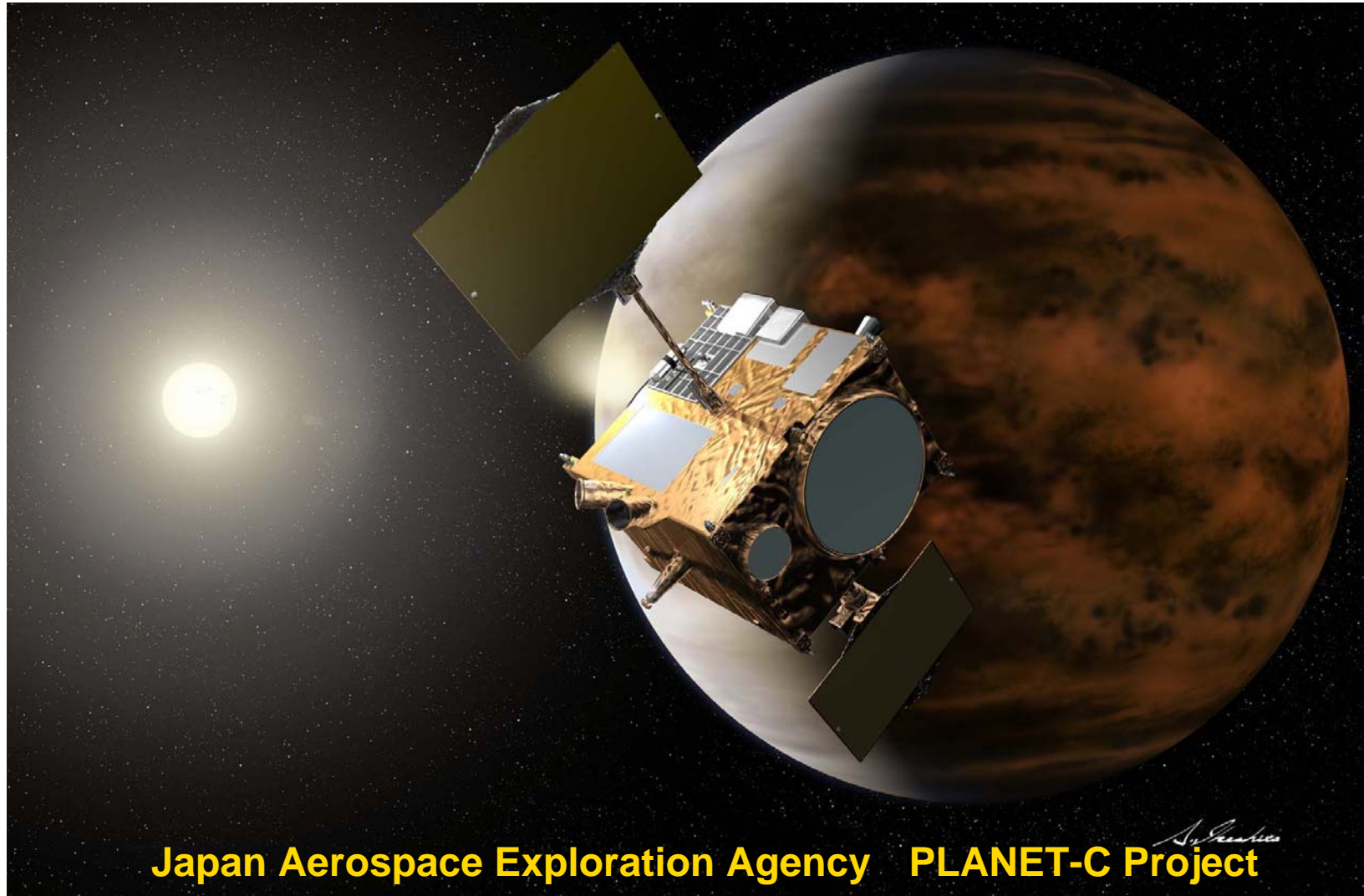




Venus Climate Orbiter "AKATSUKI"

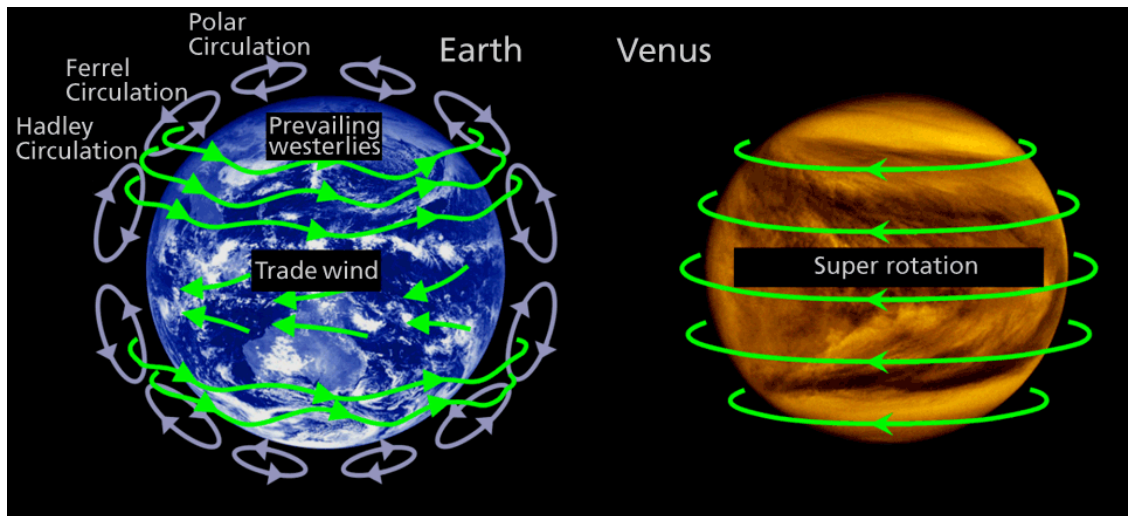


Japan Aerospace Exploration Agency PLANET-C Project *S. Kawakita*



Overview of the AKATSUKI

- ❖ Japan's first Venus explorer
- ❖ Scientific purpose
To understand the evolution of the climate of Venus, Earth's sister planet, by studying the overall movement of the Venus atmosphere.
- ❖ Launch in May 2010
Arrive at Venus in Dec. 2010



Venus

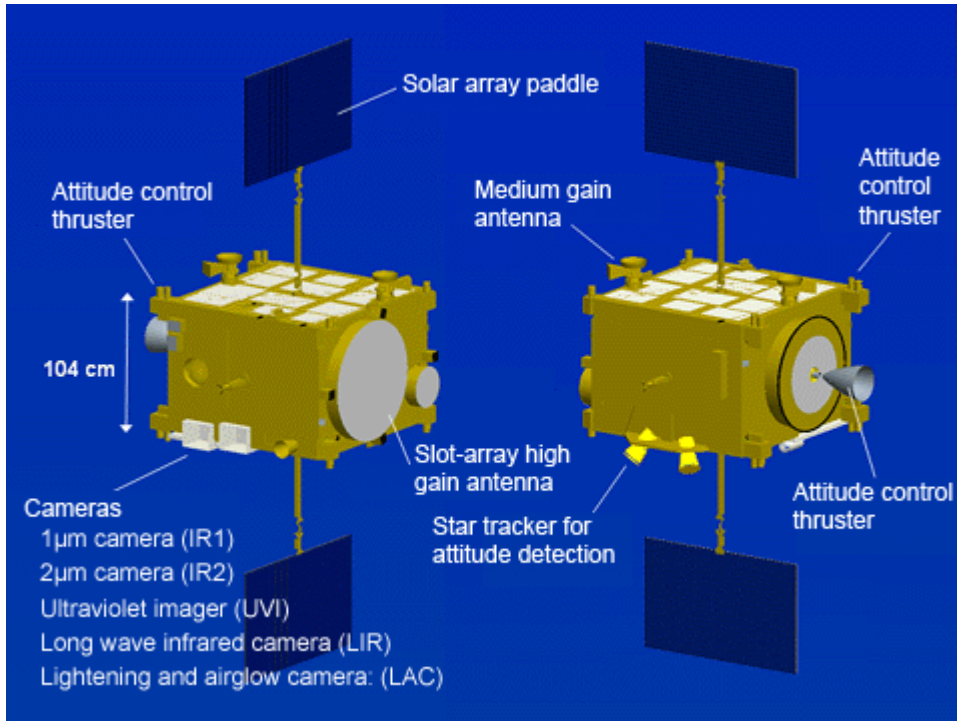
Venus has been well known as the “morning bright star” and “evening bright star” since ancient times, and its size and mass are most similar to the Earth.

However, its environment is quite different from that of the Earth. Venus is covered by a thick carbon dioxide atmosphere and sulfuric acid clouds with extremely strong winds of 100 meters per second called “super rotation.”

- Why does super rotation occur?
- How does the meridian-plane circulation work?
- How are clouds formulated?
- Do lightning and thunder occur?
- Are there active volcanoes?



Characteristics of AKATSUKI



Major characteristics	
Shape/Size	Box shape with two wing-type solar array paddles (1.04 m x 1.45 m x 1.40 m)
Scheduled orbit	Venus elliptical orbit Peri-Venus altitude: 300 km Apo-Venus altitude: about 80,000 km Orbit period: 30 hours Orbit inclination angle: 172 degrees
Design life	About two Earth years after arriving at Venus
Mass	About 500 kg at the time of liftoff
Generated Power	About 500 w in the Venus orbit (at the end of the mission)

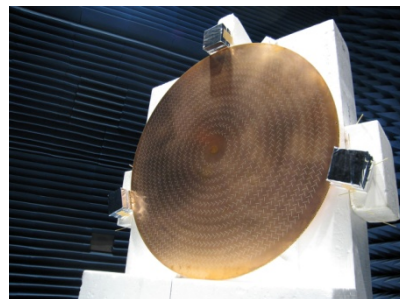
New technologies adopted to AKATSUKI



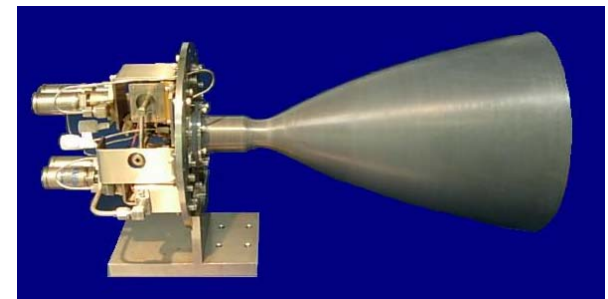
Regenerative ranging transponder



Lithium-ion battery



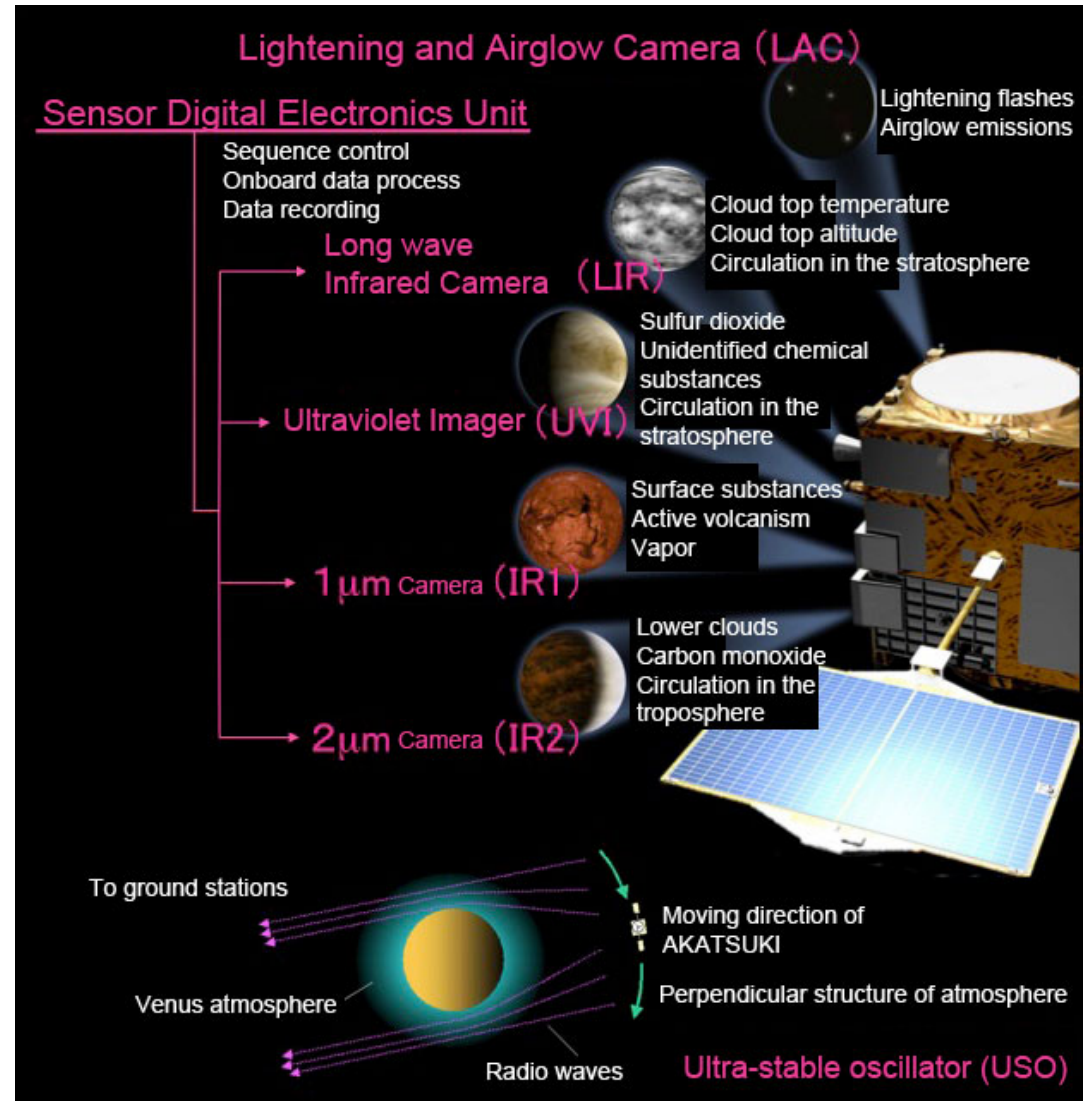
High-gain flat-type RLSA antenna



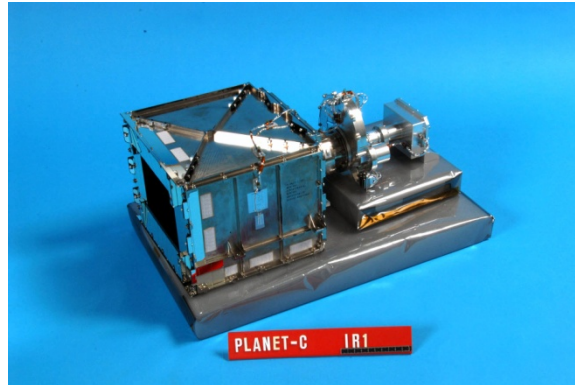
Ceramic thruster

AKATSUKI Onboard Observation Devices

- ❖ AKATSUKI is equipped with six observation devices
 - Five observation cameras that can capture various wave lengths ranging from ultraviolet to long-wave infrared (IR1, IR2, LIR, UVI, and LAC)
 - Basic signal source for radio occultation measurement (USO)
- ❖ Four cameras and their data except LAC are controlled, processed and recorded by the Sensor Digital Electronics Unit (DE, a comprehensive mission system computer.)
- ❖ Compared to the satellite mass of about 500 kg, the total mass of six observation devices and DE is only about 37 kg.



1 μ m Camera (IR1)



PI: Naomoto Iwagami (University of Tokyo)

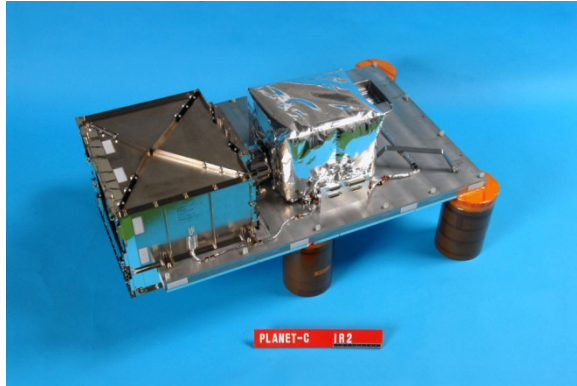
- ❖ With wavelength of around 1 μ m which enables it to penetrate through Venus clouds to the ground, the IR1 will study cloud movement in the lower atmosphere, distribution of vapor, mineral composition on the ground and existence of active volcanism.



1 μ m Camera (IR1)	
Mass	About 6.7 kg*
View	12 degrees
Detector	Si-CSD/CCD (1024 pixel x 1024 pixel)
Observation wavelength (Observation targets)	1.01 μ m (Night: ground surface, clouds)
	0.97 μ m (Night: vapor)
	0.90 μ m (Night: ground surface, cloud)
	0.90 μ m (Day: clouds)

* Including the circuit part (about 3.9 kg) shared with IR2

2 μ m Camera (IR2)



PI: Takehiko Sato (ISAS/JAXA)

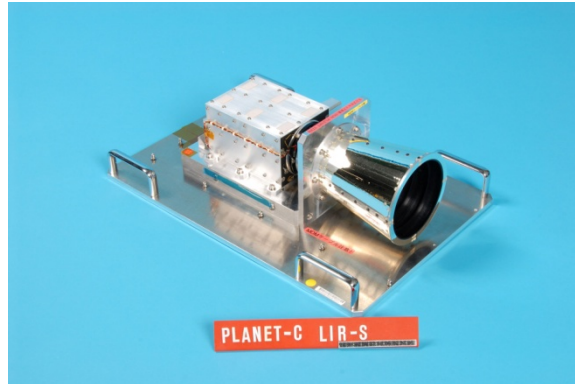
- ❖ With wavelength of around 2 μ m which enables to see through Venus clouds, the IR2 acquire basic data of circulation in the lower atmosphere and cloud physics based on its observations of cloud concentration, size of cloud particles, and distribution of carbon monoxide.
- ❖ During its trip from the Earth to Venus, it also observes zodiacal light to clarify the behavior of interplanetary dust clouds.



2 μ m Camera (IR2)	
Mass	About 18 kg*
View	12 degrees
Detector	PtSi-CSD/CCD (1024 pixel x 1024 pixel)
Observation wavelength (Observation targets)	1.735 μ m (Night: clouds, particle size distribution)
	2.26 μ m (Night: clouds, particle size distribution)
	2.32 μ m (Night: carbon monoxide)
	2.02 μ m (Day: cloud top altitude)
	1.65 μ m (Zodiacal light)

* Including a freezer and the circuit part (about 3.9 kg) shared with IR2

Long wave IR camera (LIR)



PI: Makoto Taguchi (Rikkyo University)

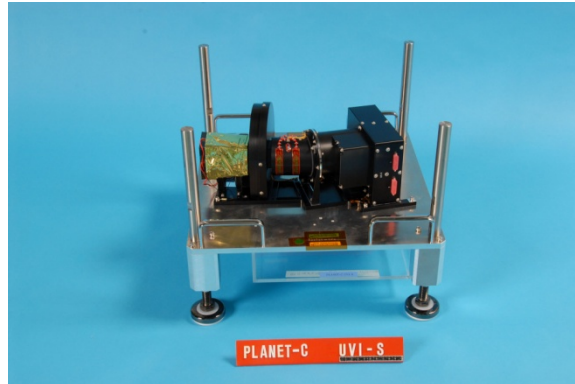
- ❖ By translating cloud temperatures into images using infrared of $10 \mu\text{m}$ in wavelength, the LIR clarifies wave motion and convection current motion in stratus and wind speed distribution at a cloud top altitude on the night side.



Long wave IR camera (LIR)

Mass	About 3.3 kg
View	12 degrees
Detector	Uncooled bolometer (320 pixel x 240 pixel)
Observation wavelength (Observation targets)	$10 \mu\text{m}$ (Day/Night: cloud top temperature)

Ultraviolet Imager (UVI)



PI: Shigeto Watanabe (Hokkaido University)

- ❖ By capturing ultraviolet radiation, the UVI observes sulfur dioxide which relates to the formation of clouds and unidentified chemical substances that absorb ultraviolet wavelengths, then, through the changes of sulfur dioxide and chemical substances, we will clarify wind speed distribution at a cloud top altitude.



Ultraviolet Imager (UVI)

Mass	About 4.1 kg
View	12 degrees
Detector	Si-CCD (1024 pixel x 1024 pixel)
Observation wavelength (Observation targets)	283 nm (Day: sulfur dioxide at cloud top) 365 nm (Day: unidentified absorbent)

Lightening and airglow camera (LAC)



PI: Yukihiro Takahashi (Hokkaido University)

- ❖ The LAC observes faint light called airglow emitted from oxygen in the upper atmosphere at an altitude of about 100 km by visible spectrum to translate changes of day and night circulation and atmospheric wave into images.
- ❖ It will also clarify if lightening flashes of lightening discharge exists in Venus by high-speed exposure of 30,000 times per second (32 μ sec temporal resolution.)



Lightening and airglow camera (LAC)	
Mass	About 2.3 kg
View	16 degrees
Detector	8 x 8 APD matrix array
Observation wavelength (Observation targets)	777.4 nm (Night: lightening flashes of lightening discharge)
	480-650 nm (Night: oxygen molecular airglow)
	557.7 nm (Night: oxygen atom airglow)
	545 nm (For calibration)



Ultra-stable oscillator (USO)



PI: Takeshi Imamura (ISAS/JAXA)

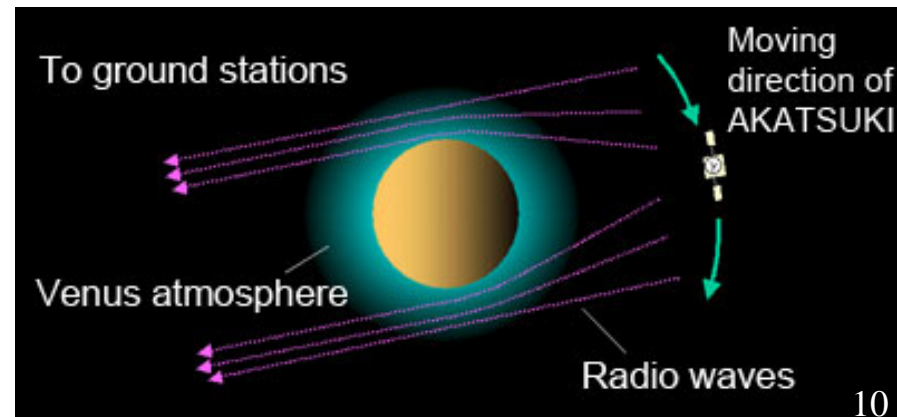
- ❖ The USO is onboard for radio occultation measures. It will acquire information on the thermal structure and perpendicular transmission wave of the Venus atmosphere by understanding altitude distribution of temperatures based on changes in frequency and intensity of radio waves emitted from PLANET-C to the ground through the Venus atmosphere.



The USO is installed in the inside of the satellite.

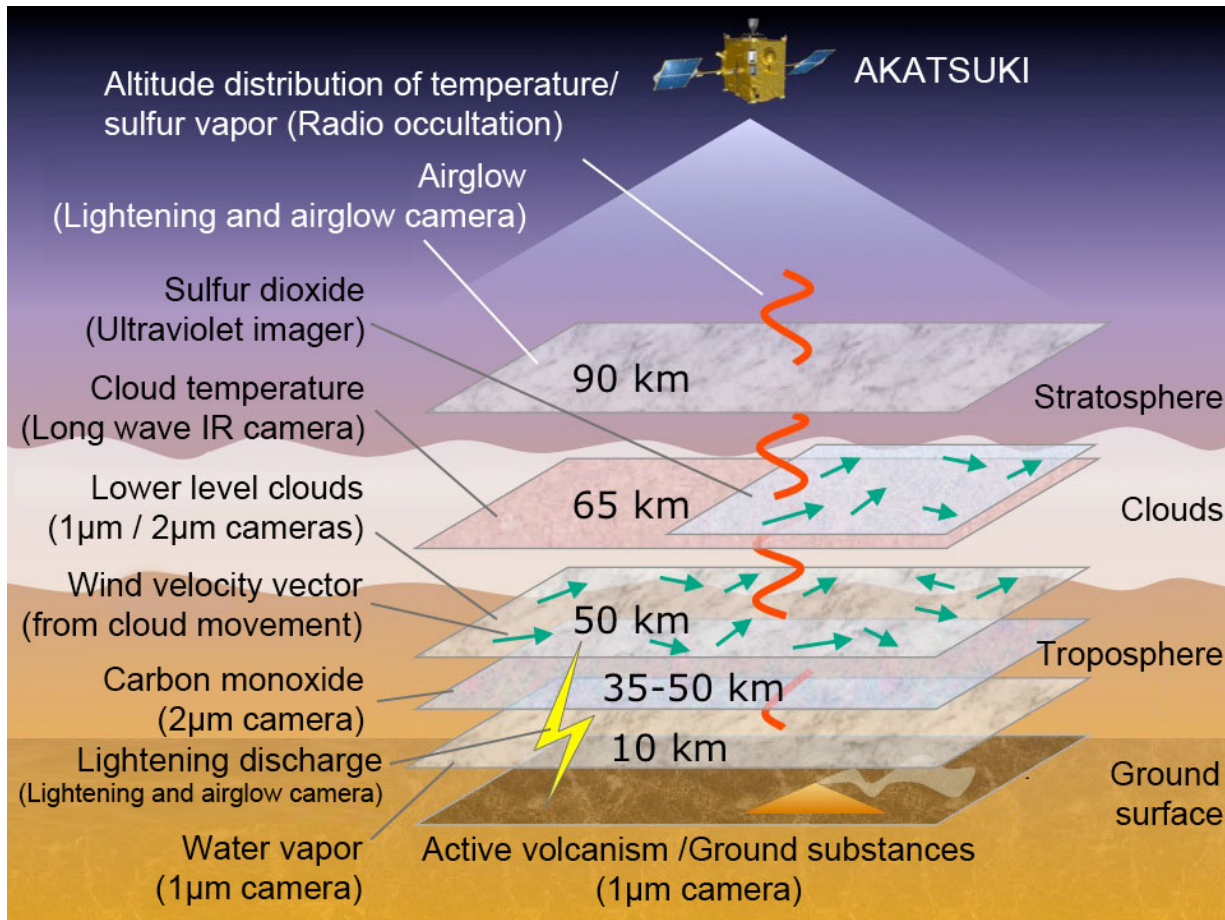
Ultra-stable oscillator (USO)	
Mass	About 2 kg
Observation wavelength (Observation targets)	USO frequency 38 MHz Transmission frequency 8.4 GHz (Temperature, sulfuric vapor, electron density)

Image of radio occultation measures



AKATSUKI Scientific Goal

By remote sensing from the Venus orbit, the AKATSUKI aims at taking images of three-dimensional movement inside the thick Atmospheric layer.



Three-dimensional image of AKATSUKI observation

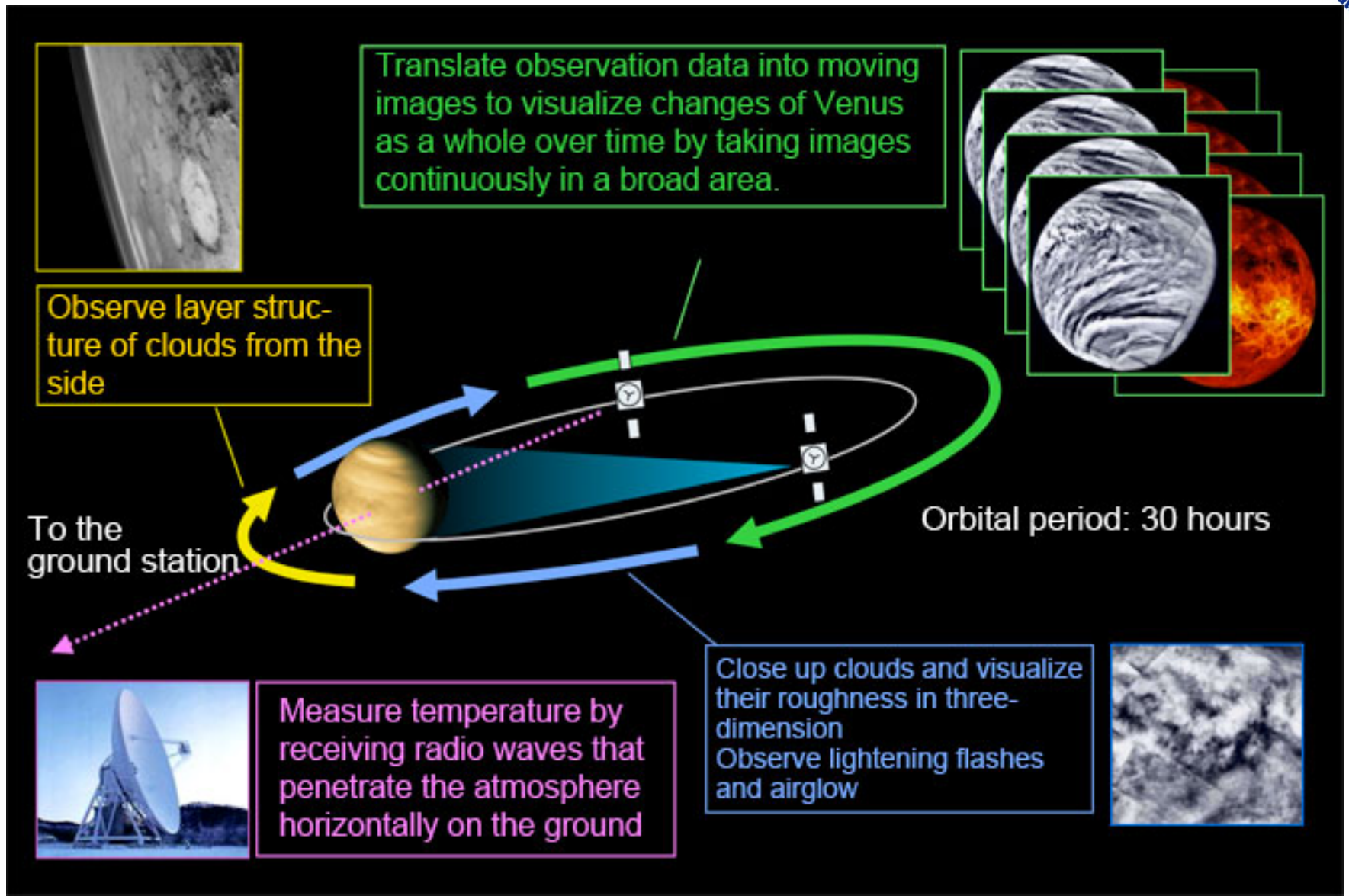
Research topics

To clarify the following:

- ❖ Comprehensive observation of wave motions and turbulent currents, and their contribution to the super rotation.
- ❖ Structure of the meridian-plane circulation
- ❖ Substance circulation in the cloud layer and its role in maintaining the cloud layer
- ❖ Time and space distribution of lightning discharge and its generation process
- ❖ Time and space distribution of airglow and upper layer atmospheric circulation



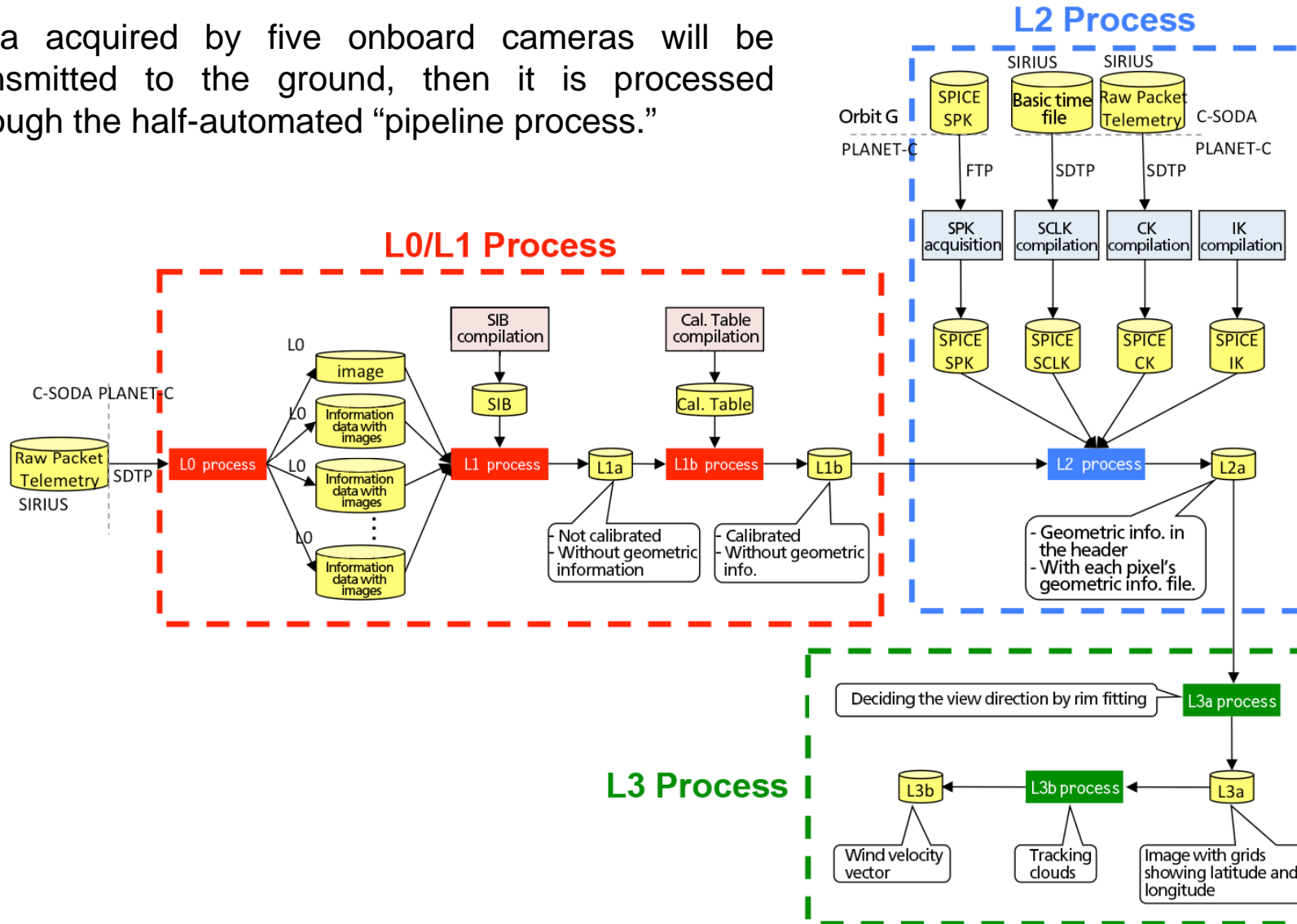
AKATSUKI Observation Plan





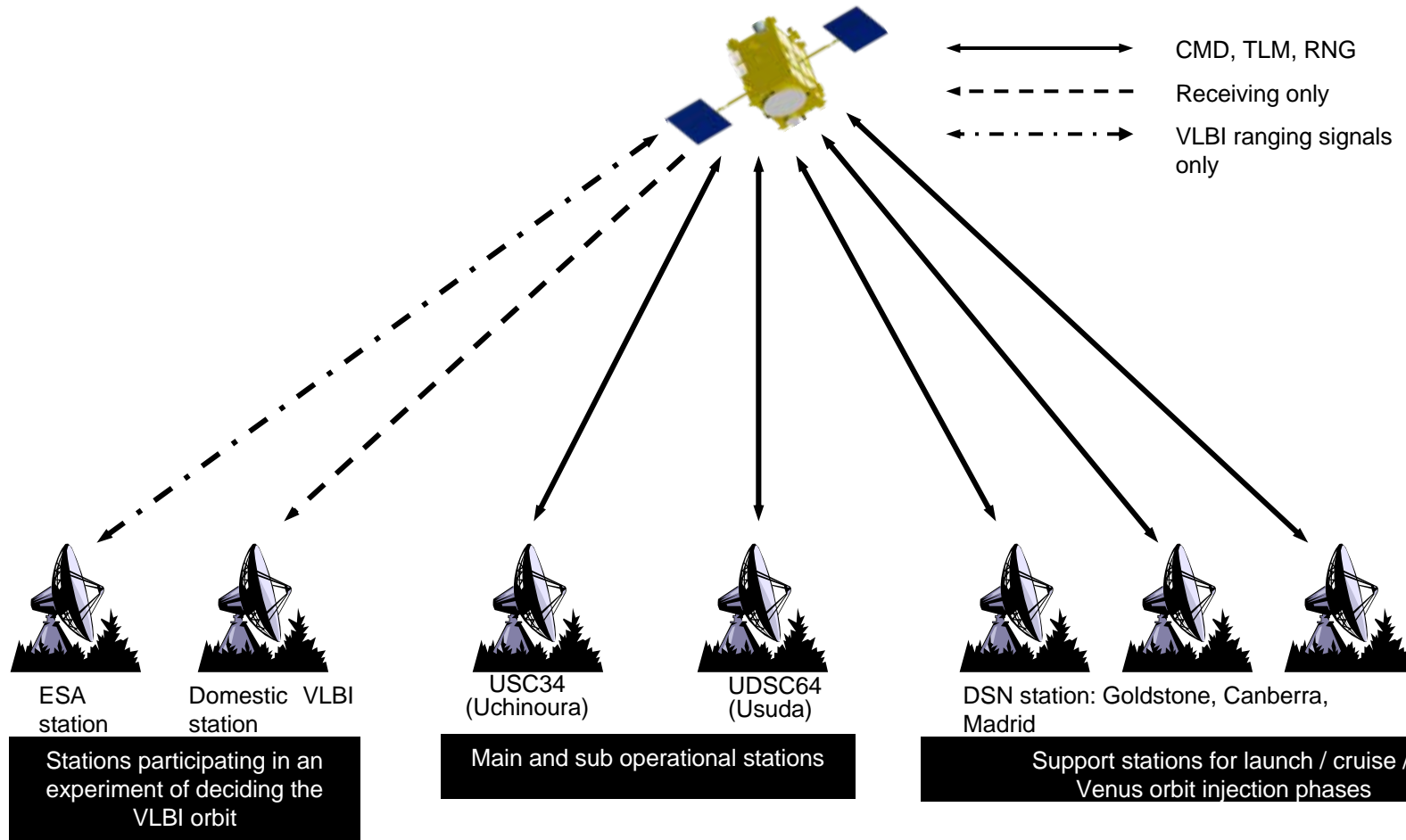
Pipeline for Image Data Processing

Data acquired by five onboard cameras will be transmitted to the ground, then it is processed through the half-automated "pipeline process."





AKATSUKI Operation Stations





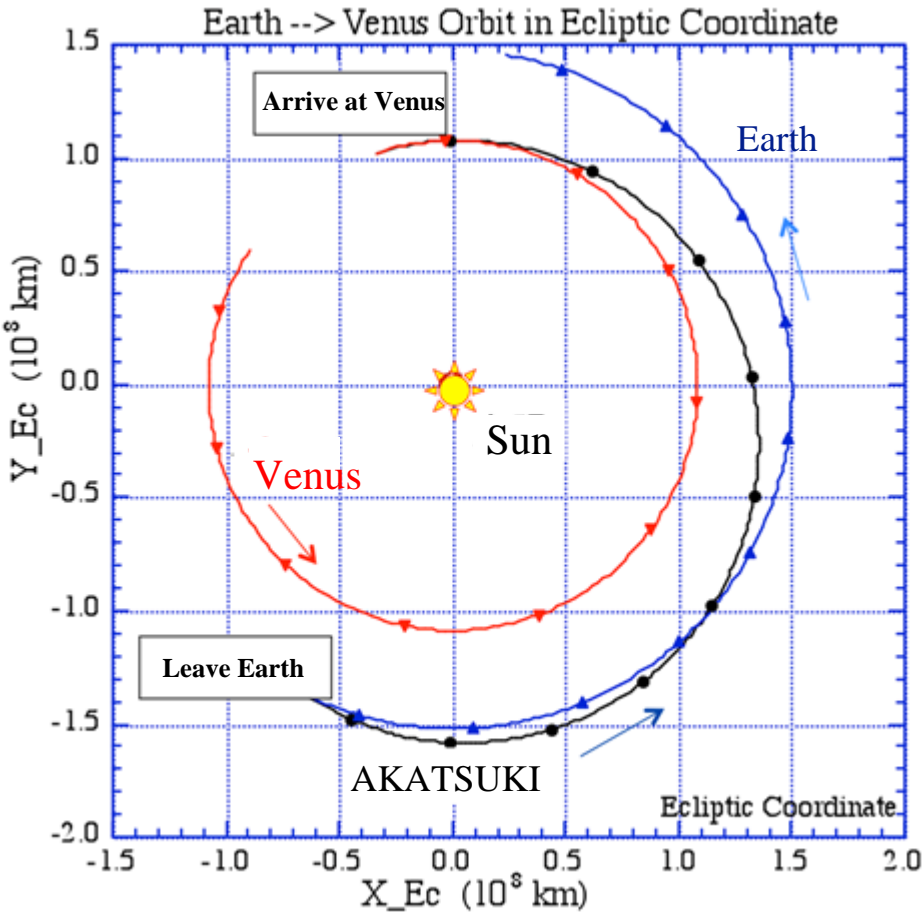
Launch Site Operation Schedule

Day	Operation	
March 19	AKATSUKI delivery	AKATSUKI to be transported to the Tanegashima Space Center
March 30/31	Detailed electric test	Final electric verification to confirm onboard device operation
April 2	Dress rehearsal	Confirm the launch operation including the ground systems
April 27	Final visual inspection	Final visual inspection before launch
April 30	Mating with the payload attach fitting (PAF) and payload support structure (PSS)	AKATSUKI to be attached to the PAF, then to be loaded onto the PSS, on which small secondary satellites are loaded.
May 4	AKATSUKI fairing encapsulation	AKATSUKI to be encapsulated in a fairing
May 9	AKATSUKI loading onto H-IIA	Encapsulated AKATSUKI to be loaded onto the H-IIA Launch Vehicle
May 18	Launch	Launch at 6:44:14 a.m. (Japan Standard Time)
(Launch window: until June 3, launch time will be different day by day.)		

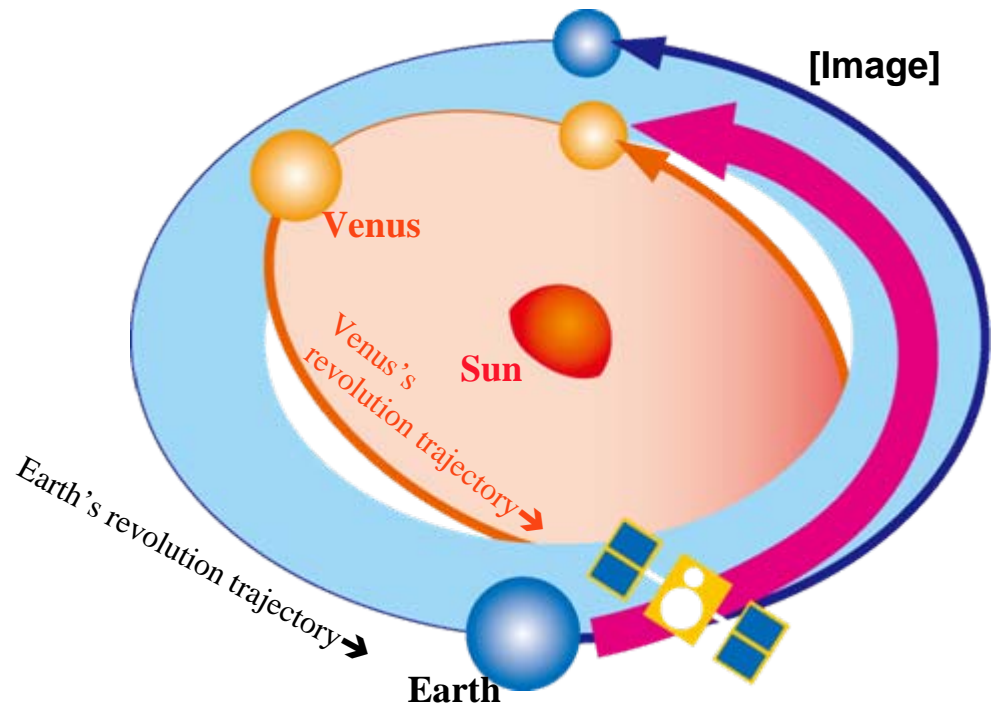
* The above schedule is subject to change due to operational progress.



Trip to Venus



- ❖ Venus's plane of revolution trajectory is tilted by 3 degrees.
- ❖ AKATSUKI launched from the Earth will fly to Venus along the Earth's plane of revolution trajectory.
- ❖ AKATSUKI can reach Venus with a small amount of energy because Venus is on the Earth's revolution trajectory plane when AKATSUKI comes closer to Venus.



- ❖ Launch in May 2010
→ Arrive at Venus in Dec. 2010



Post Launch Operation Schedule

Operation schedule after launch

- ❖ About 0.5 days after launch: First visible opportunity (check the satellite status)
 - ❖ About 1.5 days after launch: Second visible opportunity
 - ❖ About 2.5 days after launch: Third visible opportunity
 - ❖ While traveling to Venus orbit: Observing zodiacal light by $2 \mu\text{m}$ camera (IR")
 - ❖ Early December: To be injected into the Venus orbit
 - ❖ January 2011: Regular operation starts
- } try to take images of the Earth

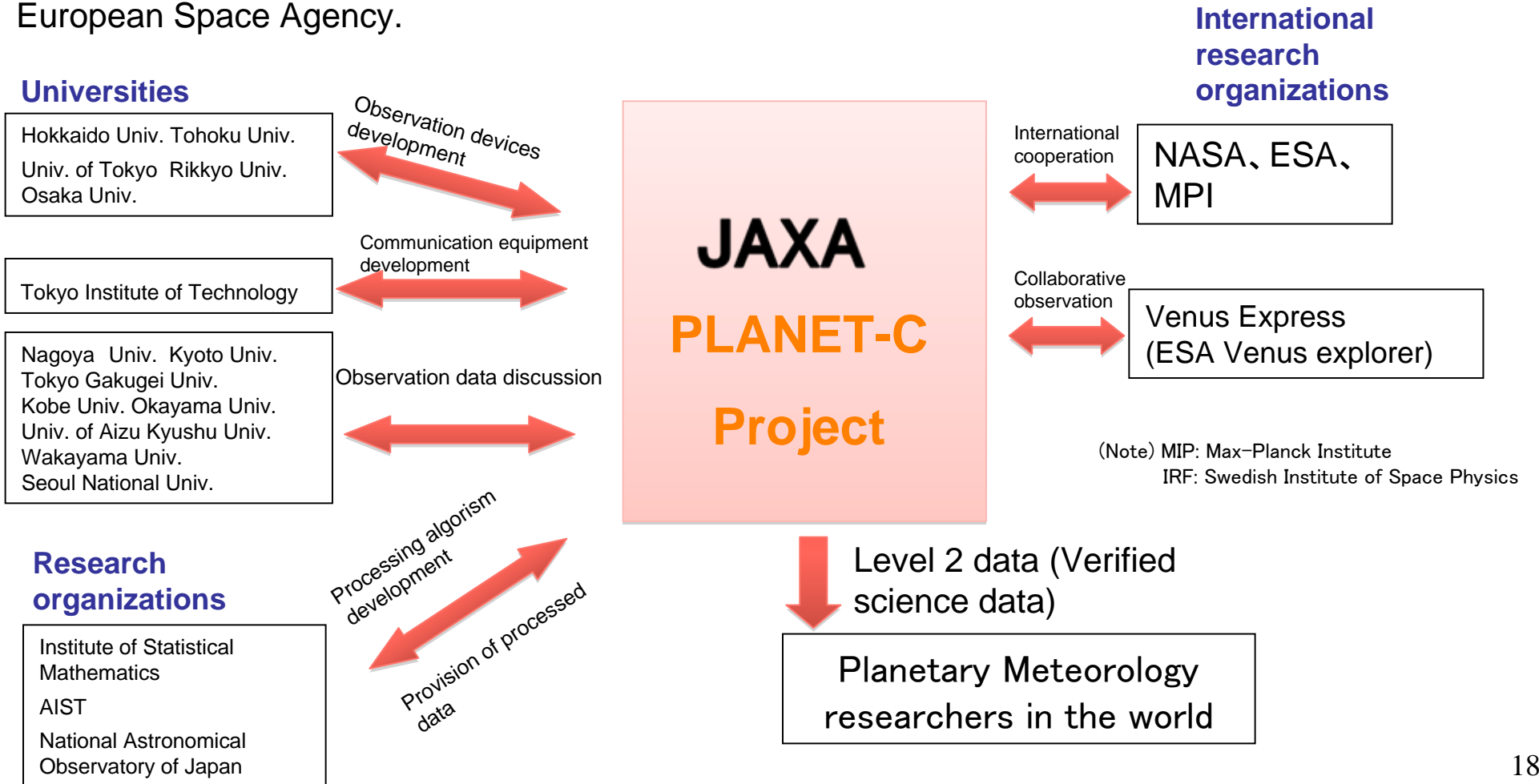
For more information about Venus Climate Orbiter "AKATSUKI"

- ❖ Special Site :
http://www.jaxa.jp/countdown/f17/index_e.html
- ❖ AKATSUKI Project Site:
http://www.stp.isas.jaxa.jp/venus/top_english.html
(Mission introduction, Scientific explanation of Venus, Project's latest information)



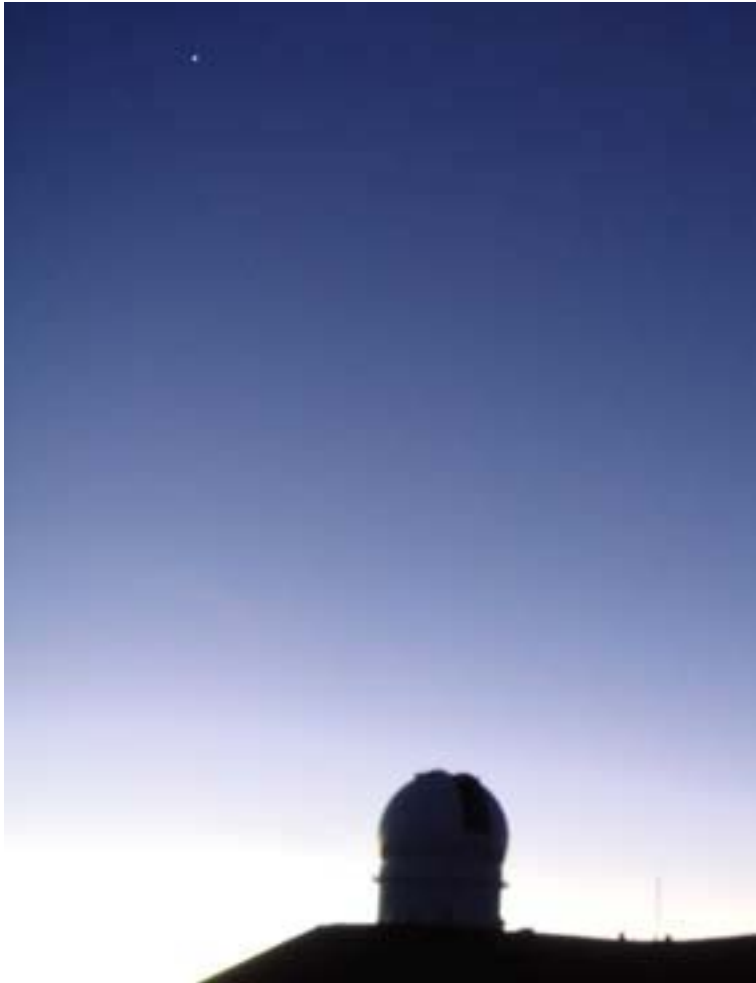
Development Organization – Domestic and International Cooperation

JAXA has been proceeding with this project through collaboration with domestic universities and research institutes while maintaining strong promotional and cooperative ties with the Venus Express (Venus exploration) mission of the European Space Agency.





Nickname "AKATSUKI"

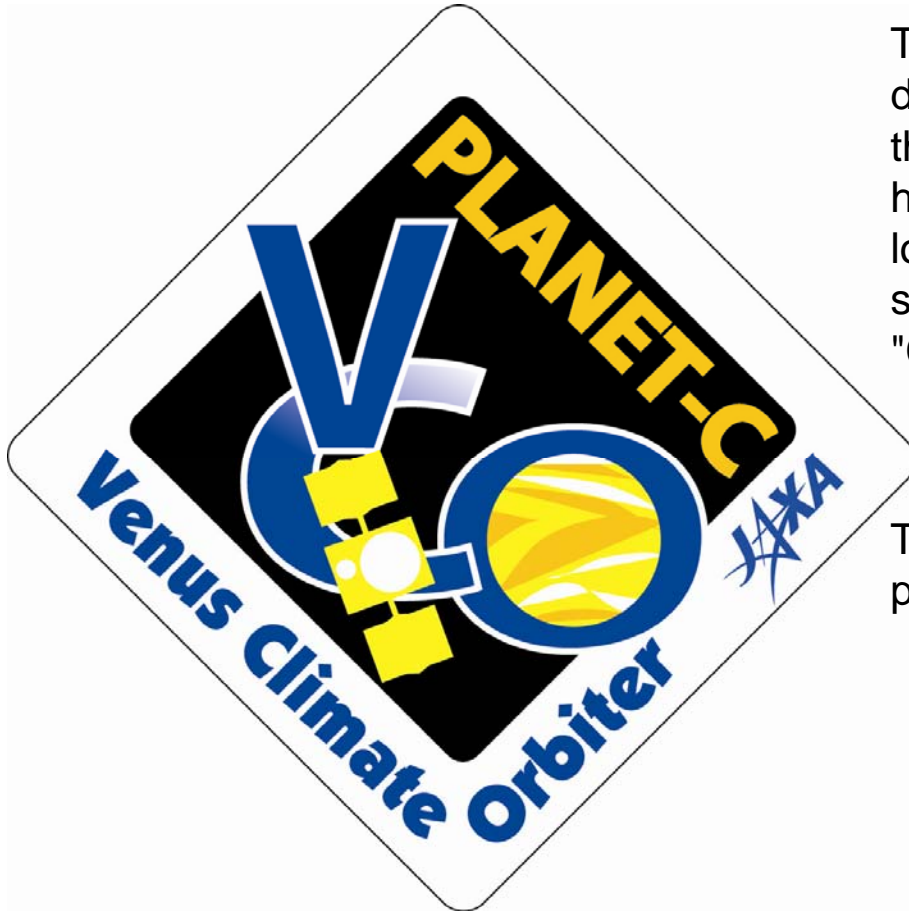


The nickname has been studied and decided among the project team who has been involved in the development of the explorer. It was announced on October 23, 2009, well before its launch, in order for people to feel familiar with the explorer.

- ❖ "AKATSUKI" means dawn or daybreak, when Venus shines most beautifully in the first graying of the east sky. The Venus Climate Orbiter "AKATSUKU" will arrive at Venus, the morning bright star in the dawn, in the winter of 2010.
- ❖ The name also matches with the image of newly creating a field of planetary meteorology through this exploration.
- ❖ The word "AKATSUKI" also implies not only the beautiful daybreak scenery, but also power to achieve a goal, thus the name reflects the determination and eagerness for the mission's success.

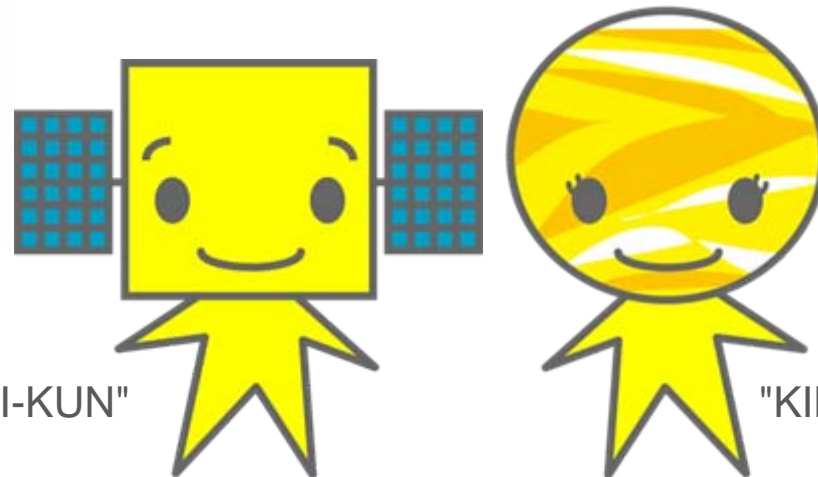


Mission Logo



The mission logo mark of the "AKATSUKI" was designed by reflecting its original nickname, "VCO," the abbreviation of the Venus Climate Orbiter, which has been used since the initial study phase. In the logo, the AKATSUKI is flying over Venus, which is shown by "O" in the drawing, on an orbit depicted by "C." It was designed by the AKATSUKI project team.

Two mascot characters were also introduced for people to feel more familiar with the AKATSUKI.



"AKATSUKI-KUN"

"KINSEI-CHAN"

"AKATSUKI" Message Campaign

❖ Campaign Overview

"We will deliver your message to the brightest morning star Venus"

JAXA held the "AKATSUKI Message Campaign" in order to enhance people's understanding of the Venus Climate Orbiter "AKATSUKI" and JAXA activities, to make people feel more interested in the exploration to the solar system, and to improve recognition of JAXA both in Japan and abroad. In the campaign, we invited people to send us messages that would be placed aboard the AKATSUKI.

- Campaign Period

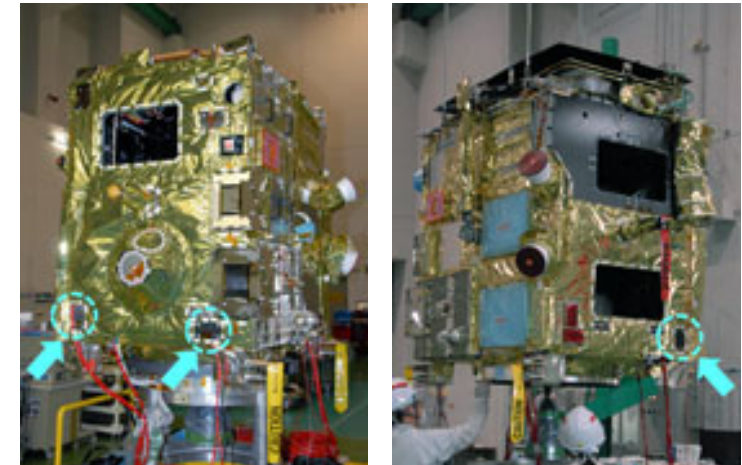
October 23 (Fri.) 2009 thru January 10 (Sun.) 2010

➔ About 260,000 people sent messages.



Messages and names were printed on aluminum plates and loaded onto the AKATSUKI. They will travel to Venus.

Aluminum plates printed with names and messages



Loading position of Aluminum plates (Three locations)