Science @ NASA

John M. Grunsfeld PhD
Associate Administrator, Science
National Aeronautics and Space Administration

Our Mission:

Innovate
Explore
Discover
Inspire

www.nasa.gov

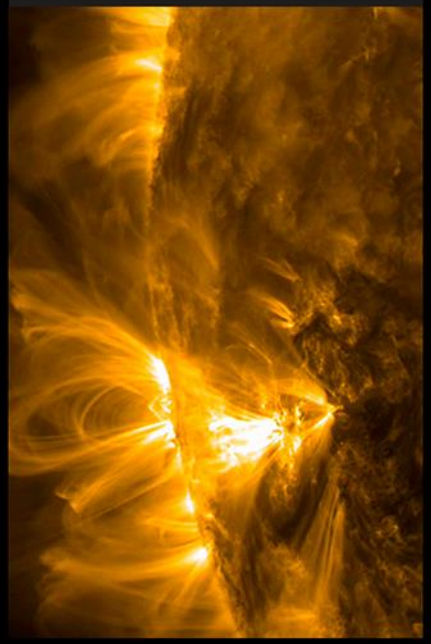
Big Scientific Questions:

Where did we come from?

Where are we going?

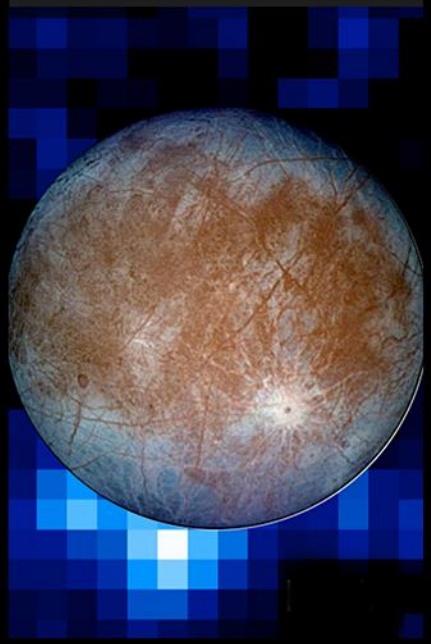
Are we alone?

Science Mission Directorate



HELIOPHYSICS

EARTH SCIENCE



PLANETARY SCIENCE

ASTROPHYSICS

An Integrated Program of Science

Science Budget Request Summary

	Actual	Enacted	Request	Notional			
	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Science	**5,243.0**	**5,589.4**	**5,600.5**	**5,408.5**	**5,516.7**	**5,627.0**	**5,739.6**
Earth Science	**1,784.1**		**2,032.2**	**1,989.5**	**2,001.3**	**2,020.9**	**2,047.7**
Earth Science Research	453.2		501.7	472.9	461.3	475.9	484.2
Earth Systematic Missions	827.3		933.0	965.5	1,021.3	1,005.0	1,000.1
Earth System Science Pathfinder	223.8		296.0	248.6	216.7	227.8	245.1
Earth Science Multi-Mission Operations	179.7		191.8	194.3	193.6	197.9	202.6
Earth Science Technology	59.7		61.4	60.4	59.7	62.7	63.7
Applied Sciences	40.4		48.2	47.9	48.7	51.5	52.0
Planetary Science	**1,446.7**		**1,518.7**	**1,439.7**	**1,520.1**	**1,575.5**	**1,625.7**
Planetary Science Research	252.8		284.7	271.6	285.7	281.6	287.3
Discovery	259.7		202.5	277.3	337.4	345.0	405.3
New Frontiers	286.0		144.0	81.6	90.7	142.8	234.0
Mars Exploration	305.0		584.8	588.8	565.0	498.4	279.9
Outer Planets and Ocean Worlds	184.0		137.3	56.0	77.8	128.0	247.3
Technology	159.2		165.5	164.4	163.5	179.7	172.0
Astrophysics	**730.7**		**781.5**	**761.6**	**992.4**	**1,118.6**	**1,192.5**
Astrophysics Research	201.7		226.1	236.3	235.7	248.5	252.0
Cosmic Origins	201.0		198.5	198.4	197.3	195.5	209.5
Physics of the Cosmos	104.1		94.1	88.0	94.1	97.7	94.0
Exoplanet Exploration	100.6		133.8	148.0	309.3	373.3	450.8
Astrophysics Explorer	123.3		129.0	91.0	156.0	203.5	186.2
James Webb Space Telescope	**645.4**	**620.0**	**569.4**	**533.7**	**304.6**	**197.2**	**149.8**
Heliophysics	**636.1**		**698.7**	**684.0**	**698.3**	**714.8**	**723.9**
Heliophysics Research	192.0		180.1	192.0	210.0	215.9	214.2
Living with a Star	263.5		374.2	398.7	244.6	135.8	127.3
Solar Terrestrial Probes	70.6		39.8	38.8	127.3	179.4	198.4
Heliophysics Explorer Program	110.0		104.6	54.5	116.3	183.8	184.0

Best Hits of 2026

Looking Back at SMD's Most Successful Decade

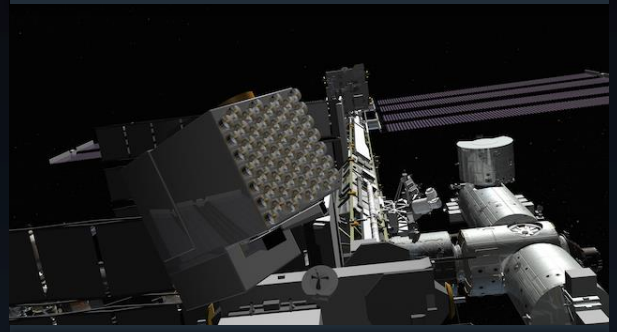
...Yet


Formulation
Implementation
Primary Ops
Extended Ops
Spitzer
8/25/2003
Kepler
3/7/2009
LISA Pathfinder (ESA)
12/3/2015
WFIRST
Mid 2020s
Euclid (ESA)
2020
JWST
2018
Chandra
7/23/1999
XMM-Newton (ESA)
12/10/1999
TESS
2017
NuSTAR
6/13/2012
Swift
11/20/2004
Hitomi (JAXA)
2/17/2016
Fermi
6/11/2008
Hubble
4/24/1990
CREAM (on ISS)
2017
NICER (on ISS)
2017
SOFIA
Full Ops 2014

Astrophysics Missions in Development

NICER
3/2016

NASA Mission



Neutron Star Interior Composition Explorer

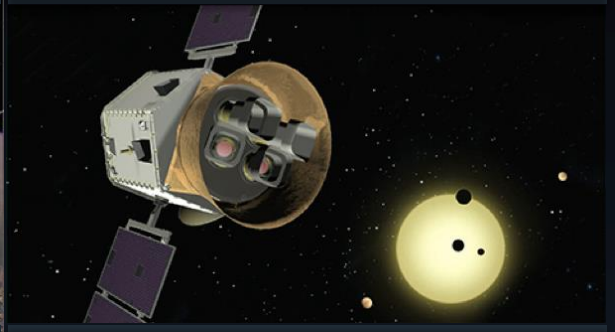
CREAM
7/2016

NASA Mission

Cosmic Ray Energetics And Mass

TESS
8/2016

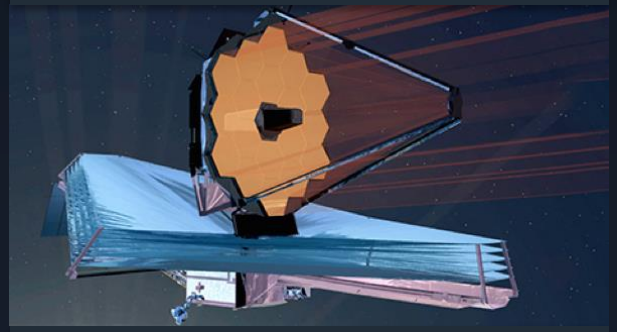
NASA Mission



Transiting Exoplanet Survey Satellite

JWST
10/2018

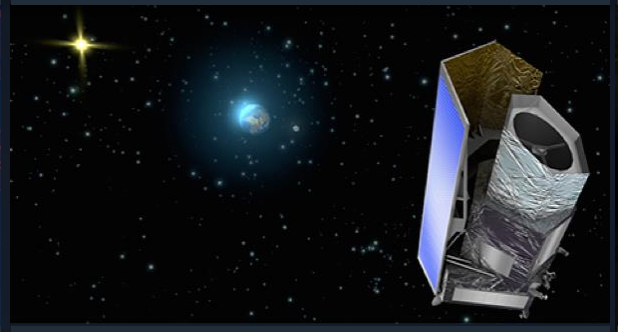
NASA Mission



James Webb Space Telescope

Euclid
2020

ESA-led Mission



NASA is supplying the NISP Sensor Chip System (SCS)

WFIRST
Mid 2020s

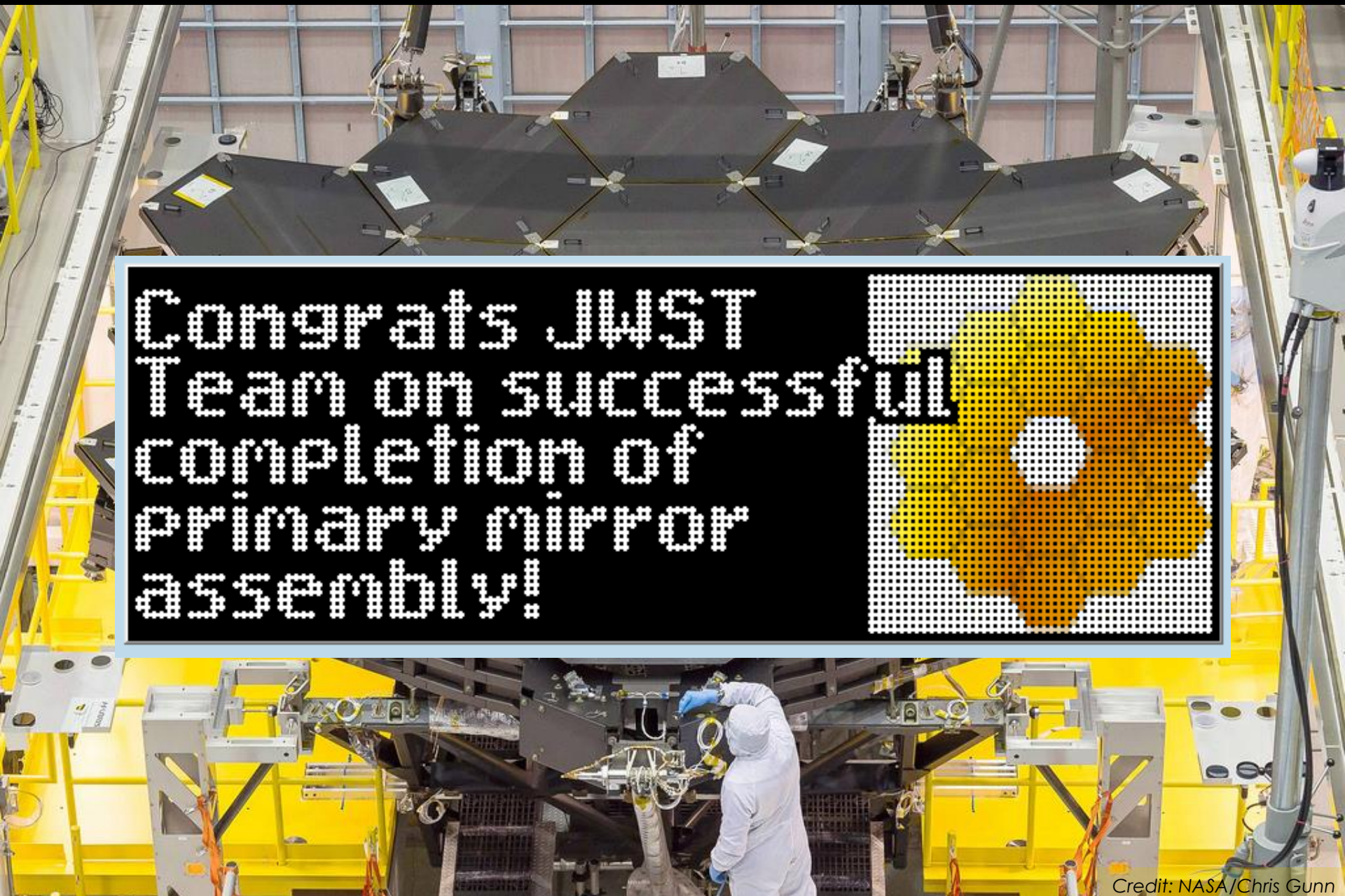
NASA Mission

Wide-Field Infrared Survey Telescope

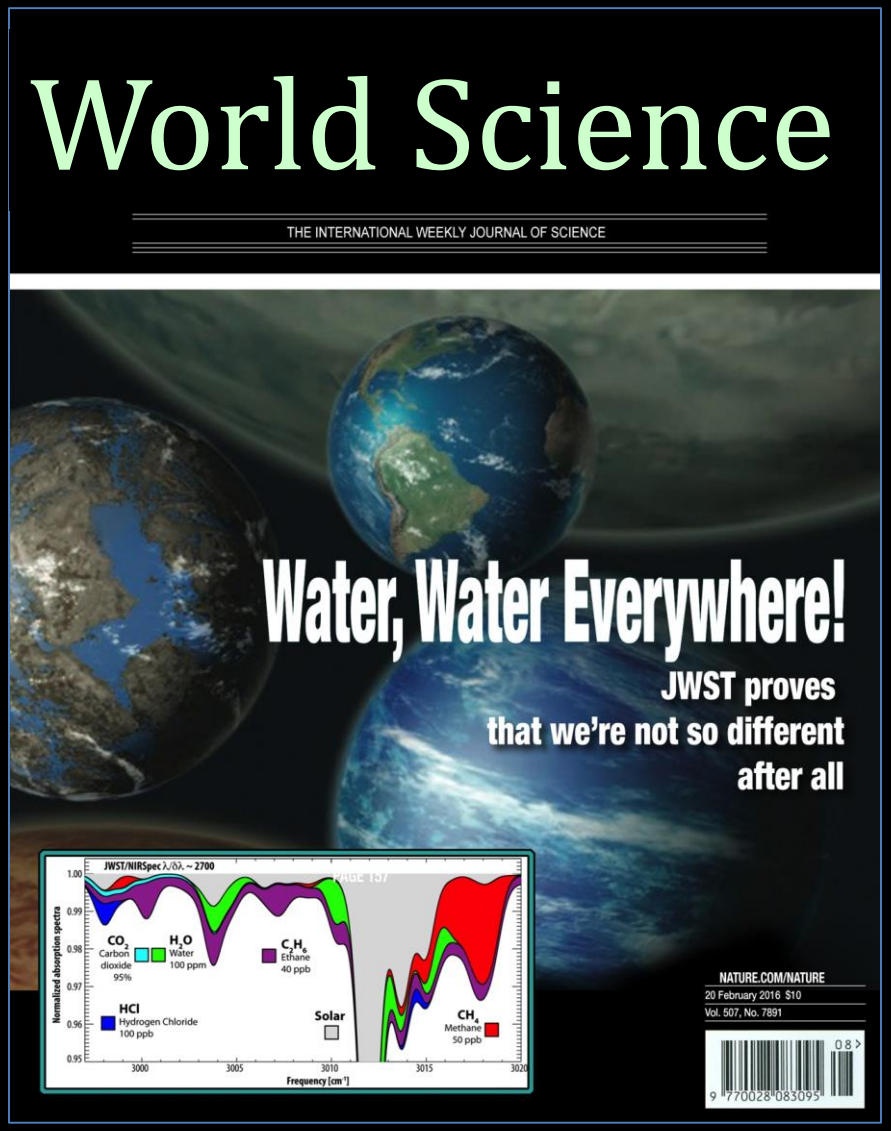
James Webb Space Telescope

…going where no Hubble has gone before

JWST Mirror Fully Assembled



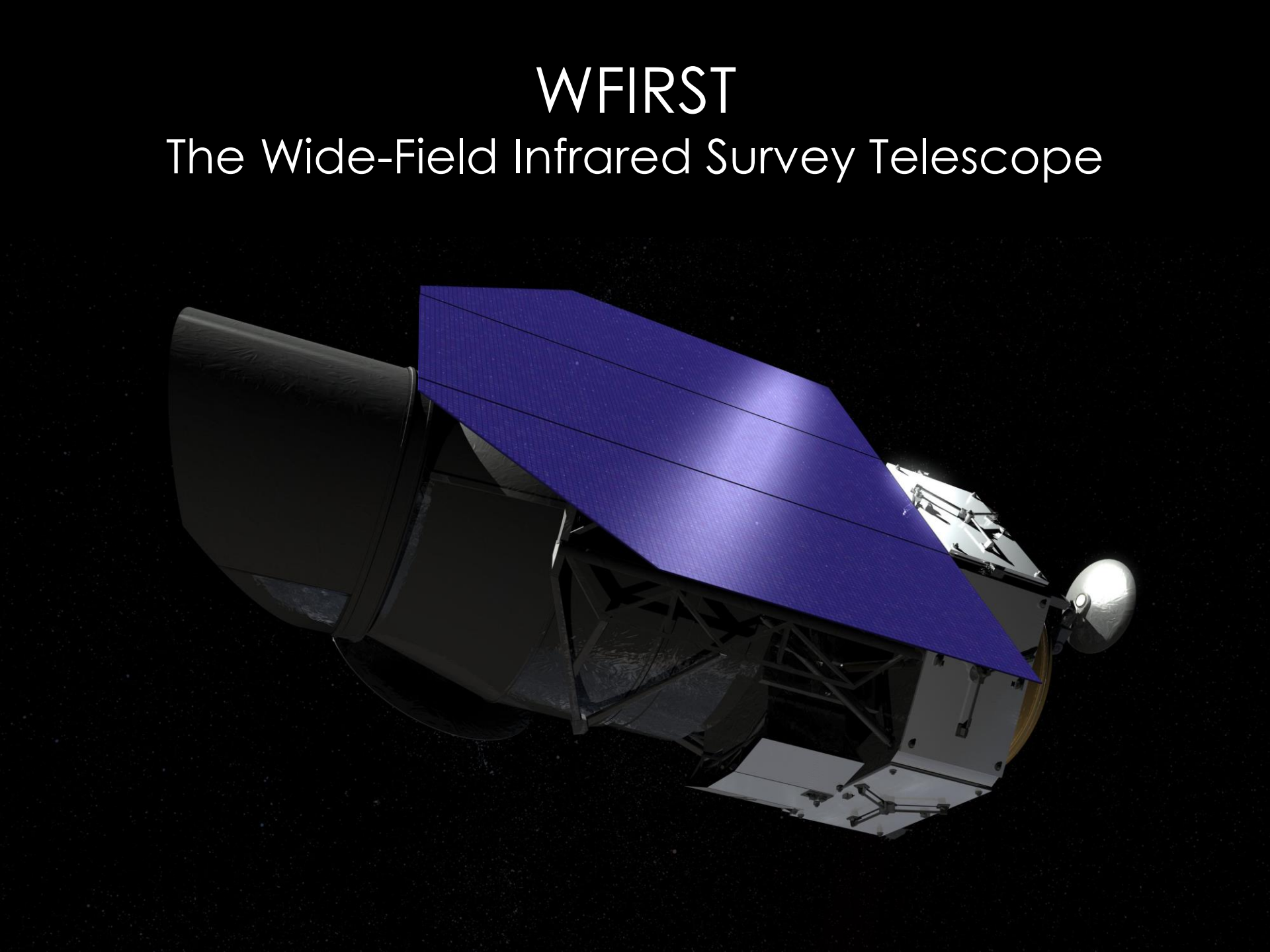
Credit: NASA/Chris Gunn



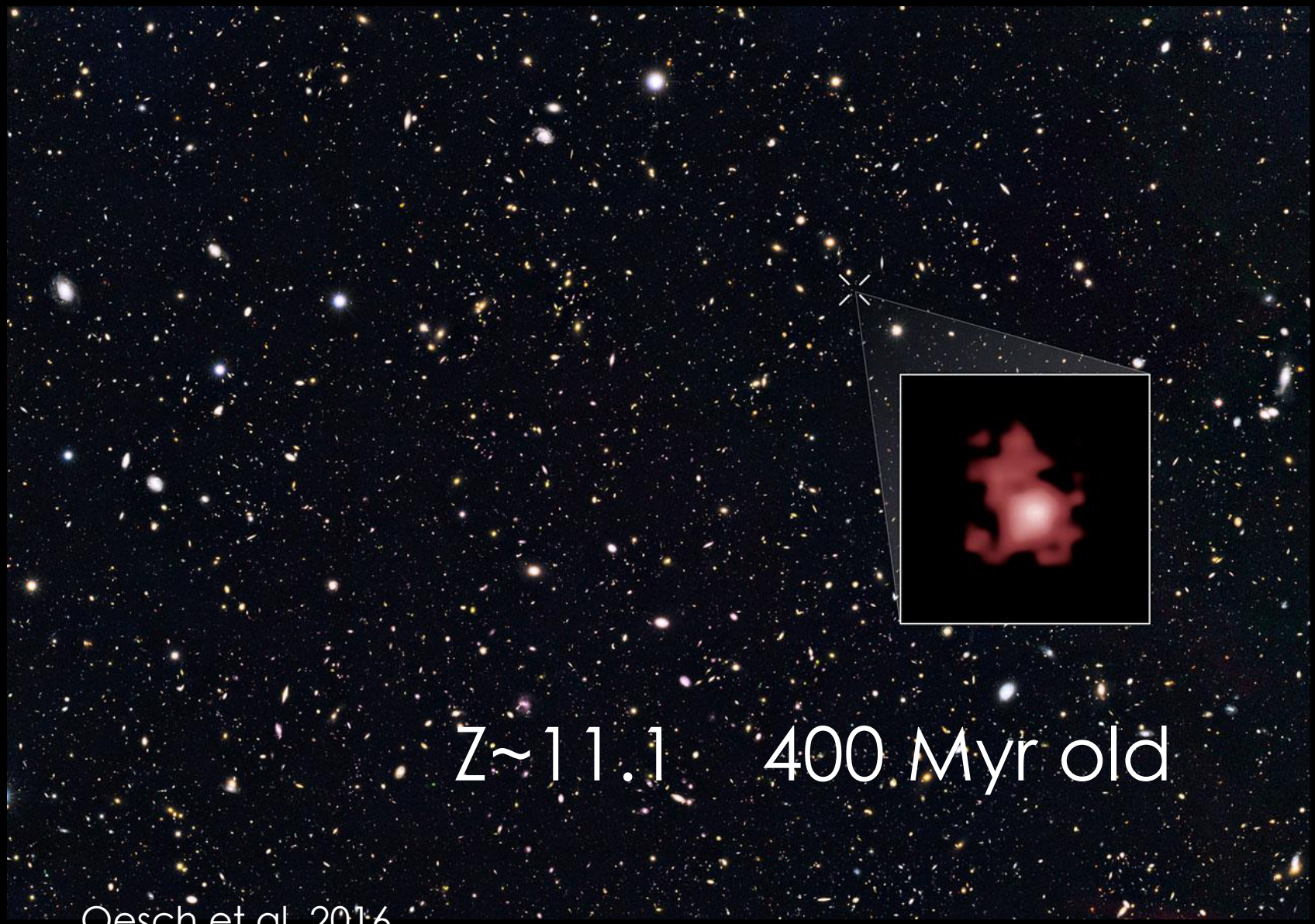
- Atomspheres of exoplanets Analyzed!
- Population III Stars Discovered!
- Assembly of Galaxies Explained!
- Birth of New Solar Systems Witnessed!
- Segmented Space Telescopes Proven

WFIRST

The Wide-Field Infrared Survey Telescope



Hubble breaks cosmic distance record



Oesch et al. 2016

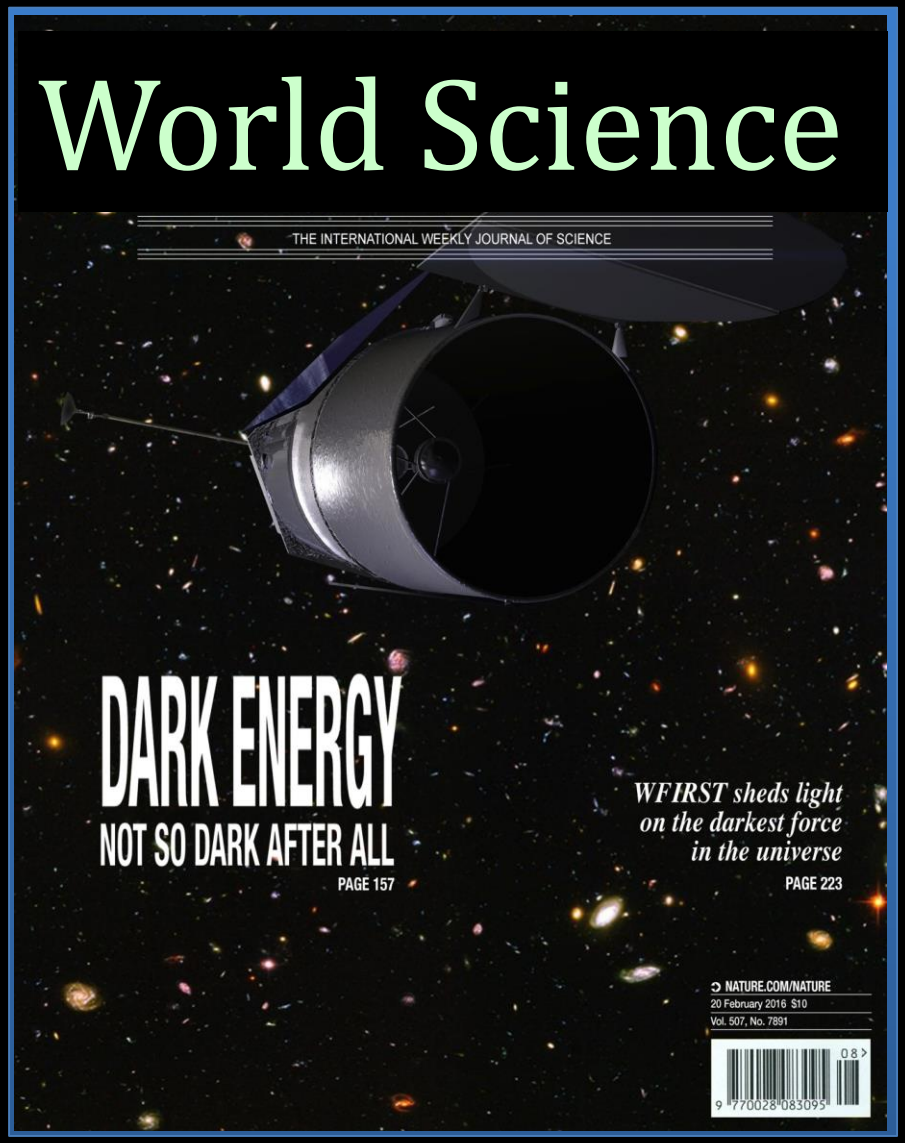
WFIRST-AFTA vs Hubble

Hubble Ultra Deep Field - IR
~5,000 galaxies in one image
(60 orbits, 4 days)

PI: Illingworth

70,000 galaxies in each field
of AFTA survey

WFIRST-AFTA Deep Field
>1,000,000 galaxies in each image



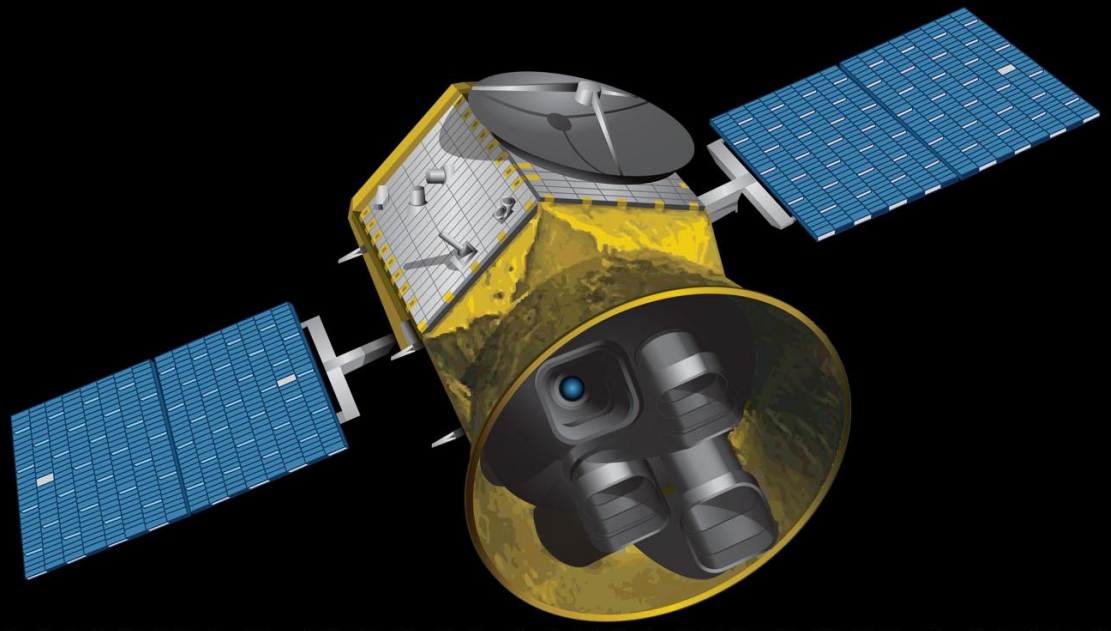
Millions and Millions of Galaxies Imaged!

Universal Cosmic Acceleration Confirmed!

Dark Energy Not So Dark Anymore!

Exoplanets Explored!

We're surrounded by rocky planets in their habitable zones!

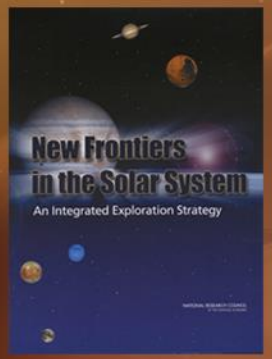


TRANSITING EXOPLANET SURVEY SATELLITE

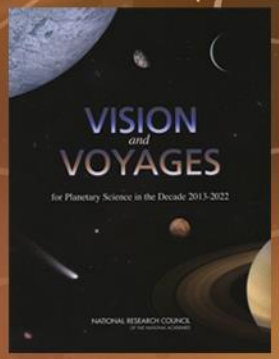
DISCOVERING NEW EARTHS AND SUPER-EARTHS IN THE SOLAR NEIGHBORHOOD

Planetary Science

Decadal Survey Missions



2003 Decadal Survey



2013 Decadal Survey

Europa

Mars Rover 2020

2018

InSight

2016

OSIRIS-REx

2013

MAVEN

2011

MSL

2011

Juno

2006

New Horizons

1997

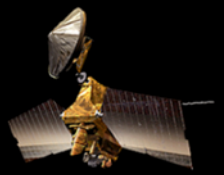
Cassini

Current & Future Mars Missions

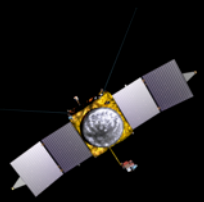
Operational
2001 - 2014

Mars Odyssey

ESA Mars Express
(NASA: MARSIS)

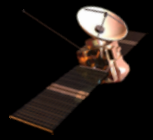


Mars
Reconnaissance
Orbiter



MAVEN

2016



ESA
Trace Gas Orbiter
(NASA: Electra)

2018

InSight

ESA
ExoMars Rover
(NASA: MOMA)

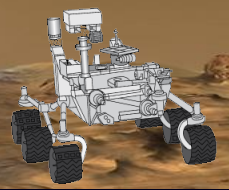
2020

Science
Rover

2022

Opportunity –
Mars Exploration
Rover

Curiosity –
Mars Science
Laboratory



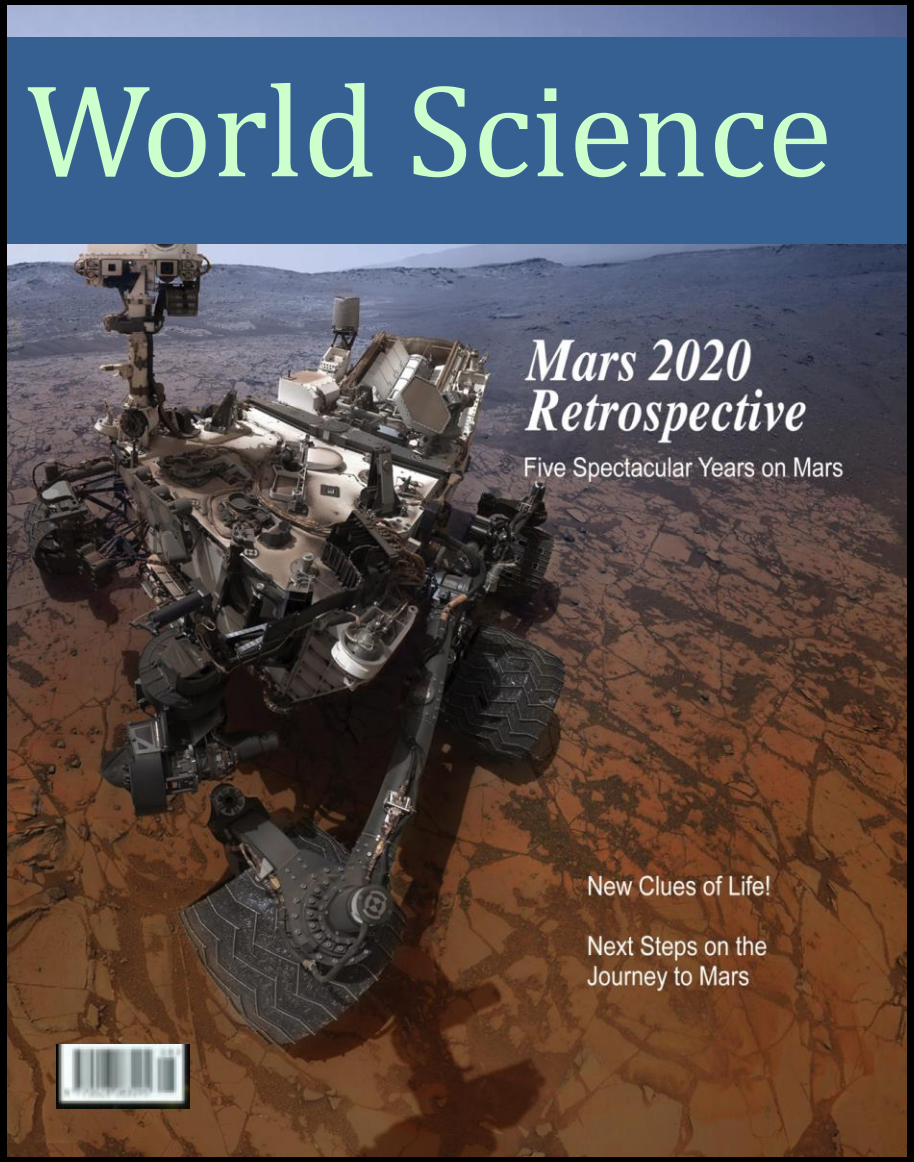
Follow the Water

Explore Habitability

Seek Signs of Life

Prepare for Future Human Explorers

EVOLVING MARS SCIENCE THEMES



Mars 2020 Rover Landed in Habitable Environment!

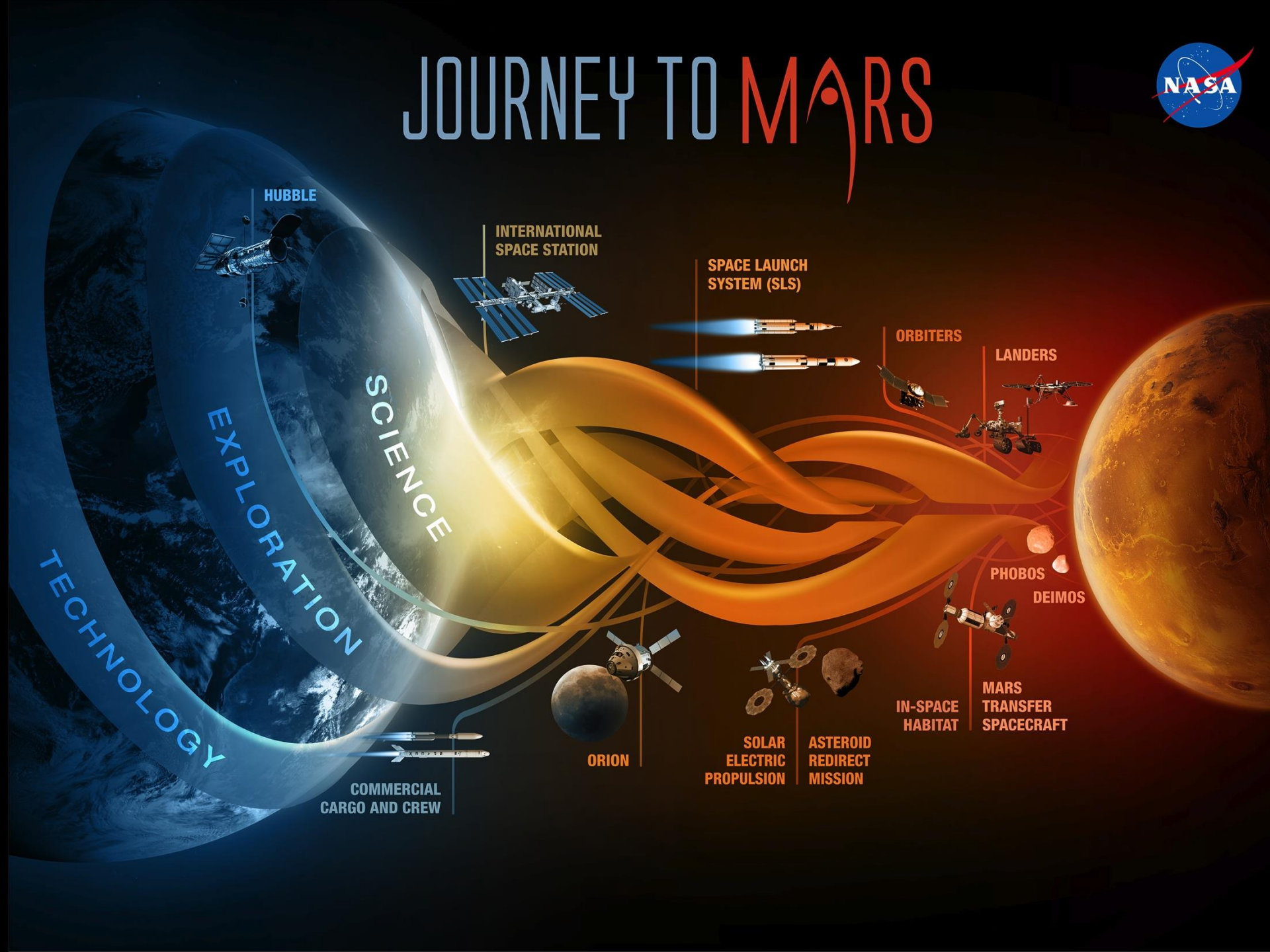
Possible Biosignatures Found!

Core Samples Cached!

In-Situ Resource Utilization Demonstrated!

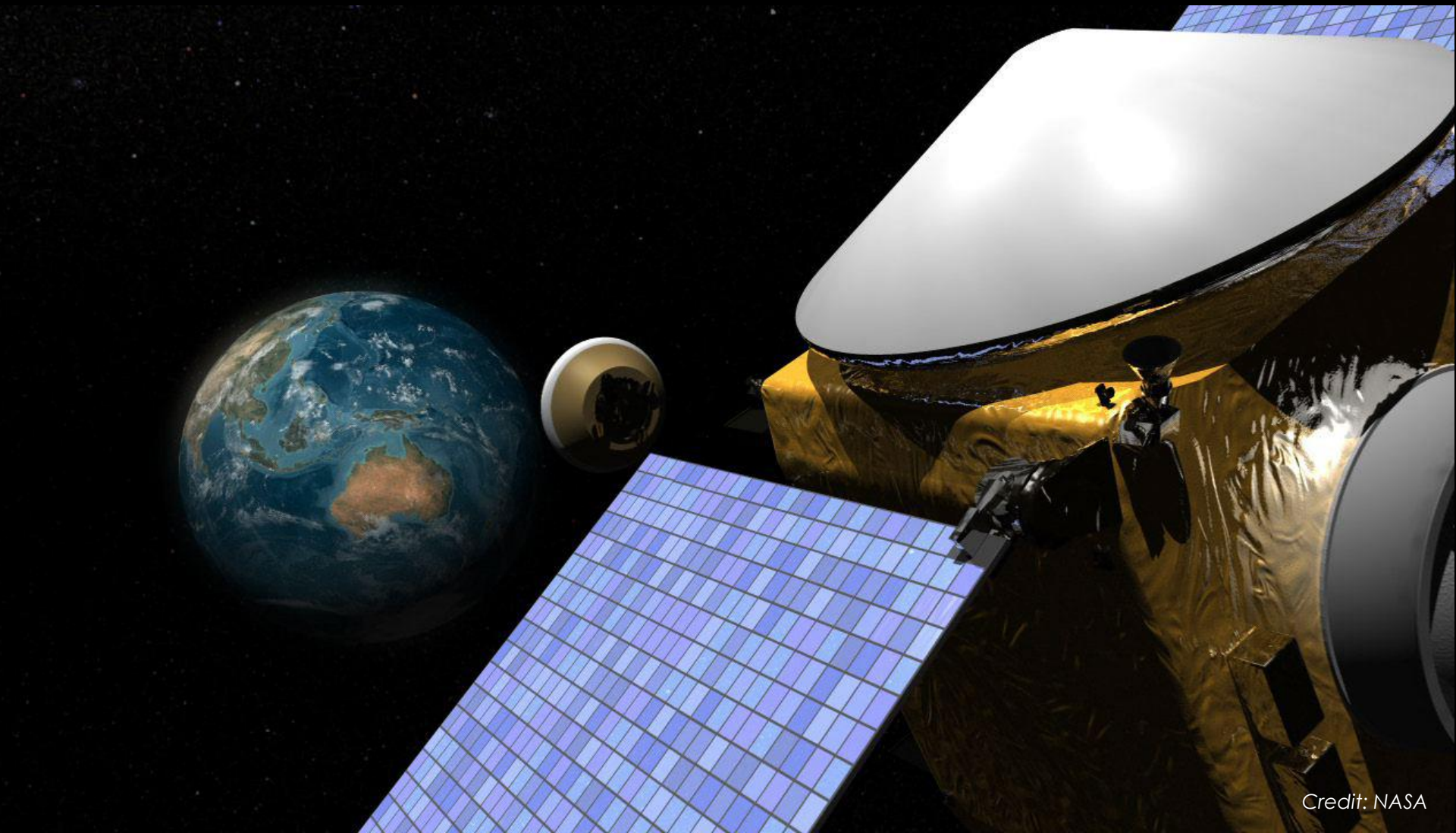
Sample Return Mission on the Way to Mars

JOURNEY TO MARS



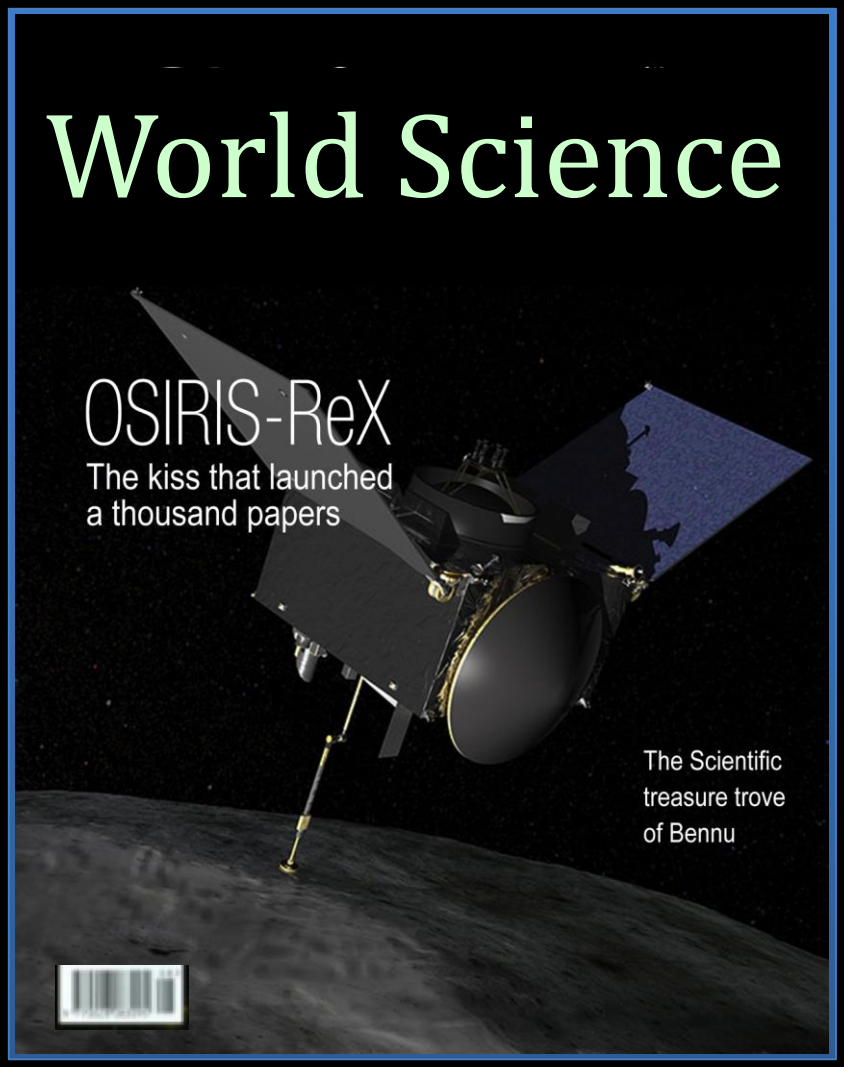
OSIRIS-REx

Origins Spectral Interpretation Resource Identification Security - Regolith Explorer



Credit: NASA


OSIRIS-REx
ASTEROID
SAMPLE
RETURN
MISSION
EXPLORING OUR PAST
SECURING OUR FUTURE



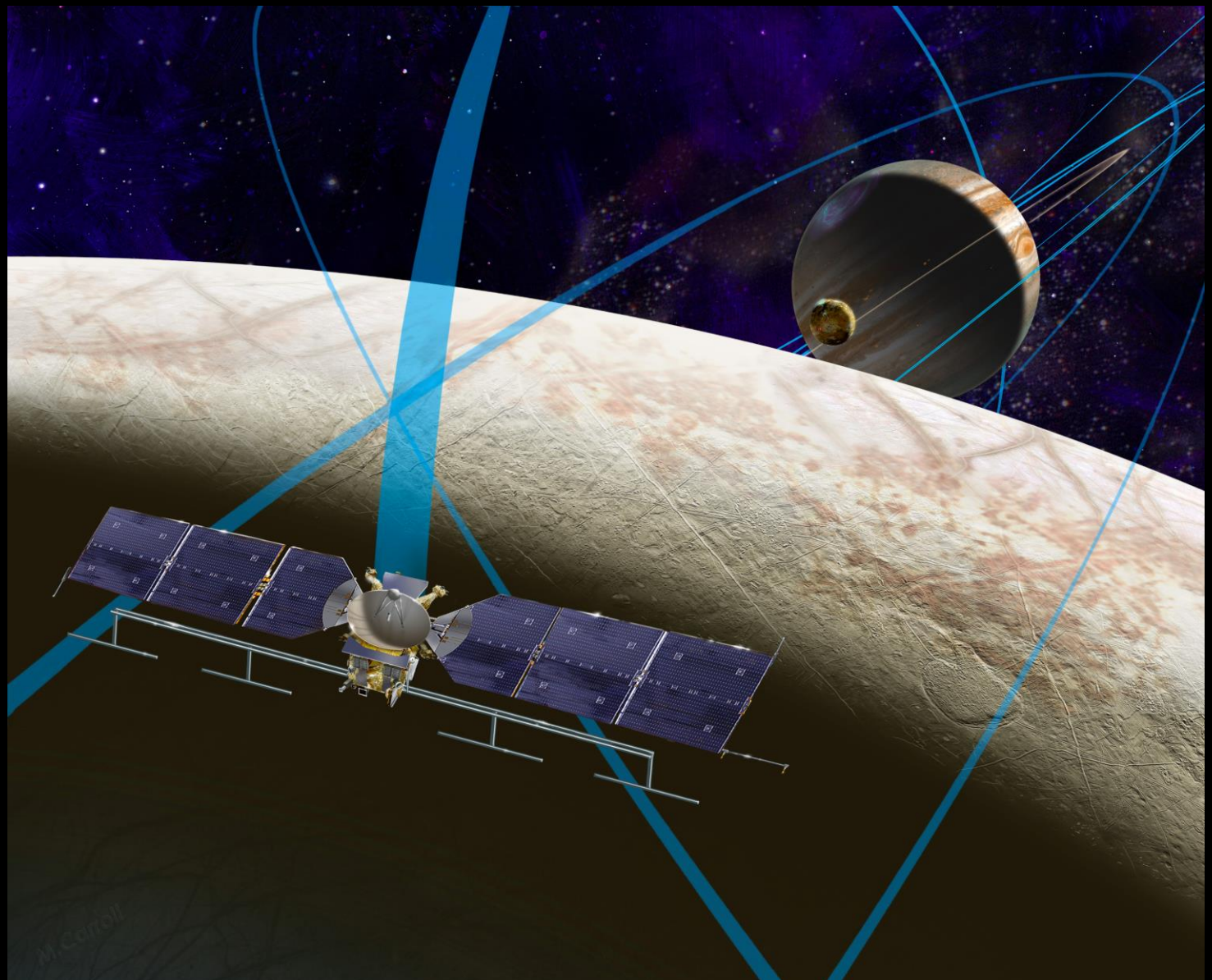
Asteroid Bennu Mapped to mm scale!

Pristine Sample of Early Solar System Returned!

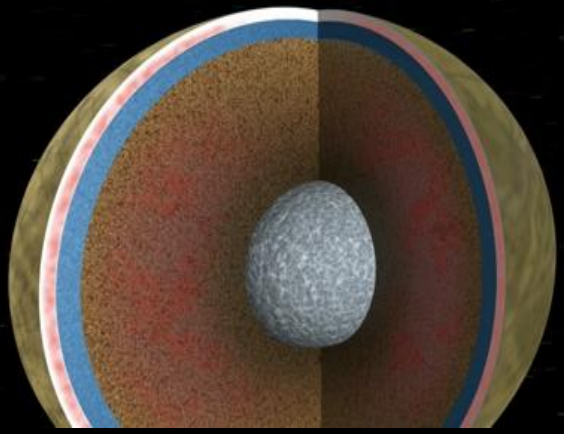
Asteroid Organics Analyzed!

Scientific Community Astounded!

Europa Clipper Arrives!



The Big Question: Is Europa Habitable?



Credit: NASA/JPL

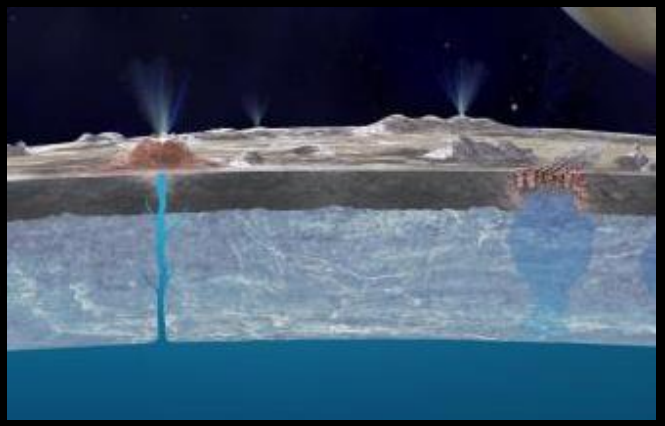
What's in the plumes?
Mass Spectrometer
(Cassini)

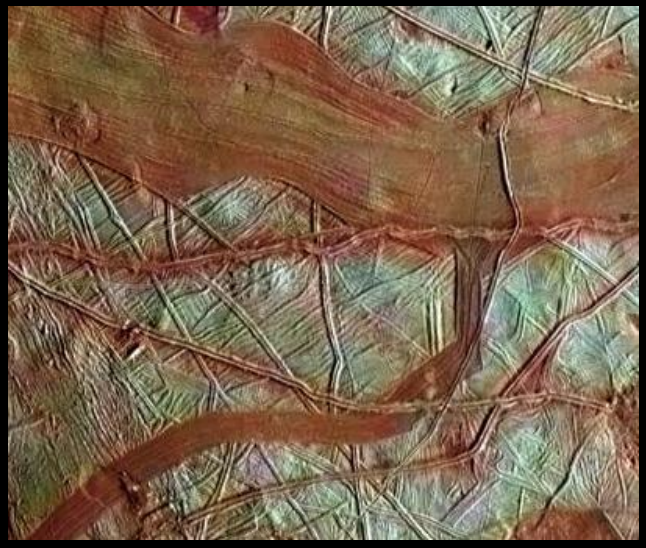
How deep and salty is the ocean?
Gravity, Magnetometer
(GRAIL, GRACE)

How active is the ice shell?
Camera, Thermal Imager
(MRO, ICESat)

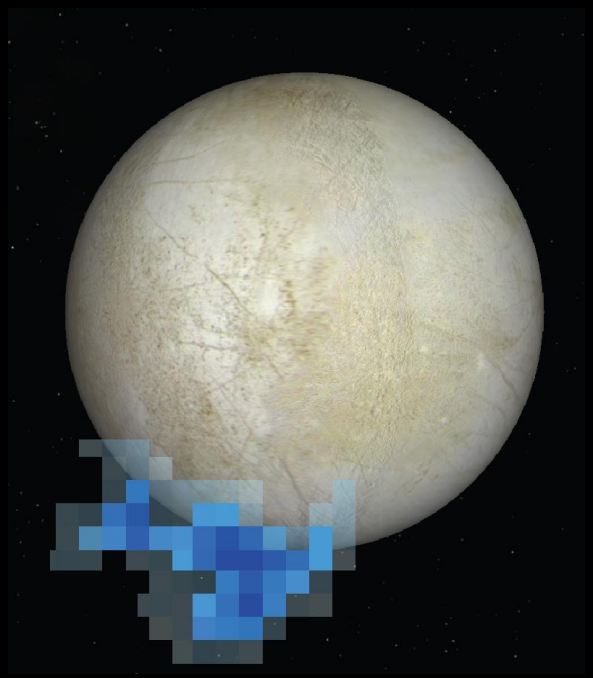
How thick is the ice shell?
Radar, Gravity
(MRO, Cassini)

What's the brown stuff?
IR & Mass Spectrometers
(Landsat, MRO)





Credit: NASA/JPL-Caltech/SETI Institute



Credit: NASA/ESA/L. Roth/SWRI/University of Cologne

Earth Science

CYGNSS
FY17

TEMPO
FY17/21

ICESat-2
FY18

GRACE-FO
FY18

CLARREO PF FY19
ECOSTRESS FY19
GEDI FY18/20
TSIS-1 FY17
TSIS-2 FY20/22

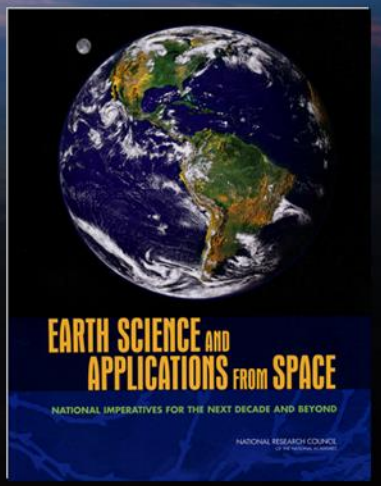
OMPS-L FY18/21
RBI FY19/21

SWOT
FY20

NI-SAR
FY22

PACE
FY22

Sentinel-6A/B
FY20/24



2007
Decadal Survey

PACE

Pre-Aerosol Clouds and Ocean Ecosystem

Global Ocean Color: Mapped!

Phytoplankton Health Assessed!

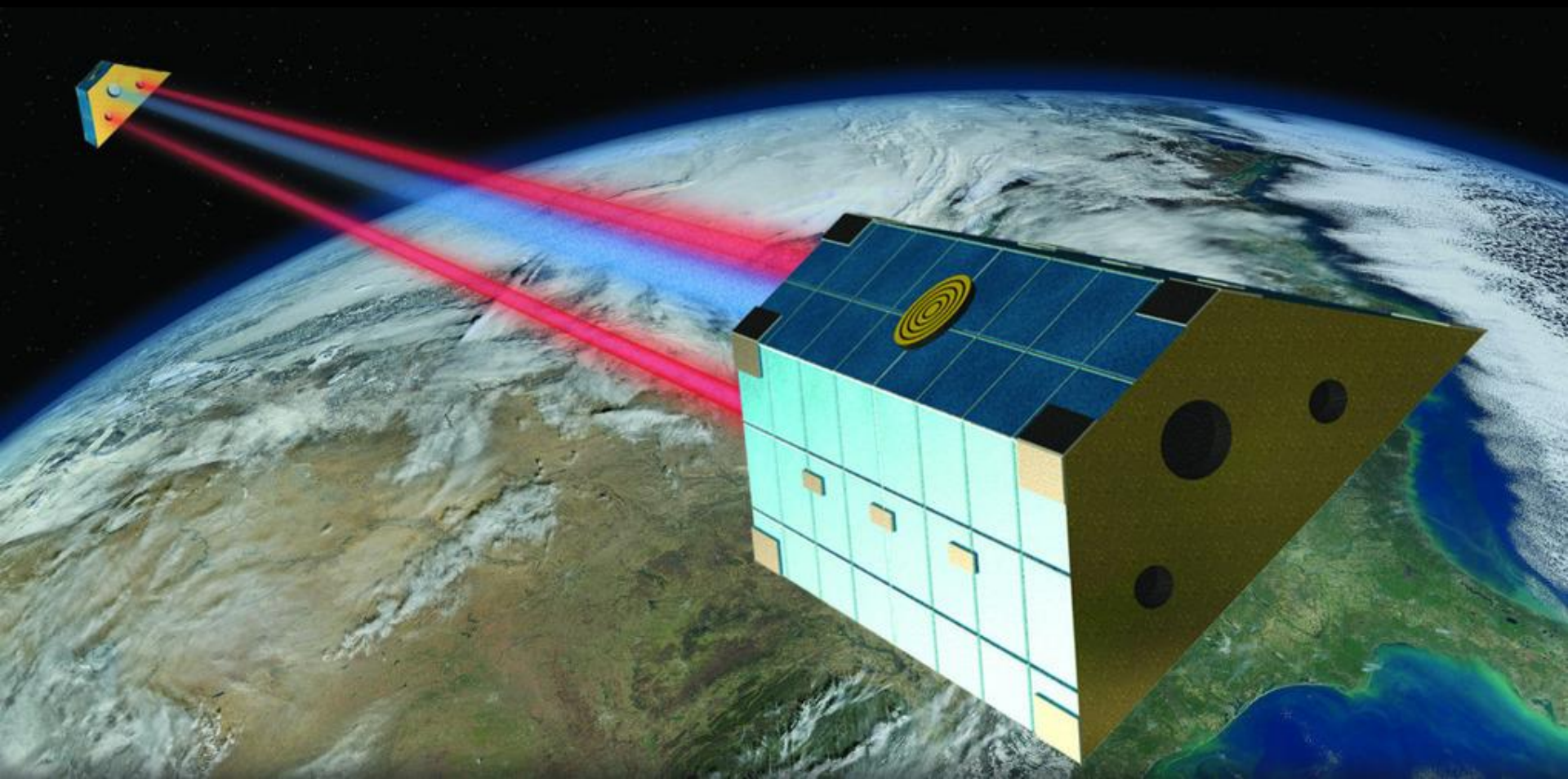
Global Carbon Cycle Better Understood!

Harmful Algal Blooms Deteteted Worldwide

News: Not Good!

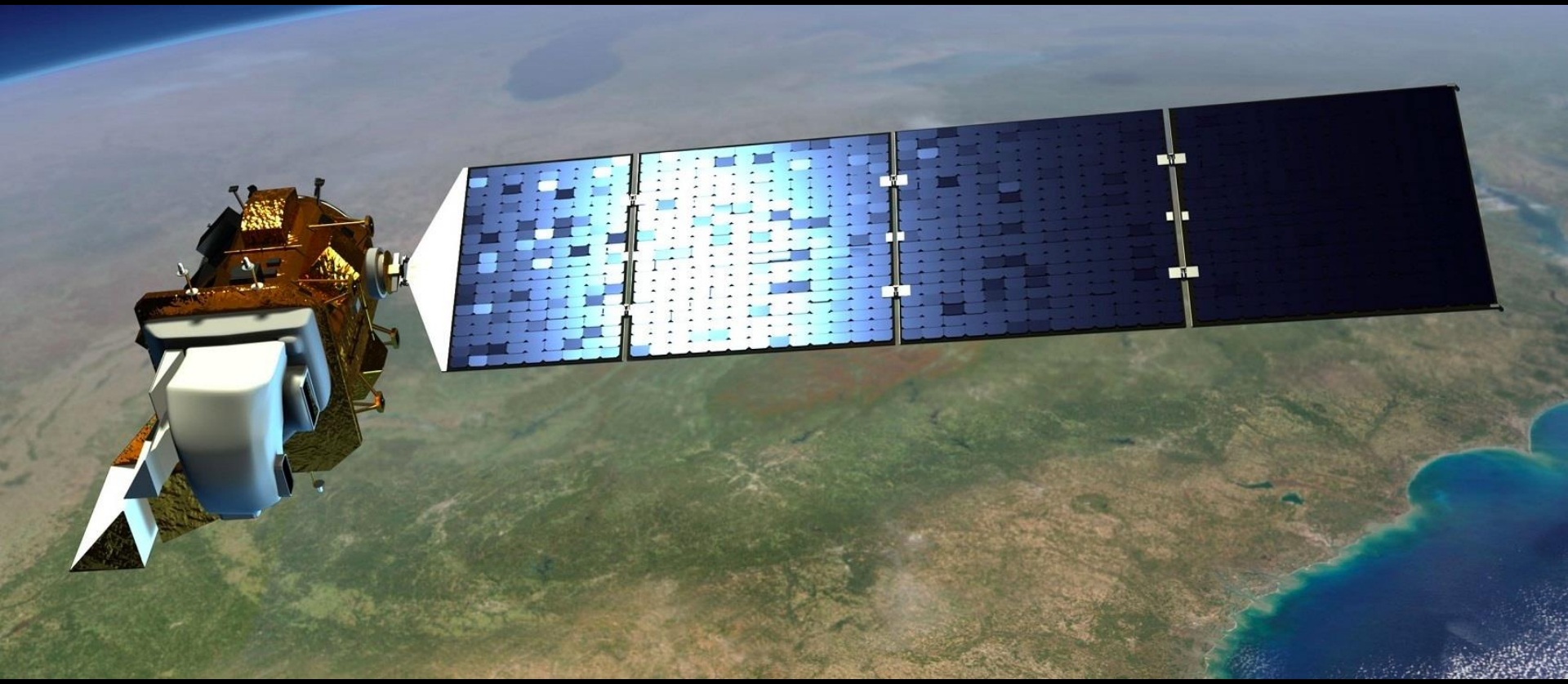
ICESat-2

GRACE Follow-On



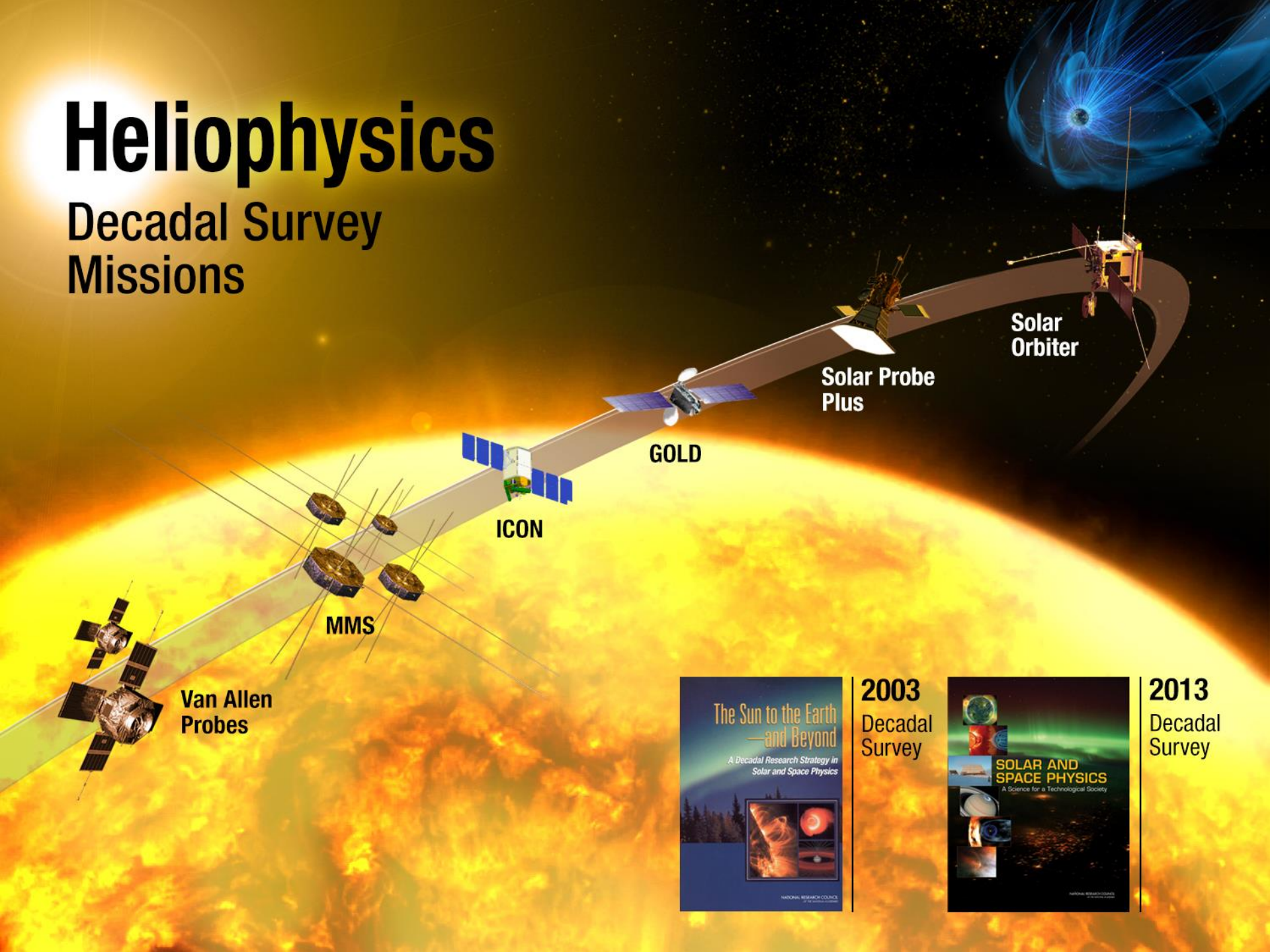
Jason-3 and Sentinel-6

LandSat-9



Heliophysics

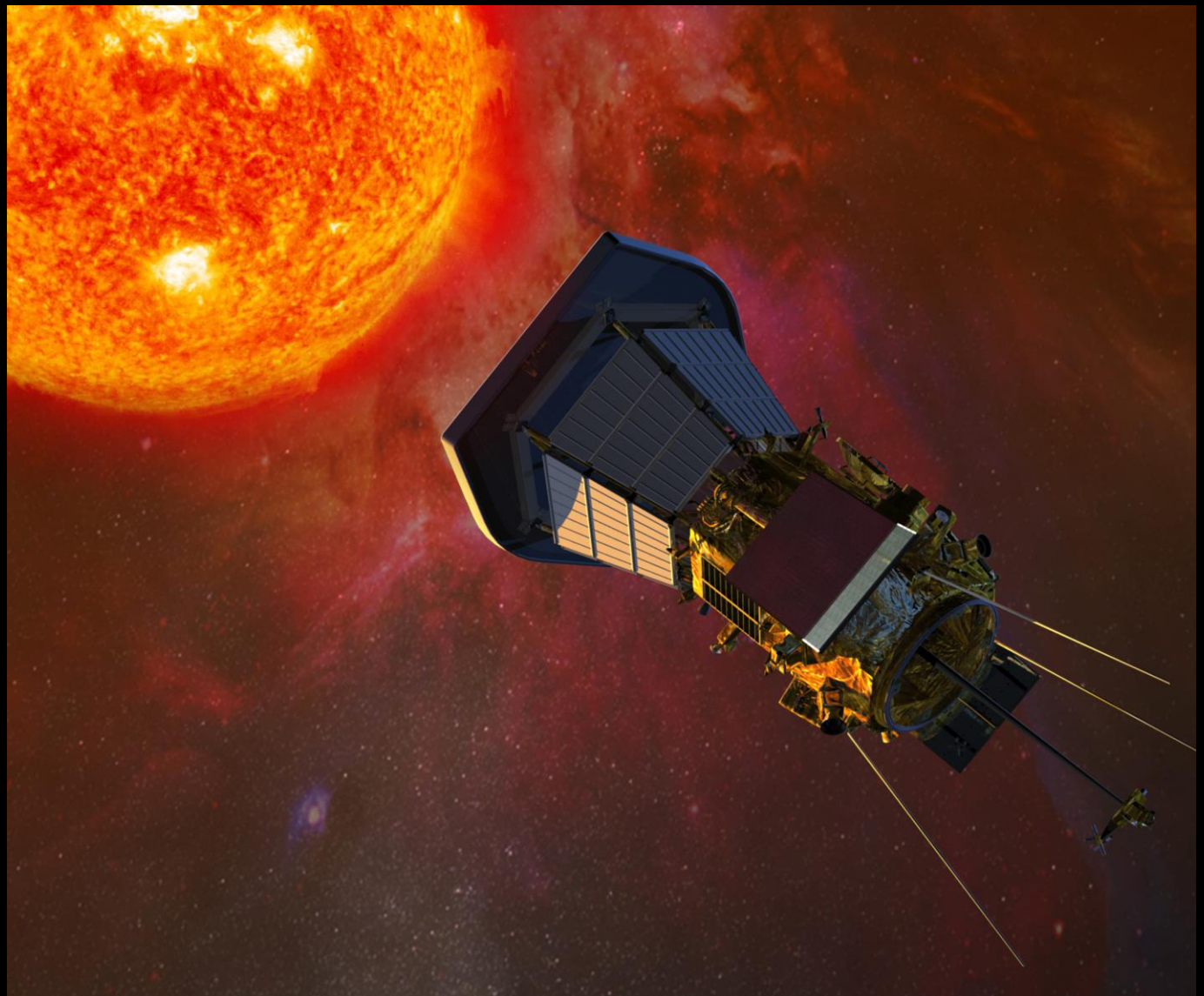
Decadal Survey Missions



2003 Decadal Survey

2013 Decadal Survey

Solar Probe Plus Solves Mystery of the Solar Corona



What Are the Challenges to this Bright Future ?

- Bold and Consistent Leadership
- Cost and Schedule Performance
- High Quality Workmanship
- Teamwork
- Scientists, Engineers, Technicians, Dreamers

  (STEM education)

Our future science looks pretty incredible