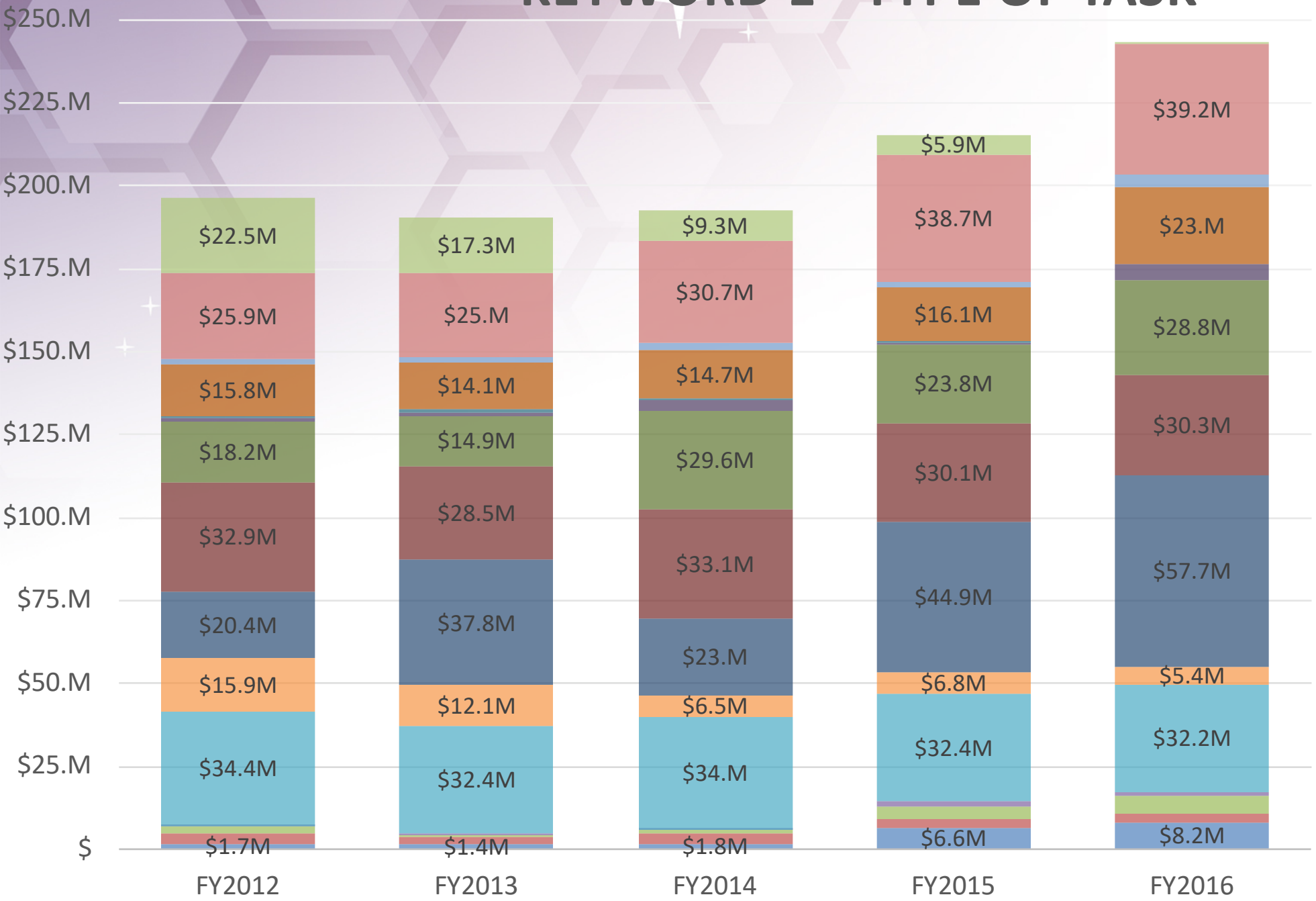
Speed of Money



Keyword Analysis

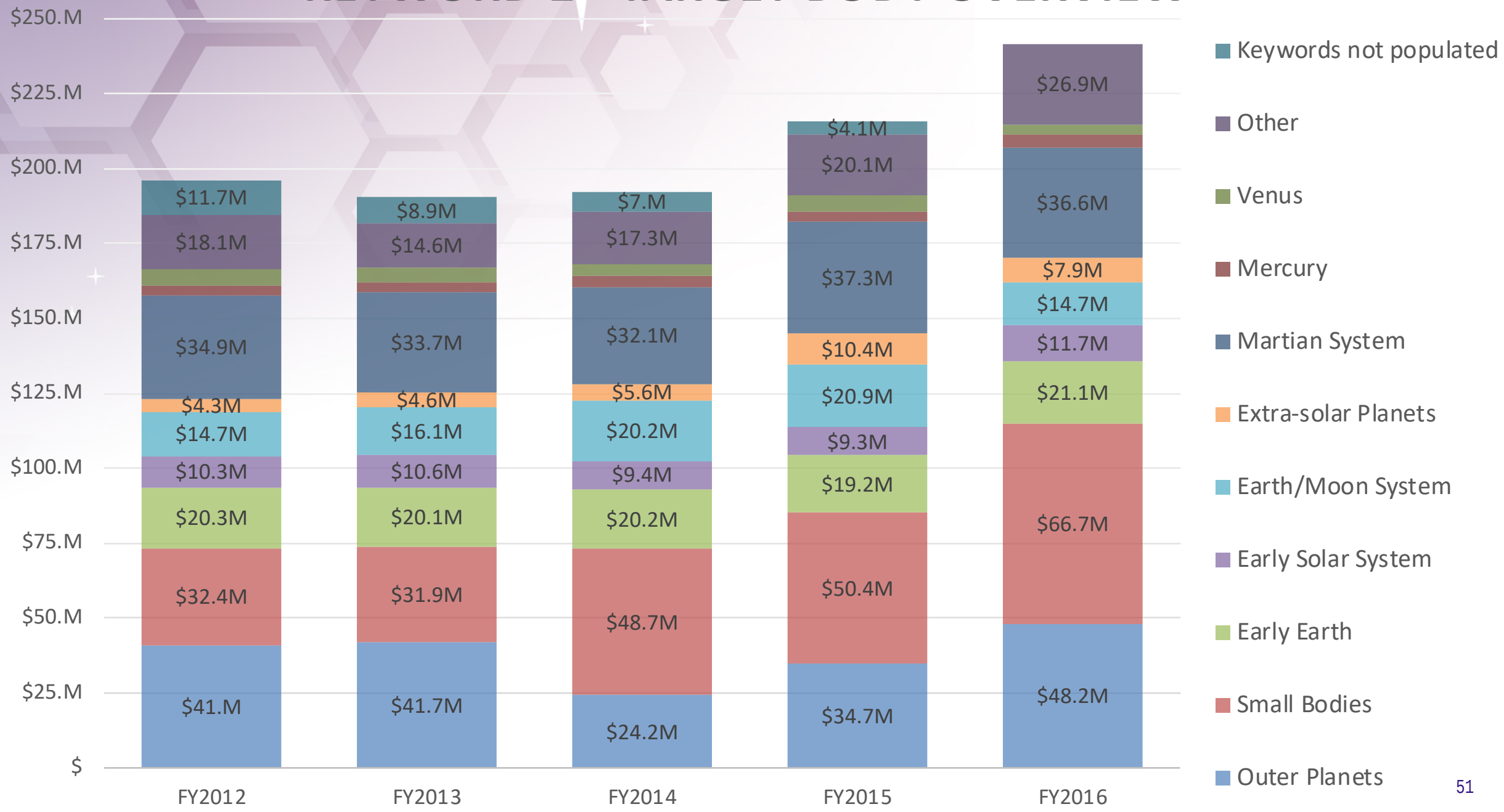
- Analysis of keyword distribution, 2012-2016 for categories:
  - Type of Task (keyword category 1)
  - Object(s) of Study (keyword category 2)
  - Science Discipline (keyword category 3)
- Analysis includes:
  - R&A awards, including NAI CAN awards
  - Data Analysis Programs
  - Participating Scientist and Guest Investigator Programs
- Analysis excludes:
  - Support activities
  - Facilities (e.g. RPIFs, AVGR, GEER, PAL, RELAB, …)
- Caveats
  - If more than one keyword was used within any category, approved amount was equally divided between keywords
  - Return rate varied from year to year, portfolio to portfolio, and keyword category to keyword category
  - Keywords might have been used inconsistently between program officers

KEYWORD 1 - TYPE OF TASK

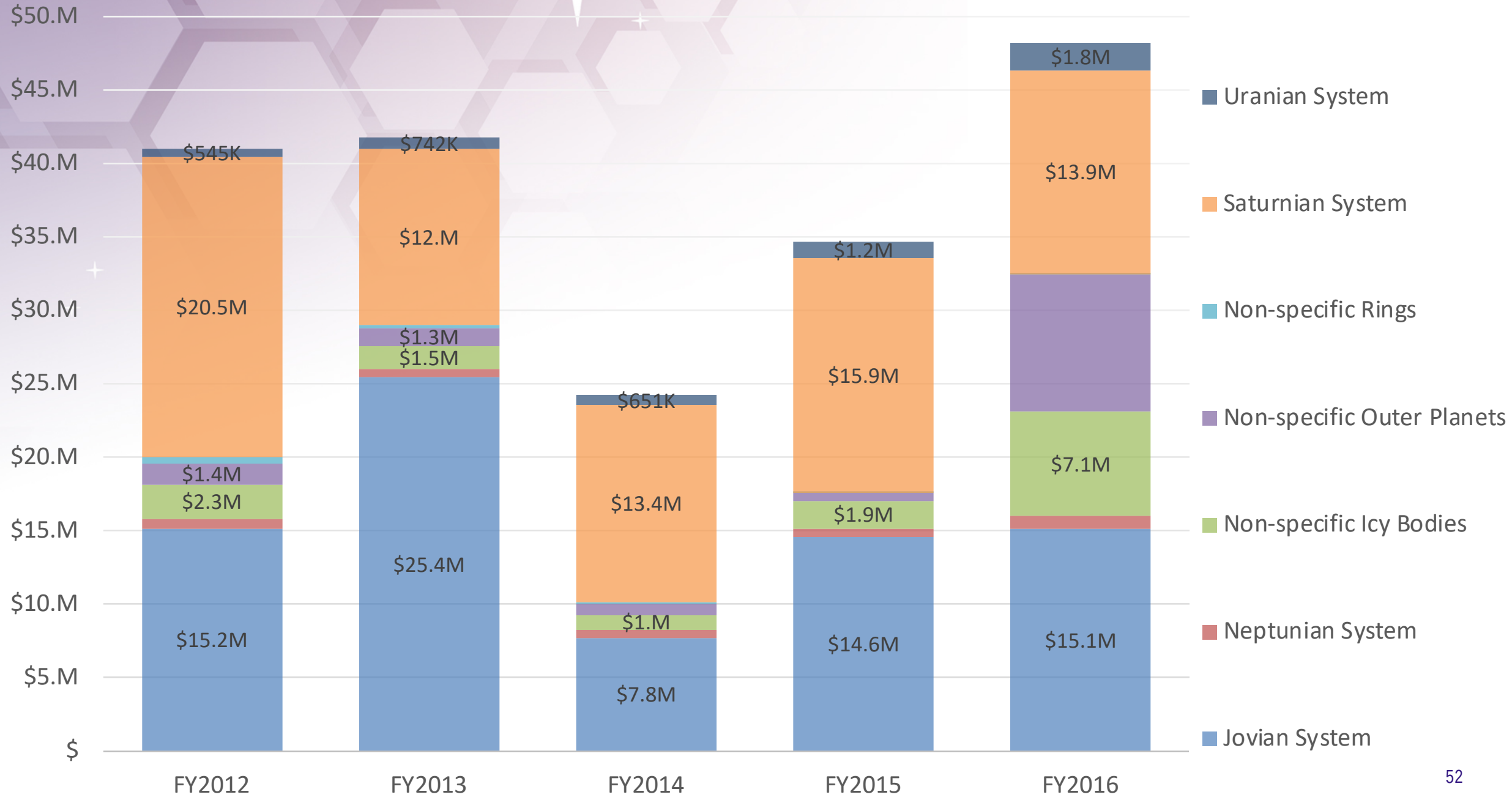


- Keywords not populated
- Theoretical/computational
- Support
- Sample analysis
- Purchase of Major Equipment
- None specified
- New observations
- Mission data analysis
- Instrument/Tech Development
- Field-based
- Experimental
- E/PO
- Archiving/Data Restoration
- Analysis of ground-based data
- Analog study

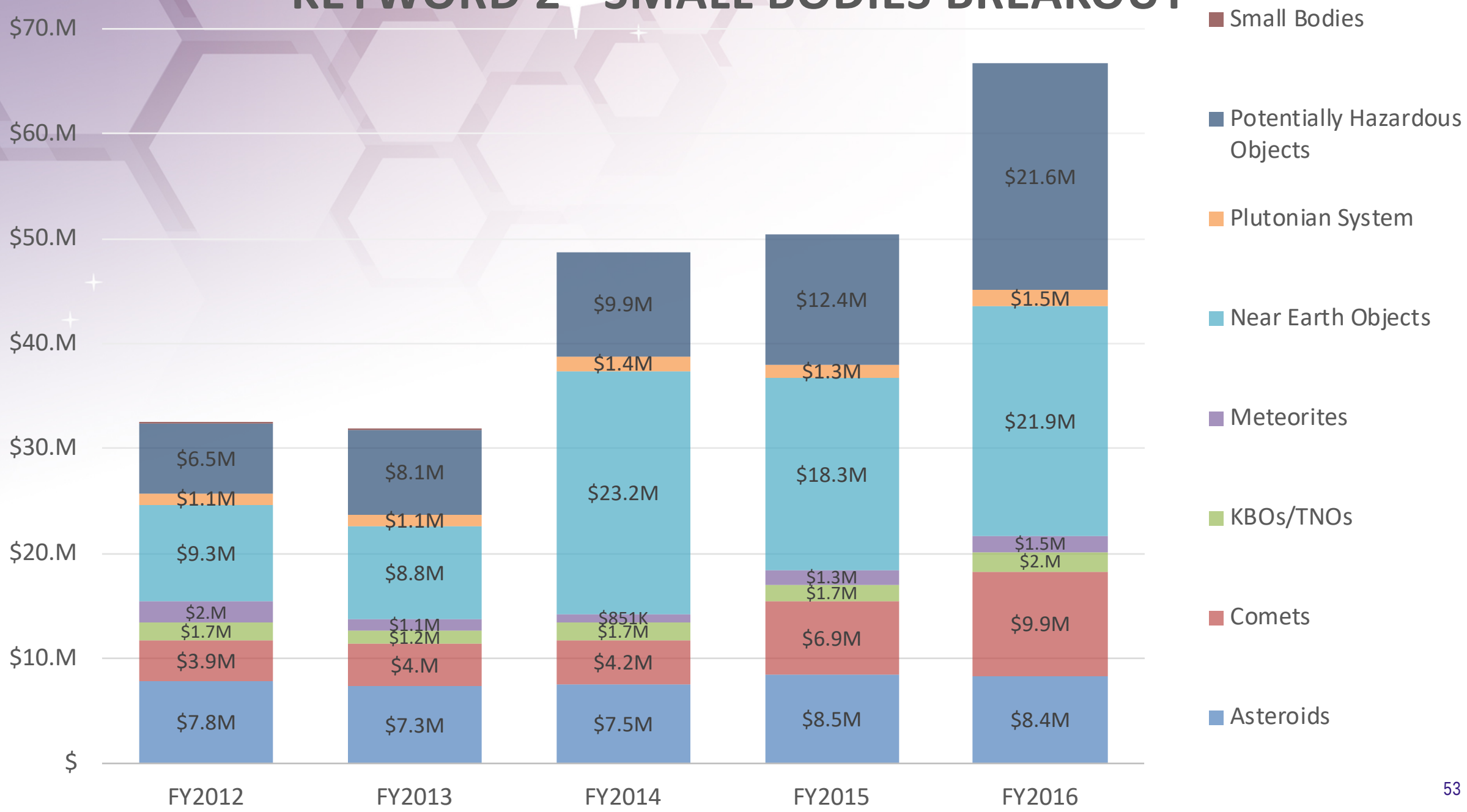
KEYWORD 2 - TARGET BODY OVERVIEW



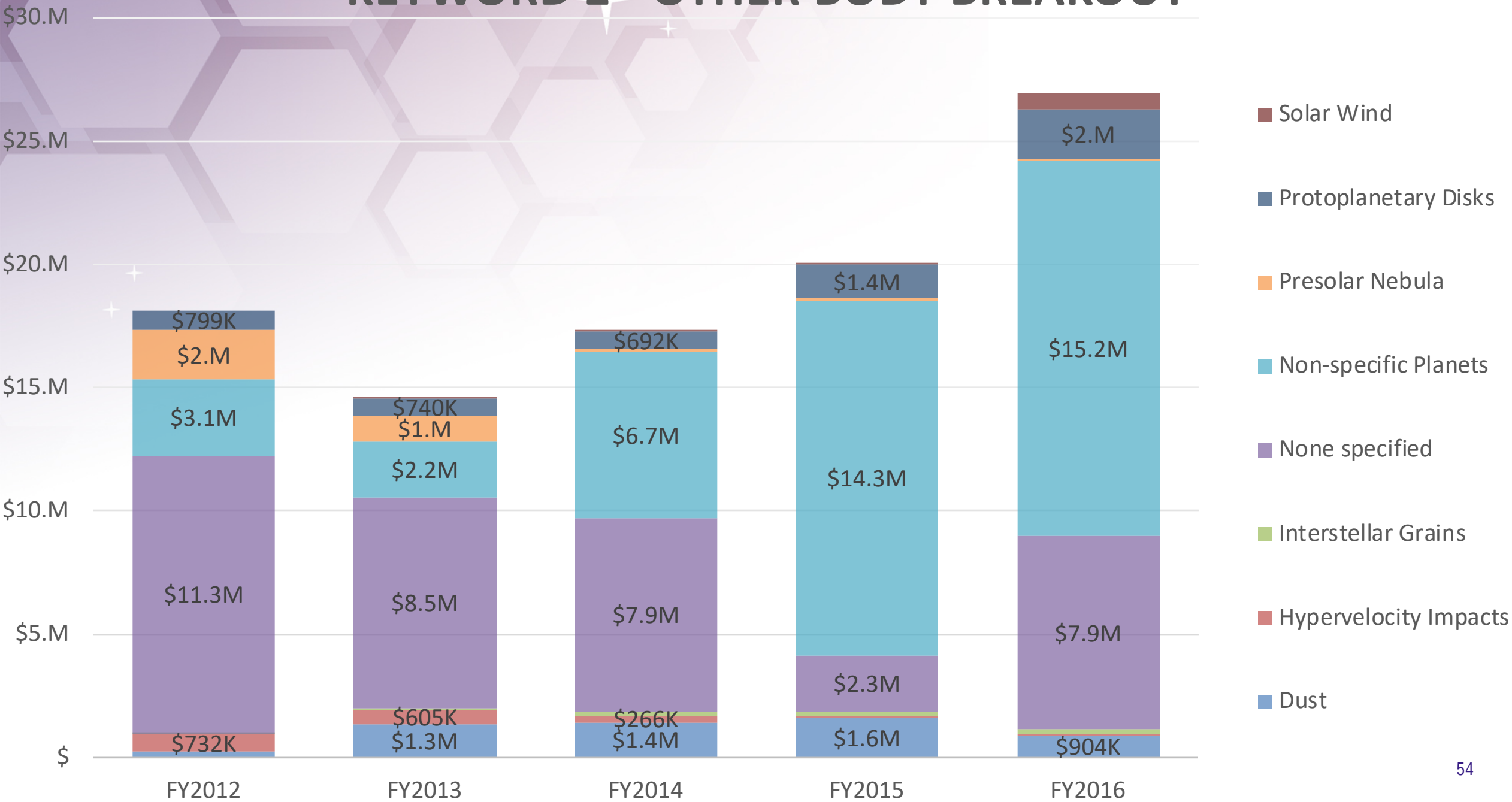
KEYWORD 2 - OUTER PLANETS BREAKOUT



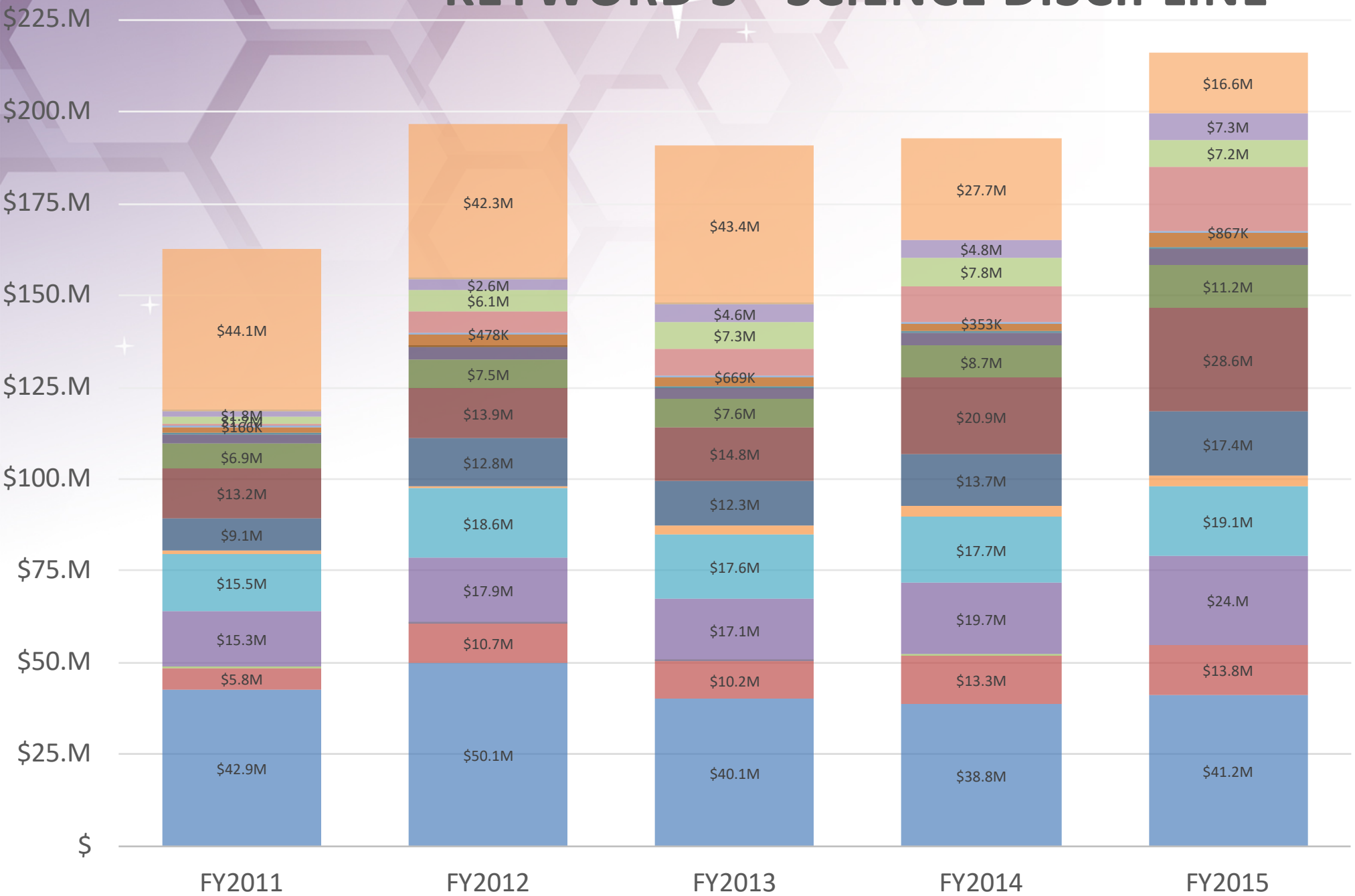
KEYWORD 2 - SMALL BODIES BREAKOUT



KEYWORD 2 - OTHER BODY BREAKOUT



KEYWORD 3 - SCIENCE DISCIPLINE



ISFM – Goddard Space Flight Center

- There are 5 GSFC work packages:
  - ✓Goddard Instrument Field Team (GIFT)
  - ✓Exosphere-Ionosphere-Magnetosphere Modeling (EIMM)
  - ✓Fundamental Laboratory Research (FLARE)
  - ✓Planetary Geodesy Capabilities
  - ✓Sellers Exoplanet Environments Collaboration (SEEC)
- Each package has already received some money in FY18.
- The total amount of support received, to date, is approximately $7.5M

*GIFT is a cross-center program that includes a small component at ARC

ISFM – Ames Research Center

- There are 6 ARC work packages:
  - ✓Center for Life Detection
  - ✓Origins of Life
  - ✓Microbial Innovation and Ecosystem Research
  - ✓Planetary Formation and Exoplanets Theory
  - ✓Habitable Environments and Biosignatures
  - ✓Mars Climate Modeling Center
- Each package has already received some money in FY18
- The total amount of support, to date, is approximately $4.6M

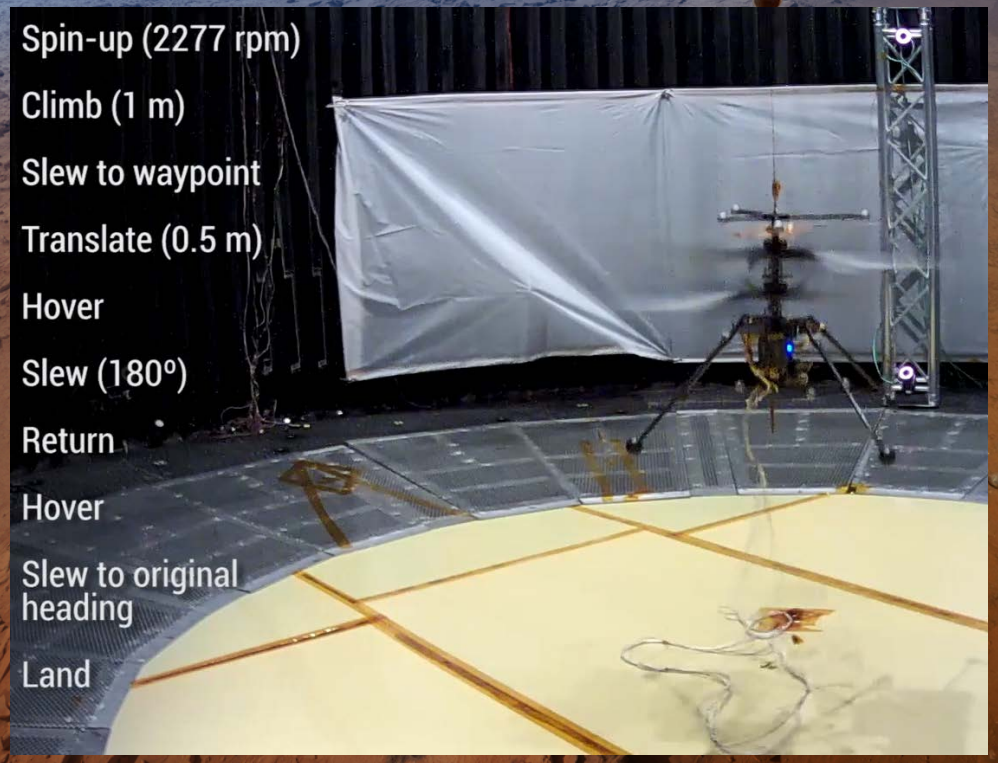
ISFM – Johnson Space Center

- There are 5 JSC work packages:
  - ✓Coordinate Analysis
  - ✓Geocosmochemistry
  - ✓Mission Enabling Research
  - ✓Organic Geocosmochemistry
  - ✓Process Simulation
- Each package has already received some money in FY18
- The total amount of support, to date, is approximately $6.6M

ISFM – Langley Research Center and Marshall Space Flight Center

- There is one combined work package between LaRC and MSFC:
  - ✓Global Reference Atmospheric Model (GRAM)
- Both centers have received money this year to support the work package
- The total amount of support, to date, is approximately $.5M

MARS HELICOPTER - TECHNOLOGY DEVELOPMENT



Full-scale free flight testing in JPL Space Simulator

Objective –

Explore utility of Mars aerial mobility

- Regional-scale high-resolution reconnaissance to facilitate surface operations of future robotic missions
- Access to extreme terrains, Rover scouting
- Mass < 2 kg, solar powered,300 m range on one charge, autonomous, dual cameras

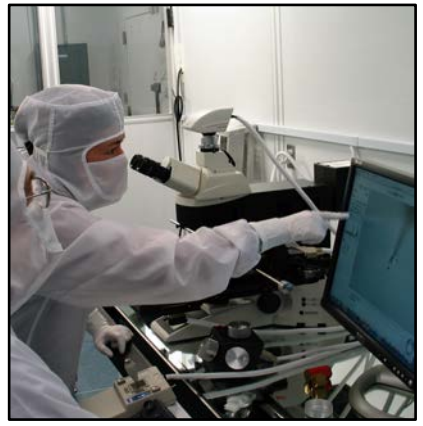
Technology Maturation Progress

- ✓ Controlled-flight feasibility demonstration – June 2016
- ✓ Engineering Model build & test complete – Feb 2018
  - 86 mins accumulated flight time in Mars environment
- ✓ Decision to demonstrate on M2020 mission – May 2018

Comet Astrobiology Exploration Sample Return

- Comets record presolar history, the initial stages of planet formation, and the sources of prebiotic organics and volatiles available for the origin of life.
- Target comet is 67P/Churyumov-Gerasimenko.
- Mission and Sample Acquisition System (SAS) have been designed for the known properties of 67P.
- SAS collects at least 80 g of comet nucleus sample.
- As volatiles evolve from the sample they are transferred to a separate reservoir, preventing sample alteration. Both non-volatile and volatile materials are returned to Earth for analysis.
- Sample stored at -80° to -40° C through return cruise, and below 0° C through entry, descent, landing, and recovery.

PI: Steve Sqyres, Cornell University. CAESAR would return the first sample from the nucleus of a comet. Sample analysis in worldwide laboratories will address questions about Solar System starting materials, and how they came together to form planets and give rise to life.



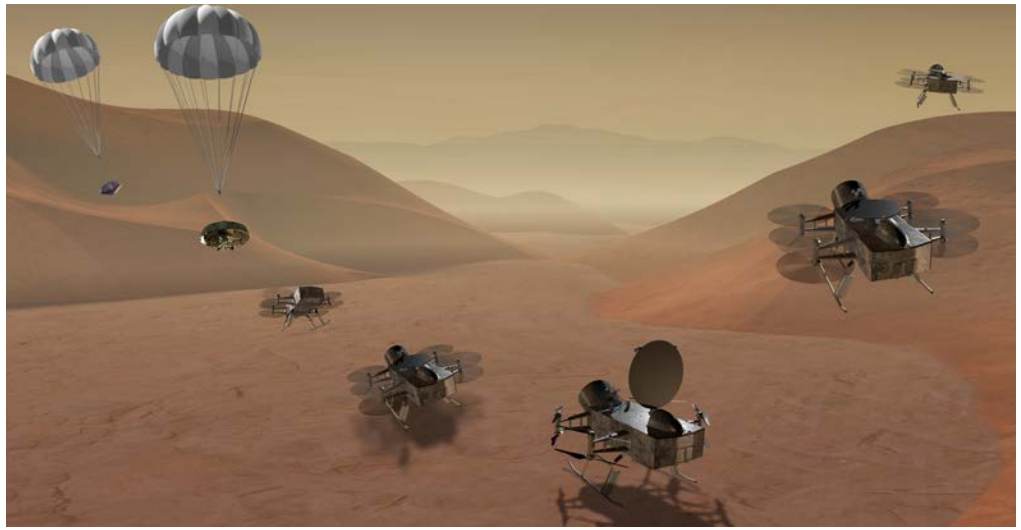
A rotorcraft to explore prebiotic chemistry and habitability on the ocean world Titan

- Flight is highly efficient on Titan, enabling Dragonfly to sample materials in a variety of settings with its science payload:
  - Mass spectrometer
  - Gamma-ray and neutron spectrometer
  - Meteorology and seismic sensors
  - Camera suite

Science Objectives:

- Analyze chemical components and processes at work that produce biologically relevant compounds
- Measure atmospheric conditions, identify methane reservoirs, and determine transport rates
- Constrain processes that mix organics with past surface liquid water reservoirs and subsurface ocean
- Search for chemical evidence of water-based or hydrocarbon-based life

Aerial mobility provides access to Titan's diverse materials at a wide range of geologic settings at dozens of sites, 10s to 100s of kilometers apart



PI: Dr. Elizabeth Turtle at APL
Dragonfly would arrive at Titan in 2034 and explore for over 2 years, performing detailed chemical analyses, measuring the atmosphere and seismic activity, and imaging the surface.