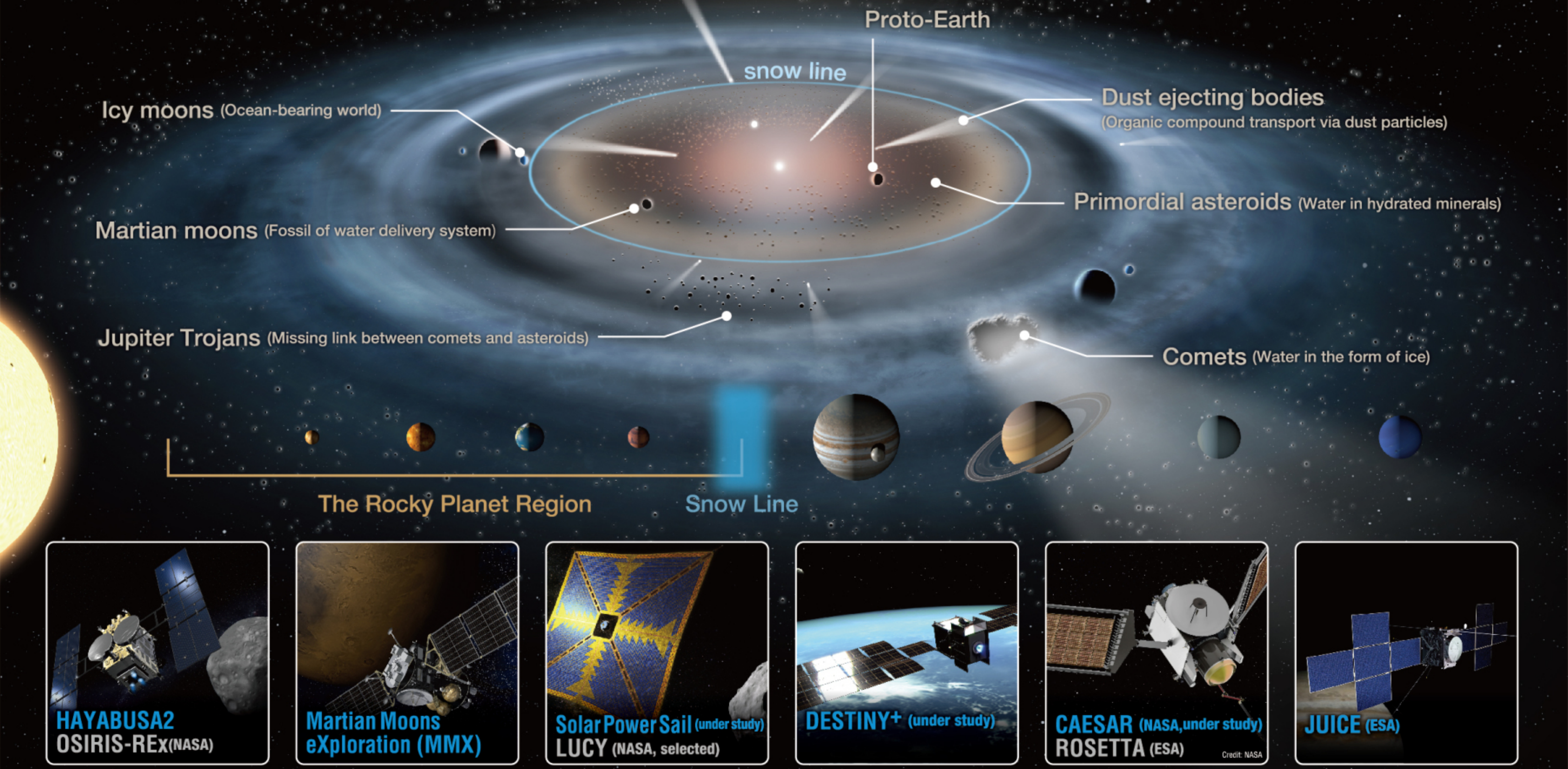
ISAS Small Body Exploration Strategy

Many small bodies are born outside the snow line. These are initially comet-like but can evolve to show a variety of faces.

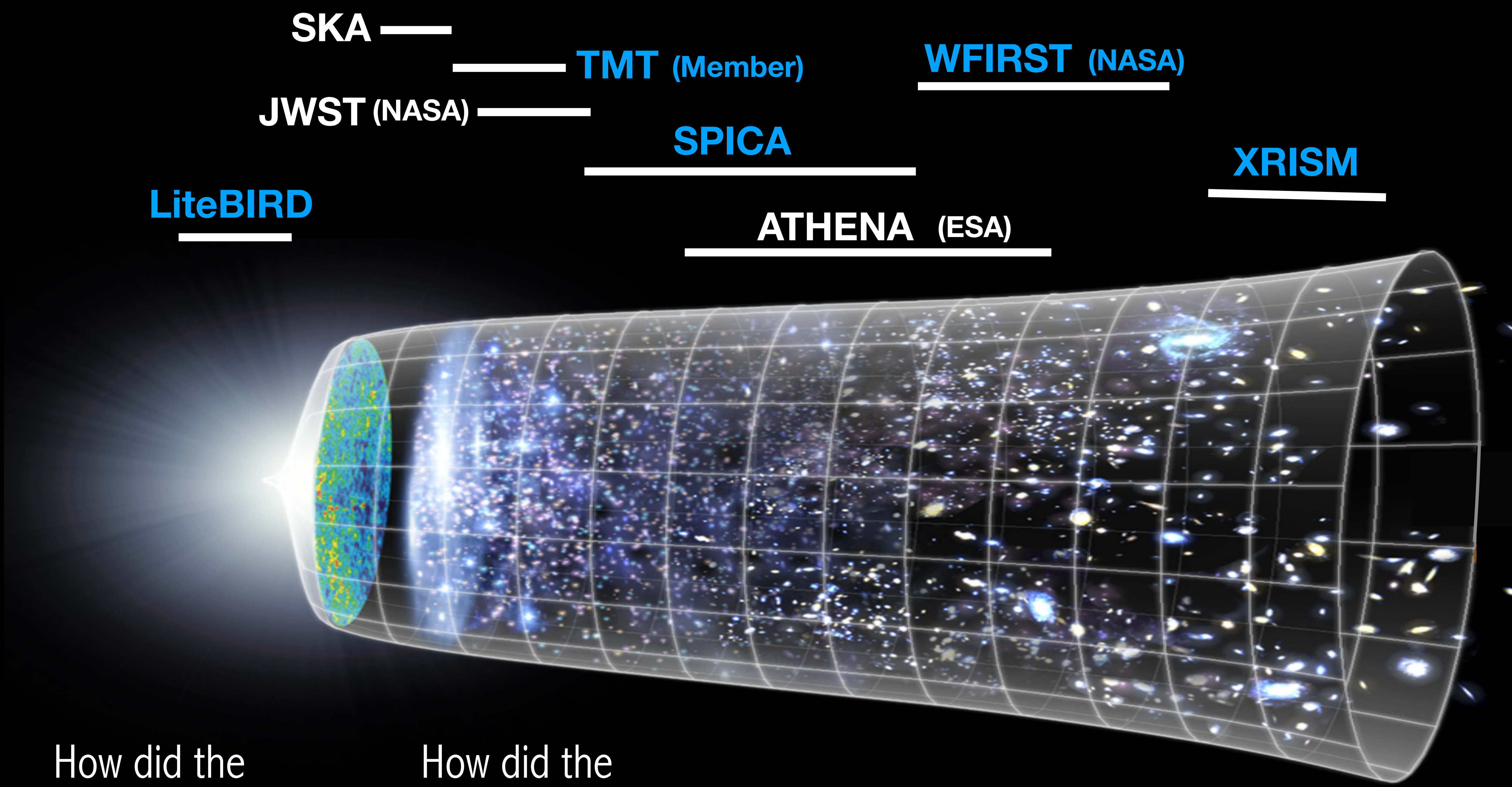
By delivering water and organic compounds, these small bodies may have enabled the habitability of our planet.

When, who and how?



The fleet of ISAS small body missions explores these questions

ISAS Astrophysics Strategy



How did the Universe begin?

How did the Universe evolve?

Understanding formation processes, diversity & universality of structure

image credit: NASA / WMAP Science team

CURRENT

Akatsuki

Venus Climate Orbiter

The Venus Climate Orbiter, Akatsuki, is in orbit around Venus, measuring atmospheric properties in the infrared, visible and ultraviolet.

Venus and Earth are similar in size and mass, yet despite receiving only slightly more radiation that the Earth, Venus harbours a thick atmosphere that traps heat to give surface temperatures high enough to melt lead. To truly understand how a temperate planet like our own is born, we must unravel why Venus evolved so differently.

Akatsuki is examining the properties of the cloud cover to gain a three dimensional view of the evolution of the Venusian atmosphere. A particular focus is the origin of Venus's "super rotation" which sees the cloud top moving 60 times faster than the planet's rotation.

JAXA-led mission

Venus orbiter designed to explore the Venusian atmosphere.

Orbit insertion: Dec 7, 2015

CURRENT

ARASE

Exploration of energization and Radiation in Geospace (ERG)

ARASE investigates the production of the highest energy particles in the geosphere; the relativistic electrons that are trapped in the Earth's radiation belts.

Like most planets with a magnetic field, the Earth is surrounded by radiation belts of trapped charged particles. During space storms, these radiation belts can become deformed and produce large variations in the flux of the high energy particles. Studying these changes is important for the space infrastructure, such as GPS and satellites, that operate in the radiation belts, as well as for exploring the role of planetary magnetic fields.

In addition to domestic collaborations, the Low-Energy Particle Sensor (LEP-e) onboard ERG was developed in Taiwan.

JAXA-led mission

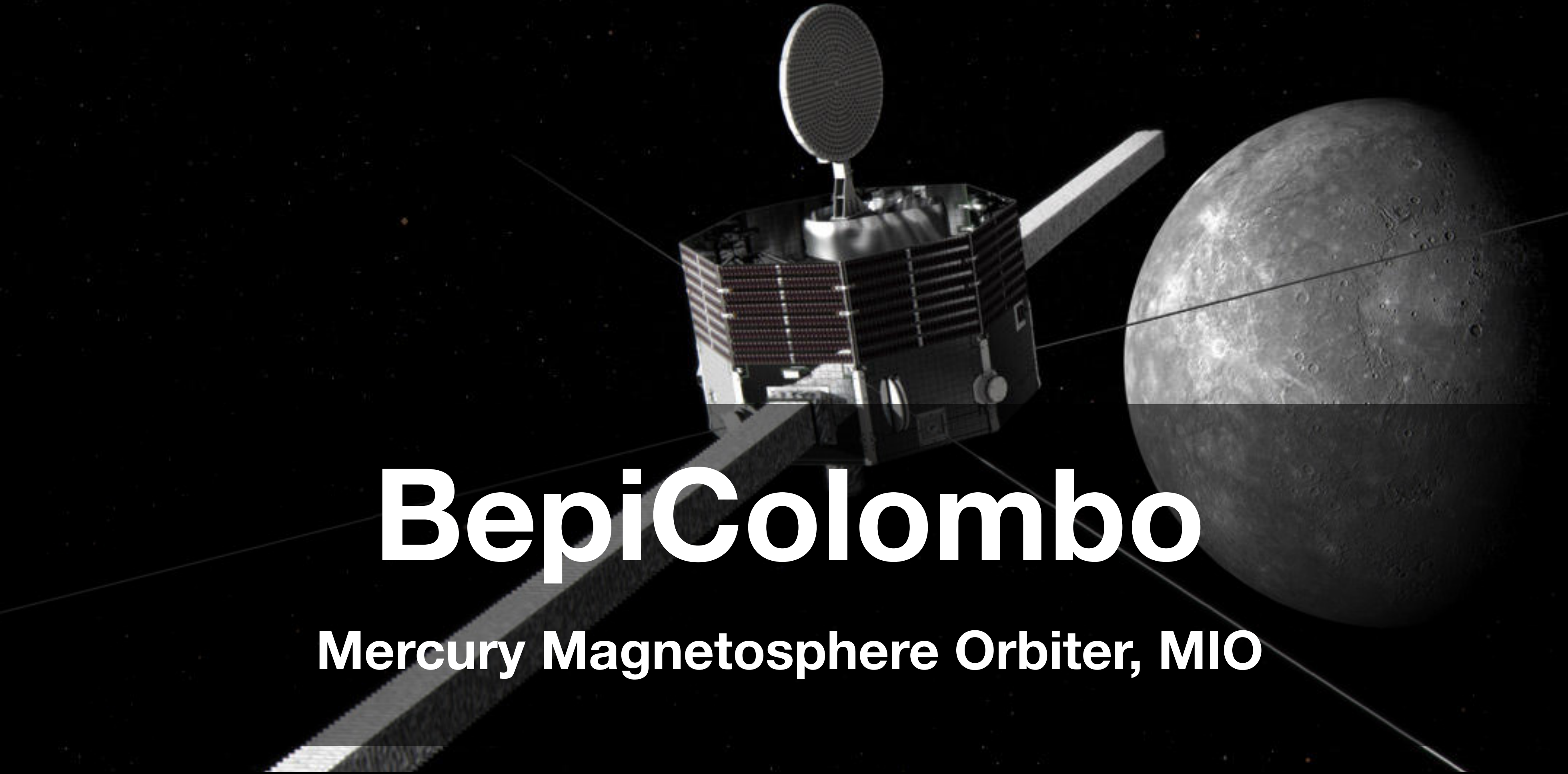
Exploration of the Van Allen radiation belts.

Launch: Dec 20, 2016

ARASE

Exploration of energization and Radiation in Geospace (ERG)

CURRENT



BepiColombo

Mercury Magnetosphere Orbiter, MIO

The BepiColombo Mercury mission consists of two orbiters each designed by ESA and JAXA. The objective of the JAXA orbiter is to explore the interaction with the solar wind and Mercury's magnetic field.

Mercury is one of only three rocky bodies in our Solar System that generates its own magnetic field. While life could not exist on Mercury's roasting surface, more temperate conditions could be present on planets on similar orbits around cooler stars. Understanding how the magnetic field interacts with the solar wind in close proximity is therefore key to understanding whether such worlds would have they atmospheres stripped or if habitable conditions could exist.

esa European Space Agency & JAXA

collaborative mission

Mercury orbiter to explore the magnetic field.

Sch. launch: Oct, 2018

BepiColombo

Mercury Magnetosphere Orbiter, MIO

By public vote, our probe recently was given the name “Mio”.


credit: JAXA/Akihiro Ikeshita

CURRENT

Hayabusa2

Asteroid explorer

Hayabusa2 is a mission to analyse and return a sample from a carbonaceous asteroid in order to explore the origin of water and organics on Earth.

Forming too close to the Sun for ice to be incorporated into the planet, water and organics may have arrived on the Earth via meteorites. One possible origin of these meteorites is the C-type (carbonaceous) asteroids, which contain organic material and are largely unaltered since the beginning of the Solar System. Analysis and samples from the C-type asteroid "Ryugu" will help unpick the beginnings of life on our planet.

Hayabusa2 also carries the MASCOT lander developed by DLR/CNES and three MINERVA-II rovers to explore operations in a low gravity environment.

JAXA-led mission

Asteroid sample return mission.

Launch: Dec 3, 2014

Arrival: June 27, 2018

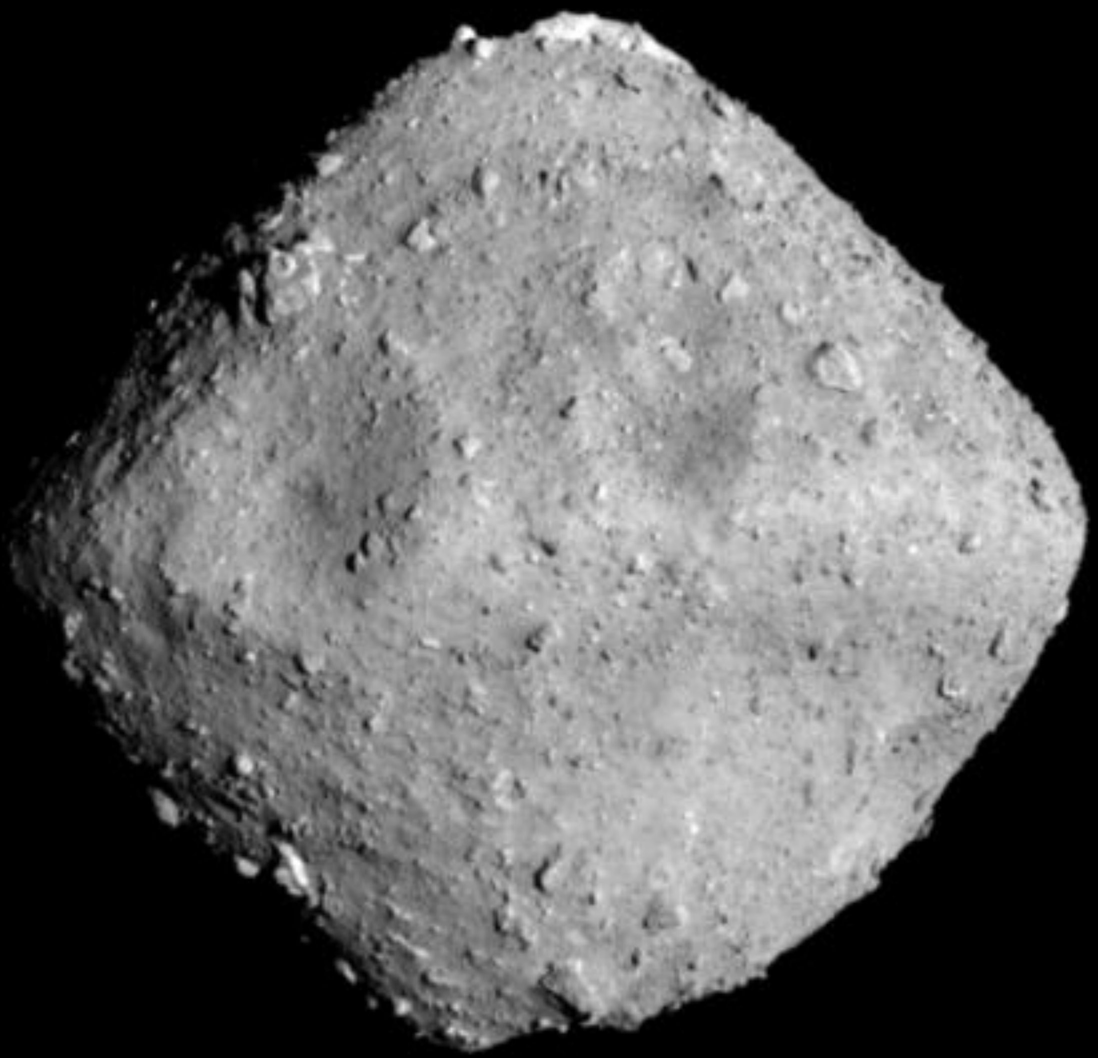
Return: Dec 2020

Hayabusa2

The destination of Hayabusa2, asteroid Ryugu, imaged by the onboard ONC-T (Optical Navigation Camera - Telescopic) on June 26, 2018 from a distance of about 20 km.

Hayabusa2 plans to collect three separate samples from Ryugu, including one of sub-surface material after exposure using a small carry-on impactor.

Hayabusa2 arrived at Ryugu (at a distance of 20 km) on June 27. The spacecraft will remotely analyse the asteroid over the summer and begin surface operations this fall. For the most up-to-date information, please see the laptop!



Credit: JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, Aizu University, AIST

WWW http://www.hayabusa2.jaxa.jp

@haya2e_jaxa

Hayabusa2

Launch Dec. 2014

Test ion engine system (IES)

Begin IES-powered flight

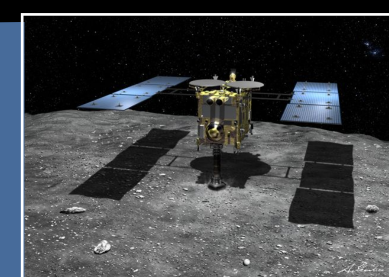
Earth swing-by
Dec. 2015

Subsequent long-term IES operation

Asteroid rendezvous by optical navigation

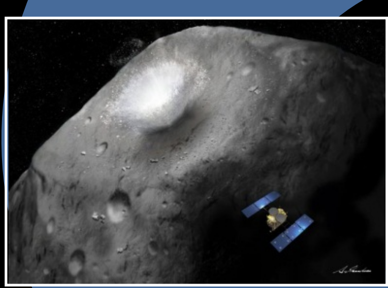
Maintain home position.

Global mapping of asteroid by proximal observations



Landing practice
Lander & rover deployment
Touchdown & sampling

Interim operations (solar conjunction)



Impactor operations (crater creation)

Debris / ejecta avoidance operations

Touchdown in artificial crater

Depart asteroid
Nov - Dec 2019

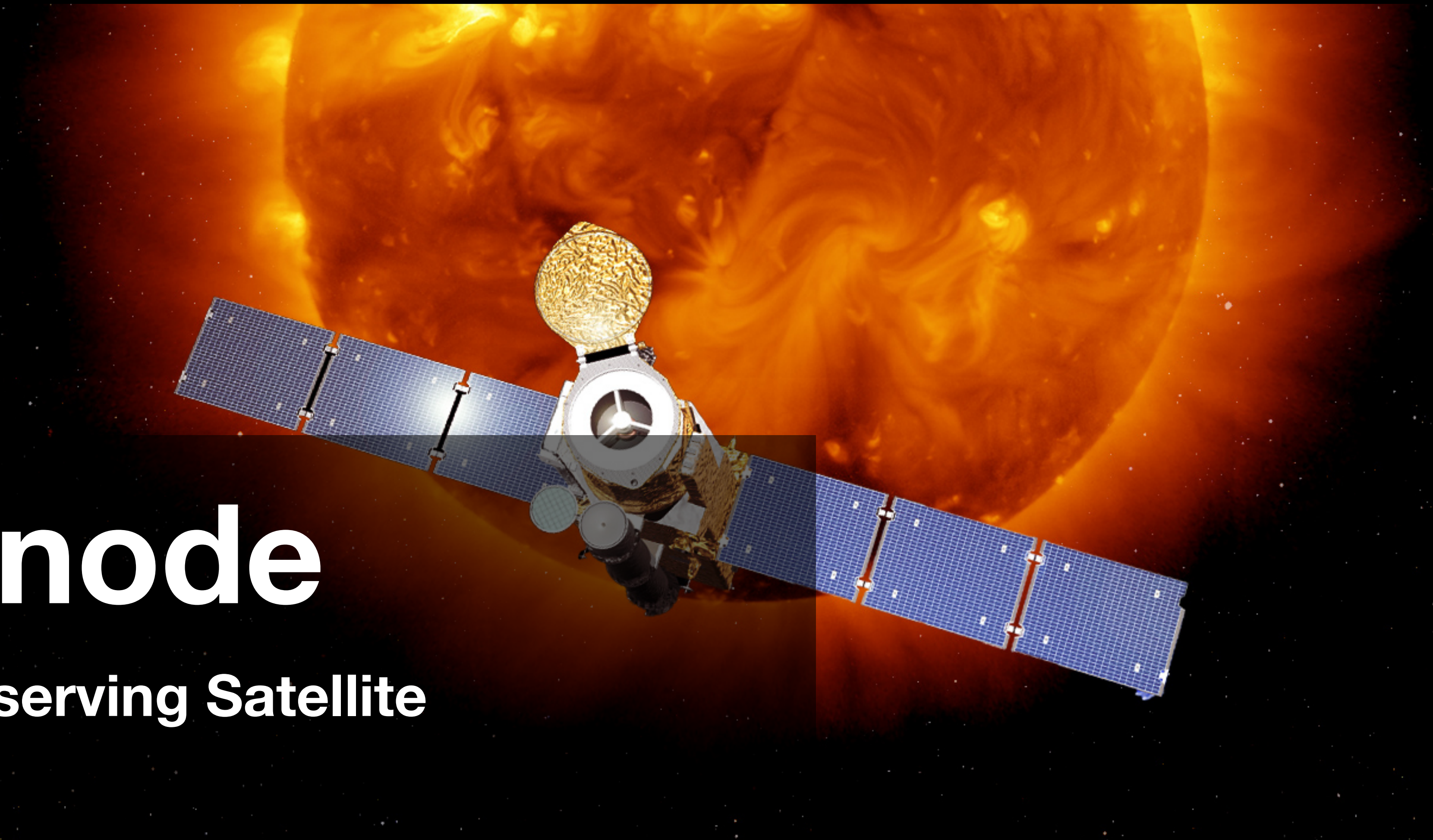
Earth re-entry
End of 2020

Hayabusa2

Year	Day / Month	Operation	Status
2018	10 Jan	Begin 3rd-stage ion engine operation	Complete
	5 June	Ion engine operation ends	Complete
	5 June	Begin asteroid approach (dist. 2,500 km)	Complete
	27 June	Arrive at astroid Ryugu (alt. 20 km)	Complete
	Late July	Medium altitude observation #1 (alt. 5km)	Est.
	August	Gravity measurement decent (alt. 1km)	Est.
	Sept - Oct	Touchdown operation slot #1	Est.
	Sept - Oct	Rover descent operation slot #1	Est.
	Nov - Dec	Solar conjunction (communication unavailable)	Est.
2019	Jan	Medium altitude observation #2 (alt. 5km)	Est.
	Feb	Touchdown operation slot #2	Est.
	Mar - Apr	Crater creation operations	Est.
	Apr - May	Touchdown operation slot #3	Est.
	Jul	Rover descent operation slot #2	Est.
	Aug - Nov	Stay in asteroid vicinity	Est.
	Nov - Dec	Depart astroid	Est.

Hayabusa2

CURRENT



Hinode

Solar Observing Satellite

Hinode is a solar observatory, detecting radiation in the visible, extreme ultraviolet and X-rays to explore phenomena in the solar corona, chromosphere and photosphere.

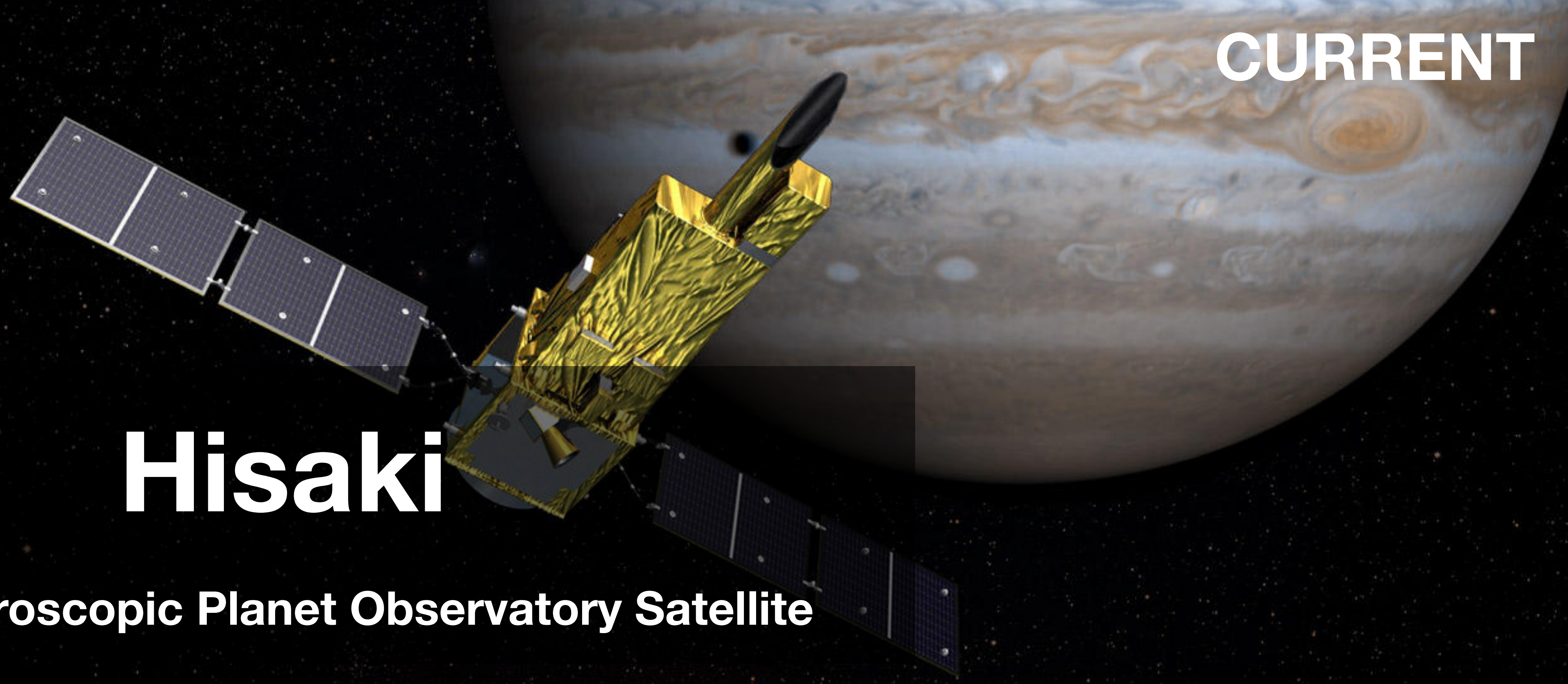
The Sun is the only star in the Universe which we can examine in detail. From a source of energy to potentially devastating solar flares, understanding the Sun is key to the evolution of the Universe and the development of life.

Hinode has a high spatial resolution of 0.2 - 0.3 arc seconds (depending on the observed wavelength), capturing phenomena on the solar surface at scales around 140 - 210 km. The goals of the observatory focus on coronal heating, the driving of the solar wind and solar flares and the generation of the sunspot magnetic field.

JAXA & NAOJ National Astronomical Observatory of Japan collaborative mission

Observations of solar magnetic activity.

Launch: Sept 23, 2006



CURRENT

Hisaki

Spectroscopic Planet Observatory Satellite

Hisaki is the world's first space telescope for remote observation of the Solar System planets from Earth's orbit. The telescope detects extreme ultraviolet radiation to explore processes such as atmospheric loss.

Early in their formation, the Earth, Mars and Venus were likely similar worlds. Yet, now their atmospheres and resulting surface conditions are wildly different. On the other end of the scale, Jupiter has the strongest magnetic field in the Solar System which results in a complex relationship with the planet, its inner moons and the solar wind. Hisaki is observing the atmospheric escape from the terrestrial worlds and the inner magnetosphere of Jupiter to understand planet diversity.

JAXA -led mission

Telescope for remote observations of planetary atmospheres.

Launch: Sept 14, 2013

FUTURE

CAESAR

Comet Astrobiology Exploration SAmple Return

The CAESAR mission in a finalist for the NASA New Frontiers Program to explore the origins of the Solar System by returning a sample of material from Comet 67P to Earth.

Comets are known to carry organic material that could have seeded life on Earth. Whether these compounds formed within the comet or were accreted after formation earlier in the Solar System's history is unknown. A sample of the cometary system could untangle what processes could occur in this cosmic kitchen and what must have occurred elsewhere.

Comets are heavy in easily evaporated compounds such as ices. Preserving these during the 14 year mission is tough challenge, requiring a large and complex sample container. JAXA are designing the capsule that can bring this safely to the Earth's surface.

NASA -led collaboration

Comet sample return.

Sample return capsule provided by JAXA.

Est. launch ~ 2024

Est. return ~ 2038

FUTURE

DESTINY+

Demonstration and Experiment of Space Technology for INterplanetary voYage

DESTINY+ is a proposed mission to make a fly-by observation of the parent body of a meteor shower, performing an in-situ analysis of interplanetary dust generation.

Interplanetary dust particles are one of the main candidates for delivering organic matter to the young Earth. Roughly 40,000 ton/year of cosmic dust is accreted by the Earth, with particles less than 100 microns surviving to the Earth's surface. One source of this dust is active asteroids that produce meteor showers as they pass by the Earth.

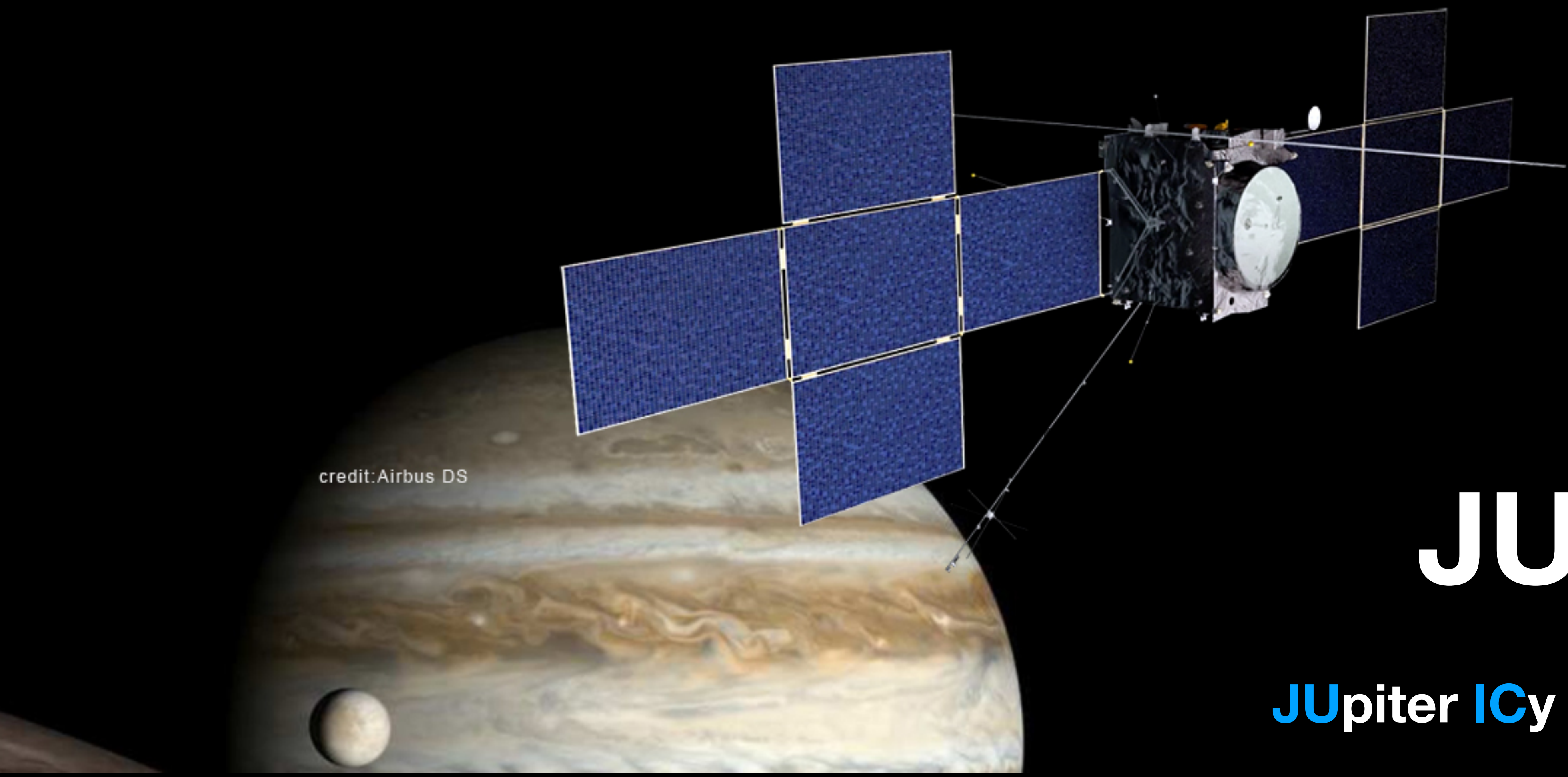
DESTINY+ will visit Phaethon, the parent body of the annual Geminid meteor shower. The spacecraft will characterise the physical properties of the dust, its chemical composition and the dust ejection mechanism.

JAXA -led mission

Fly-by observation of an active asteroid.

Est. Launch: 2022

FUTURE



JUICE

JUpiter ICy moon Explorer

JUICE will explore the three largest Jupiter moons, Ganymede, Europa and Callisto, and orbit Ganymede to study this potential habitat for life beyond the Earth.

With subsurface oceans kept warm enough to stay liquid by the tidal flexing from Jupiter's gravity, the icy moons around our largest gas giant are thought to be one of the best places to find life outside the Earth. JUICE will focus on Ganymede, the largest moon in our Solar System and the only one to generate its own magnetic field.

JAXA researchers are on the science team for two of JUICE's eleven instruments and will provide hardware for three other instruments.

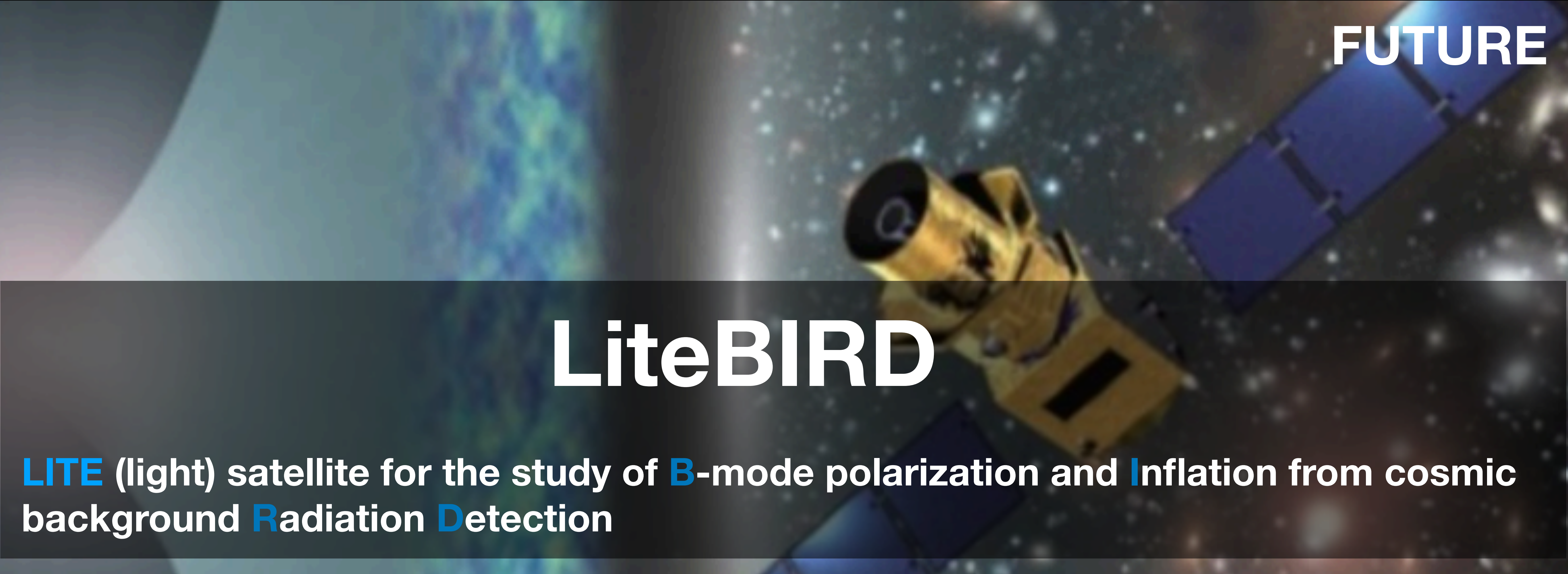
esa -led collaboration

European Space Agency

Icy moon explorer & Ganymede orbiter.

Est. launch ~ 2022

Arrival ~ 2029



FUTURE

LiteBIRD

LITE (light) satellite for the study of B-mode polarization and Inflation from cosmic background Radiation Detection

LiteBIRD is a proposed mission to test models of cosmic inflation by searching for evidence of primordial gravitation waves in the polarisation of the cosmic microwave background.

Within 10^{-38} seconds after the Big Bang, the Universe is through to have undergone a phase of explosive growth known as "cosmic inflation". Models predict the rapid expansion of the Universe during this period gave rise to the existence of primordial gravitational waves. These ripples in space-time should be detectable today as polarisation in the oldest photons of light we can observe: the cosmic microwave background (CMB).

JAXA -led mission

CMB B-mode polarisation mission.

Est. Launch: 2027

LiteBird will perform a full-sky survey the CMB to detect B-mode polarisation over large scales.

The MMX Mission is a journey to the moons of Mars, Phobos & Deimos. The proposed mission will explore the environment surrounding Mars and return a sample to Earth from Phobos.

The formation of the Martian moons is a long standing mystery. Their shape and spectra are similar to D-type asteroids, suggesting the small moons could be captured objects. However, their low inclination and orbit indicate the moons formed together from material ejected from Mars during a giant impact. Analysis of the moon composition should differentiate between these formation mechanisms.

The spacecraft will include an high resolution infrared mass spectrometer (MacrOmega) designed by CNES and a Gamma ray and neutron spectrometer (MEGANE) deigned by NASA / APL.

JAXA -led mission

Sample-return to the moons of Mars.

Est. launch ~ 2024
Est. return ~ 2029

FUTURE

OKEANOS

Outsized Kite-craft for Exploration and AstroNautics in the Outer Solar system

OKEANOS is a solar powered sail mission to rendezvous and land on a Jupiter Trojan asteroid.

OKEANOS is the successor to IKAROS, the 14m solar sail mission that demonstrated the feasibility for interplanetary travel using the push from the Sun's photons. OKEANOS will use a 40 meter-square thin-film solar sail and ion engine propulsion to travel to the outer Solar System without the use of a radioisotope thermoelectric generator (RTG).

The Jupiter Trojans follow and precede Jupiter on its orbit around the Sun and are considered to be rich in ices and organics. However, their origin and evolution remains unknown, making their exploration important for understanding Solar System evolution.

JAXA -led mission

Solar sail mission to the Jupiter Trojan asteroids.

Est. Launch: 2026

Est. Arrival: 2050s

FUTURE

SLIM

Smart Lander for Investigating the Moon

SLIM is a mission to demonstrate pinpoint landing techniques for small spacecraft on the surface of the moon.

High precision landing will be indispensable for future lunar and planetary exploration. As our knowledge has grown about the celestial bodies in our Solar System, the need to land in a very precise location has increased. Moreover, there is the continual need in space exploration to reduce the weight of spacecraft to allow greater resources for scientific instruments. SLIM therefore aims to demonstrate both precision landing and a lightweight system to meet the future needs in exploration.

JAXA -led mission

Small scale demonstration lunar lander.

Launch: TBD

FUTURE

SPICA

SPace Infrared telescope for Cosmology and Astrophysics

SPICA is a proposed infrared space telescope to study the spread of heavy elements. Starting with the creation of metals and dust in the first galaxies, SPICA will explore the impact on the production of stars and down to the formation and dispersal of protoplanetary discs.

SPICA will use mechanical cryocoolers developed at JAXA to keep the 2.5m mirror at just 8K, making SPICA the largest cold telescope ever constructed. As a result, SPICA is expected to be more than 100 times more sensitive that previous IR observatories.

The two main instruments on SPICA are the mid-infrared SMI (developed at JAXA) and long-infrared SAFARI (developed by an international consortium).

esa -led collaboration
European Space Agency

2.5m infrared telescope (17 - 230 microns)

Cooled ~8K

Est. launch ~ 2030

FUTURE

XRISM

X-Ray Imaging Spectroscopy Mission

XRISM is a space telescope to explore the Universe at X ray wavelengths. XRISM will explore extended sources of X rays, such as the hot gas within galaxy clusters.

XRISM is the recovery mission for ASTRO-H, which was lost one month after launch in 2016. The telescope will carry a replica of the SXS (Soft X-ray Spectrometer) that flew on ASTRO-H. Before its loss, the SXS presented tantalising evidence that the hot gas within clusters of galaxies is far less turbulent that expected, raising questions as to what keeps this medium hot enough to emit the very short wavelength X rays.

The SXS is developed in close collaboration with NASA, who have designed both the instrument sensors and part of the cooling system for the instrument.

JAXA -led mission

X-ray space telescope.

Est. Launch: early 2020s

The ITYF was established at ISAS/JAXA as a prestigious fellowship program to attract outstanding, highly motivated, early-career researchers in any of the space science fields covered by ISAS, namely:

Structure and origin of the Universe
Formation of the Earth and Solar System
Utilization of the space environment for microgravity experiments
Engineering and technology development for the exploitation of space.

Fellowships last for 3 years (extendable to 5) in Japan and include an excellent remuneration package, including a research budget to ensure the fellow can extend their international profile as well as develop collaborations within Japan.

There a spring and fall call for applicants with deadlines May 31st and October 31st, respectively. See http://www.isas.jaxa.jp/en/researchers/ityf/ for more information.