CanSat & Rocket Experiment(‘99～)

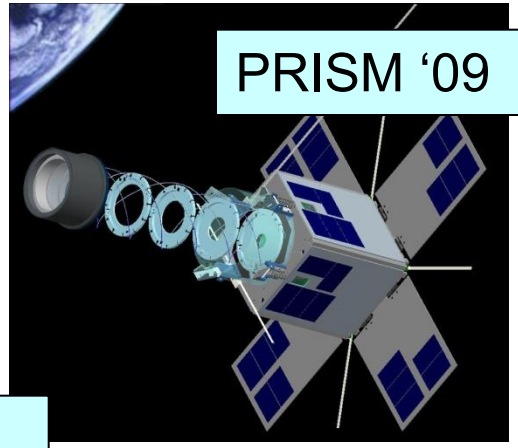
Hodoyoshi-1 ‘14

Overview of Micro/nano/pico-satellite

Part 1

Shinichi Nakasuka
University of Tokyo

CubeSat 03,05

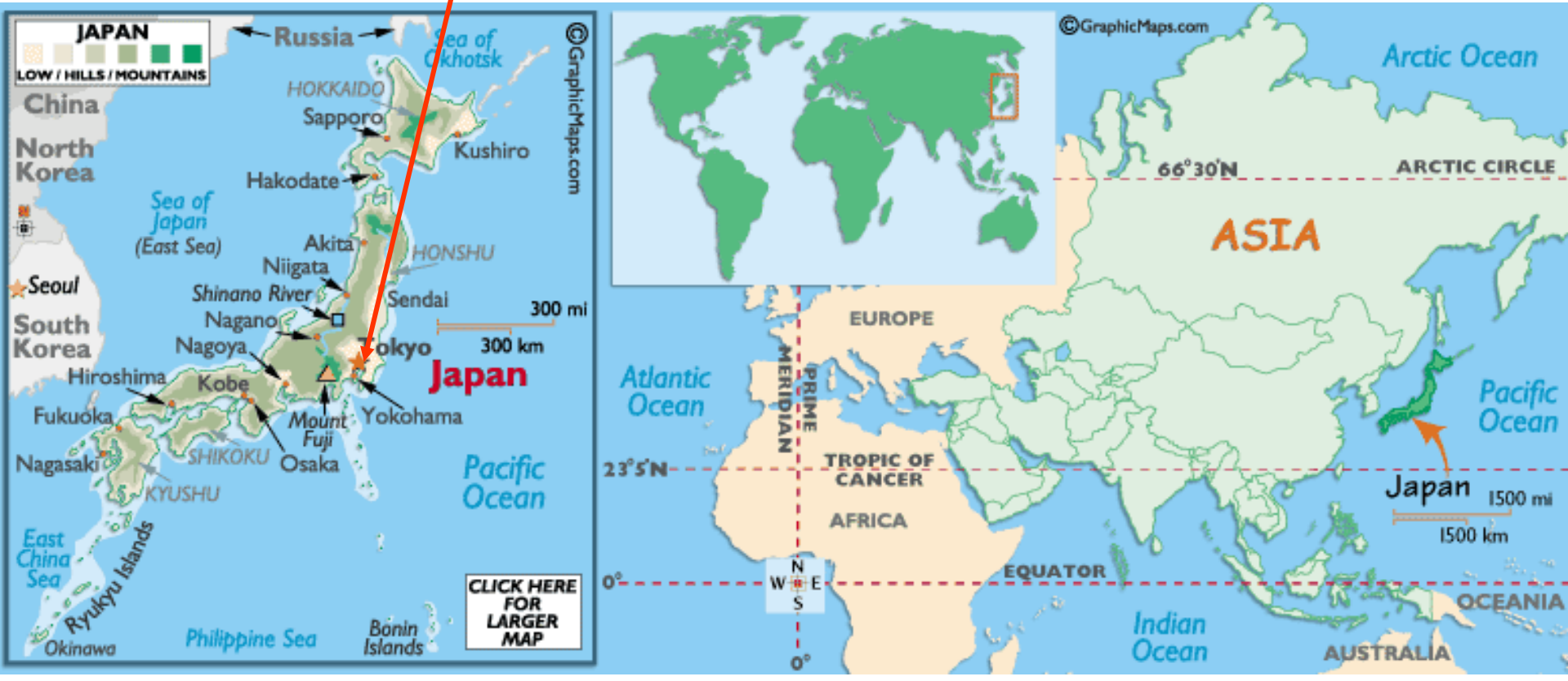


PRISM ‘09

Nano-JASMINE (TBD)

Where is Our University ?

- University of Tokyo: 28,000 students, 7800 staffs
  - School of Engineering: 22 departments
    - Intelligent Space Systems Laboratory



Statistics about University of Tokyo

- The University of Tokyo
  - Established in 1886
  - 11 Faculties/Graduate Schools
  - 14000 undergraduate/14000 graduate students
  - 3900 academic staffs/ 3900 supporting staffs
  - **World QS ranking: 23th**

- School of Engineering
  - 1050 undergraduate students/year
  - 2053 master student/1066 Ph.D candidate
    - Including 921 foreign students from 74 countries
  - 453 academic staffs/ 206 supporting staffs
  - Yearly budget: about $ 250M
  - **World QS ranking: 8th**
    - **Mechanical/Aerospace: 9th ranking**

Graduate School of Engineering

18 Departments, 2 Institutes, 7 Centers

- Civil Engineering
- Architecture
- Urban Engineering *3
- Mechanical Engineering
- Aeronautics and Astronautics
- Precision Engineering
- Electrical Engineering and Information Systems
- Applied Physics
- Systems Innovation
- Materials Engineering
- Applied Chemistry
- Chemical System Engineering
- Chemistry and Biotechnology
- Advanced Interdisciplinary Studies *1
- Nuclear Engineering and Management
- Bioengineering
- Technology Management for Innovation
- Nuclear Professional School *2

- Institute of Engineering Innovation
- Institute of Innovation in Engineering Education (IIIEE)
- Center for Water Environment Technology
- Quantum-Phase Electronics Center
- Frontier Research Center for Energy and Resources
- Photon Science Center
- Medical Device Develop. and Regulation Research Center
- Resilience Engineering Research Center
- Center for Spintronics Research Network

- ✓ ***1 Doctoral course only**
- ✓ ***2 One year professional graduate course**
- ✓ ***3 "Master's Program in Sustainable Urban Regeneration" also offered**

Department of Aeronautics and Astronautics

- Department of A&A
  - Aerodynamics: 2 labs
  - Aircraft design: 1
  - Structure/material: 2
  - Aircraft Control: 1
  - Information Technology 1
  - Space Systems: 1
  - Engine 2
  - Electric propulsion 1
  - Combustion 1
  - Tribology 1

- Research Center for advanced Science and Technology (Univ. Tokyo)
  - Remote Sensing 1
  - AI and Space Robots 1

- ISAS (outside)
  - Aerodynamics 2
  - Material/Structure 2
  - Control/Systems 2
  - Propulsion/Engines 2

http://www.aerospace.t.u-tokyo.ac.jp/index-e.html

Shinichi Nakasuka, Ph.D, Prof

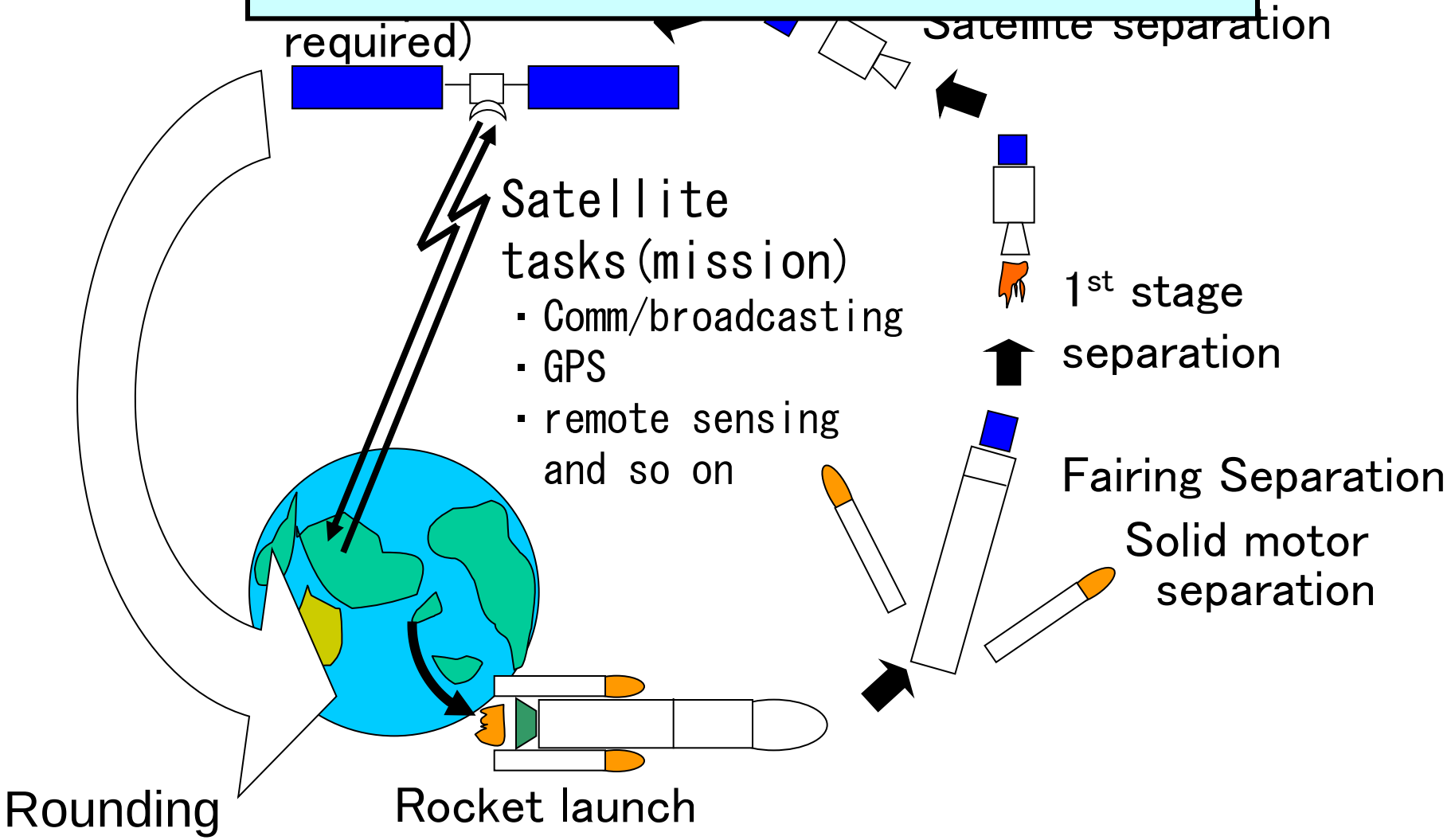
- Graduated from University of Tokyo in Aeronautics in 1983
- Received Ph.D in Aeronautics in 1988
- Joined IBM Research from 1988 to 1990
- Has been working for School of Engineering, University of Tokyo since 1990 as;
  - Lecturer: 1990-1992
  - Associate Professor: 1993-2004
  - Professor: 2004-now
- Space Policy Committee of Government

Major Research Fields

- Navigation, Guidance and Control of Spacecraft
- Micro/Nano/Pico Satellite Design, Development and Operation
- Novel Future Space Systems
- Autonomy and Intelligence for Space Systems
- Artificial Intelligence, Machine Learning

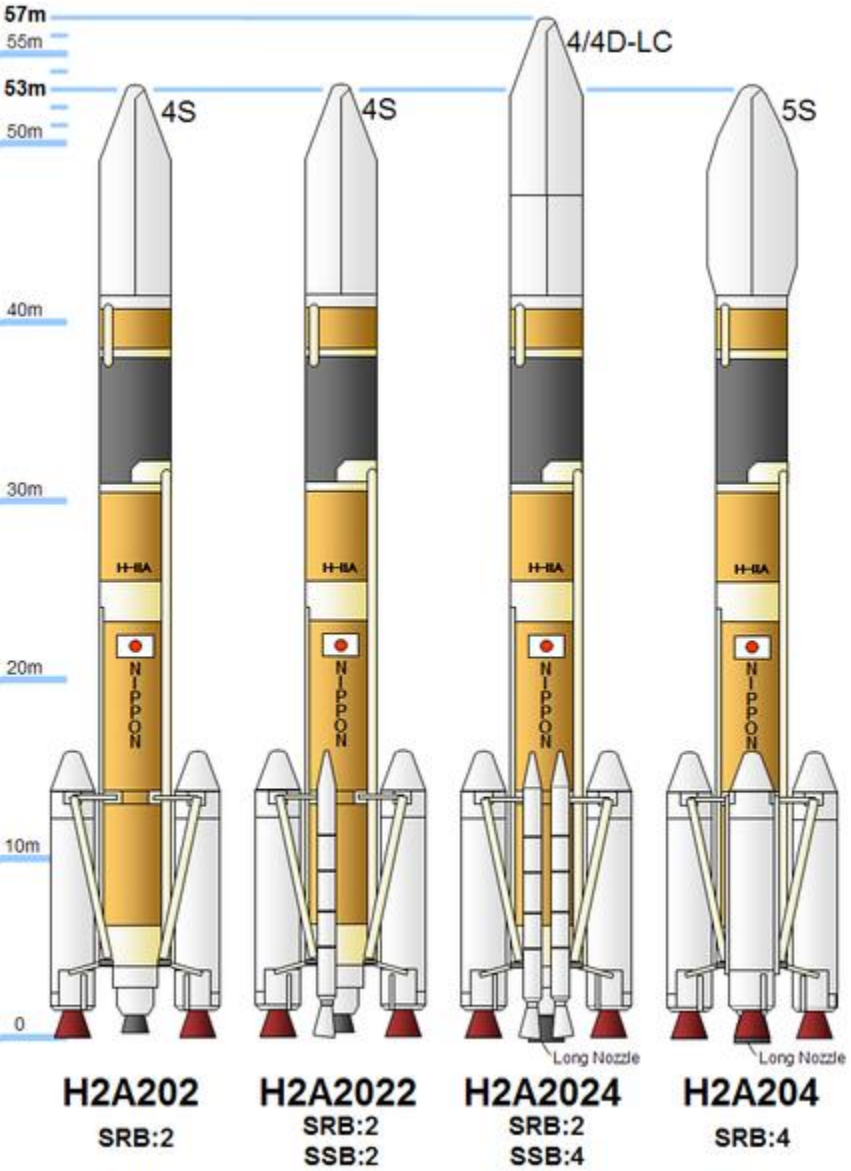
Rocket and Satellite

Rocket and Satellite



“Rocket” Carries “Satellites” to Orbits

H-IIA 46/47



Height	53 5m (173 ft)
Diameter	4 m (13.1 ft)
Mass	285,000 - 445,000 kg (628,317 - 981,057 lb)
Stages	2
Capacity	
Payload to LEO	10,000 - 15,000 kg (22,046 - 33,069 lb)
Payload to GTO	4,100 - 6,000 kg (9,038 - 13,227 lb)

Designation	Mass (tonnes)	Payload (tonnes to GTO)	Addon modules
H2A202	285	4.1	2 SRB-A (SRB)
H2A2022 (discontinued)[4]	316	4.5	2 SRB-A (SRB) + 2 Castor 4AXL (SSB)
H2A2024 (discontinued)	347	5	2 SRB-A (SRB) + 4 Castor 4AXL (SSB)
H2A204	445	6	4 SRB-A (SRB)
H2A212 (cancelled)	403	7.5	2 SRB-A (SRB) + 1 LRB
H2A222 (cancelled)	520	9.5	2 SRB-A (SRB) + 2 LRBs

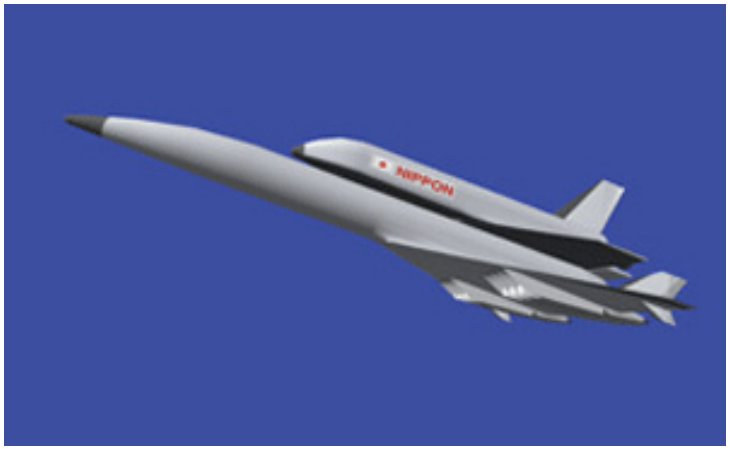
EPSIRON 4/4

Development cost	20.5B YEN
Cost/flight	E-X：5.3B YEN（1-3） E-X：3.8B YEN（4-） E-I：< 3 B YEN
Base	H-IIA SRB-A, M-V 3,4 stages
Features	
Stages	3 (base) 4 (option)
Booster	No
Total weight	90.8t
Length	24.4 m
Diameter	2.6 m
Payload Capability	
To LEO	1,200 kg 250 km × 500 km
To SSO(Sun Synchronous)	450 kg 500 km × 500 km

Future Rocket？

Expendable
→ Reusable

Cylinder type
→ Winged type

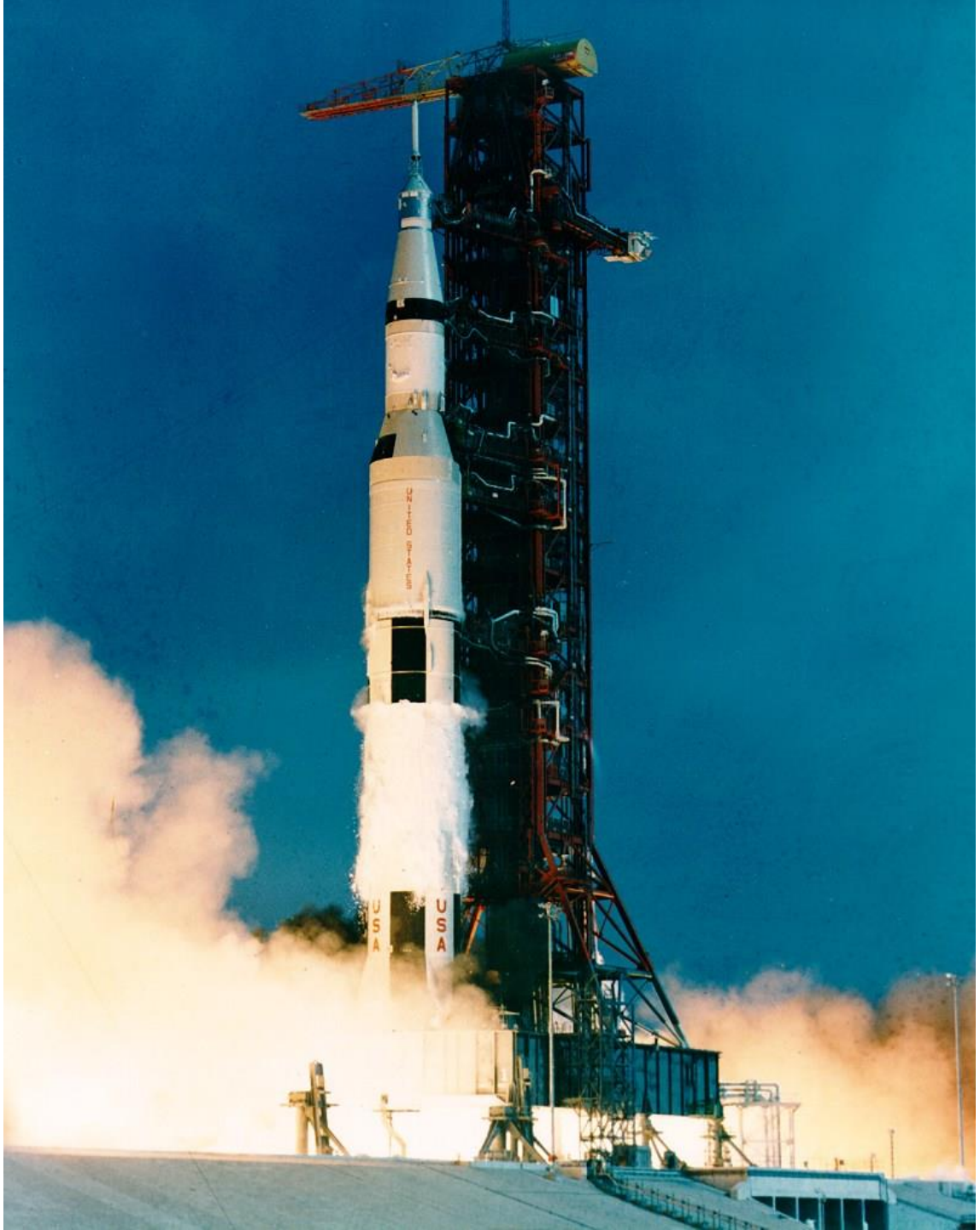


Manned Space Flight

In 1961, when I was born, what happened in space ?

First human flight in space
（April 12, Soviet’s Yuri Gagarin）
Vostok-1

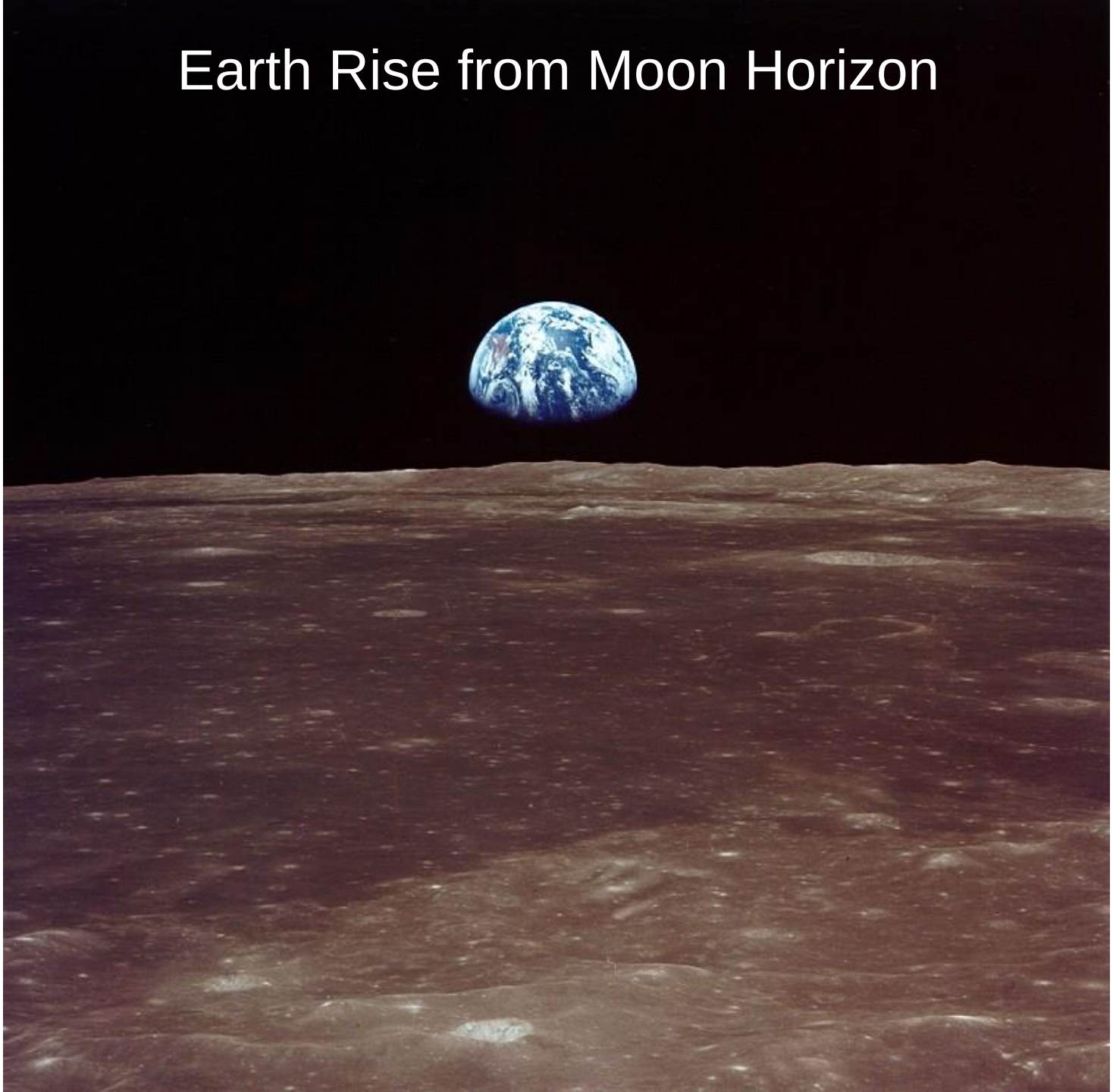
Just 4 years after the successful launch of the world first satellite “Sputnik”



July 16, 1969

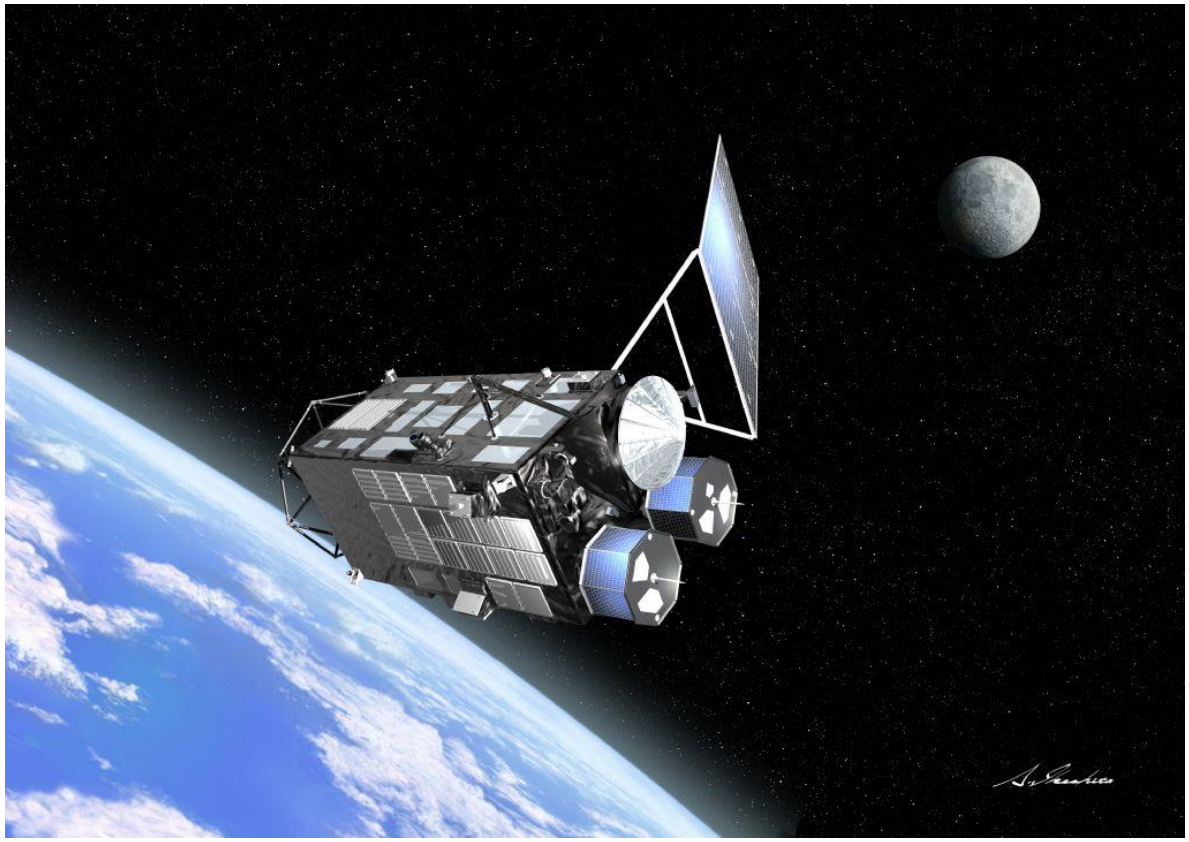
Apollo11

Earth Rise from Moon Horizon



“That's one small step for man, one giant leap for mankind. (1969.7.20)”

Japanese Lunar Exploration Satellite



3 ton

Various sensors to observe the moon

KAGUYA（SELENE)

Manned Flight → Manned Stay in Space

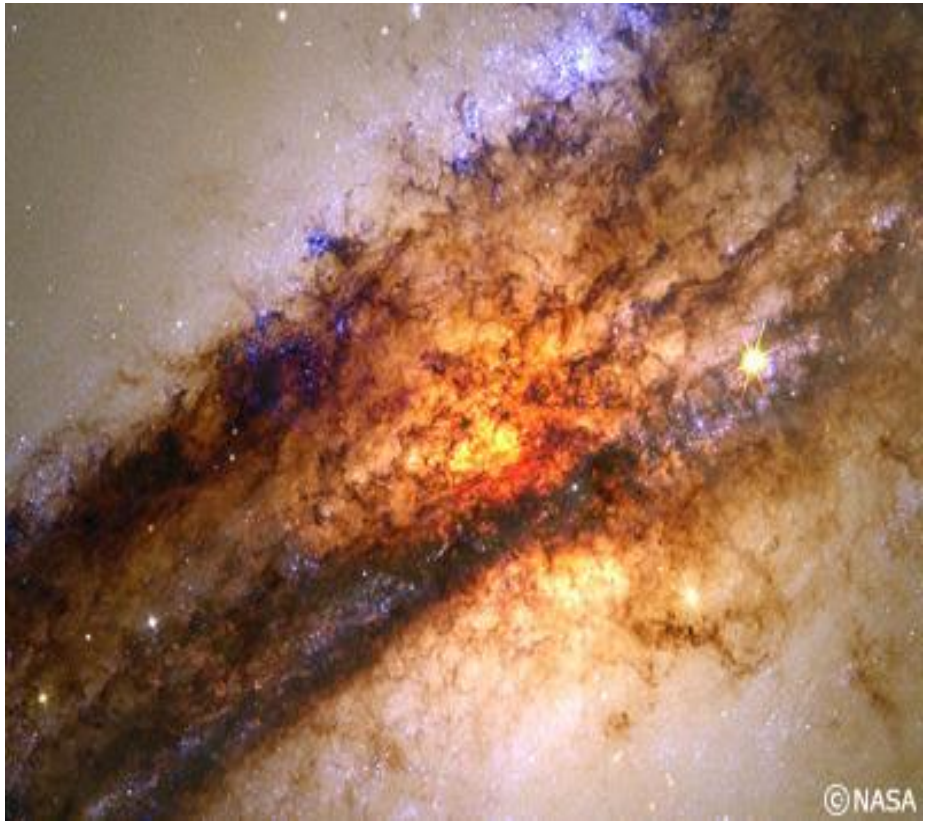
Skylab (1973-74) Mir (1986-2001)

International Space Stations (ISS)

- 5 principals and 15 partners -

Space Science and Exploration

Space Telescope

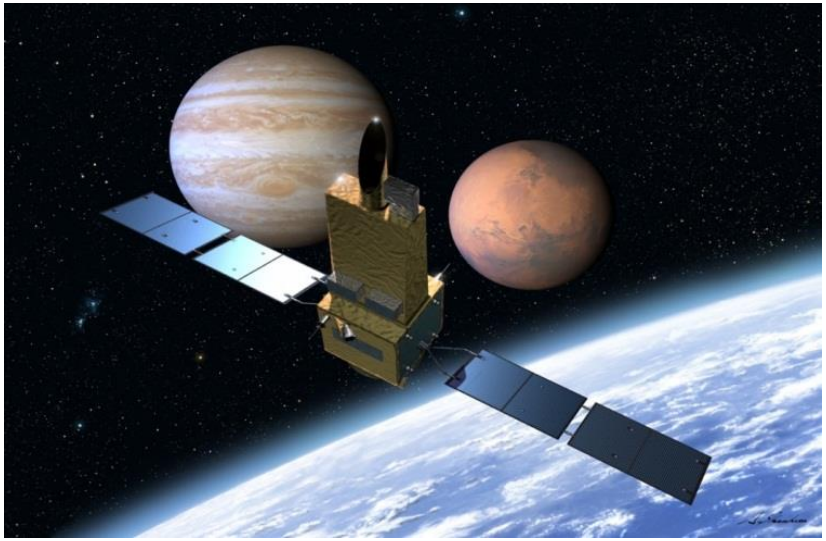


Hubble Space Telescope (1990～)　　Φ2.4m　11 **t**

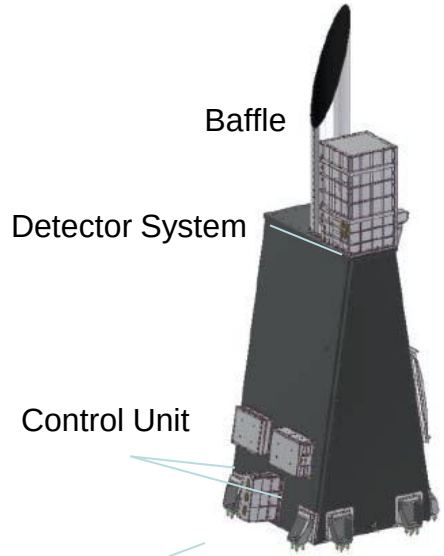
M-Class (1): SPRINT-A/EXCEED (HISAKI)

Launched on 14 Sep. 2013 (335kg) on first Epsilon rocket launch

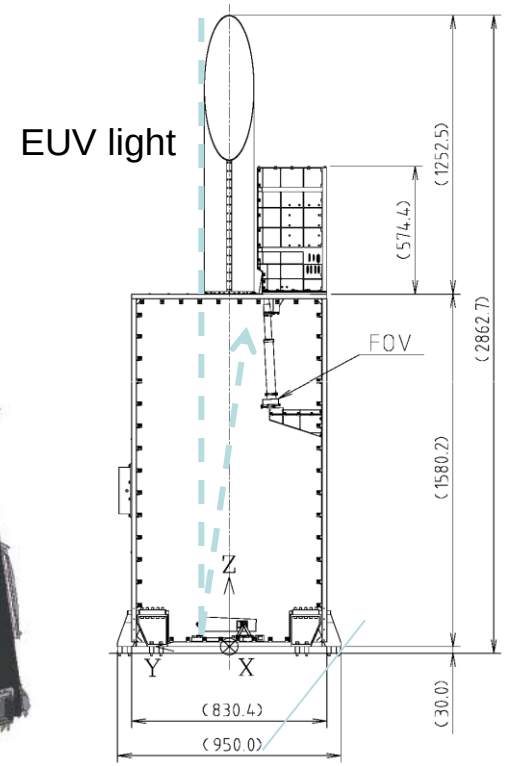
- **Ex**treme ultraviolet spectros**C**ope for **E**xosph**E**ric **D**ynamics
- The mission is spectroscopic and imaging observation of EUV (extreme ultraviolet: 60-145nm) emissions from tenuous plasmas around ***Venus, Mars, Mercury, and Jupiter***.
  - measuring the plasma escape rates from the terrestrial planets (Venus, Mars, and Mercury)
  - understanding the electron energy and density distribution around the Jovian inner magnetosphere.



SPRINT-A/EXCEED



Mission Data Processor (MDP)



Primary mirror

M-class (2) ERG (Energization & Radiation in Geospace)

Launched in December 2016 (350kg), named "ARASE"

ERG is a mission to elucidate acceleration and loss mechanisms of relativistic electrons of Van Allen belts during space storms.

Significance of the project:

- Direct observations on generation of relativistic electrons at the magnetic equator in the inner magnetosphere
  → contribution to understanding of the particle acceleration.
- Instrumental development to measure plasma and fields under the incidence of radiation belt particles with small satellite
  → contribution to a future Jovian mission.
- Understanding the acceleration and loss mechanisms.
  → contribution to predictable space weather model for space radiation environments.

M-class (3) SLIM (Smart Lander onto the Moon)

Planned to be launched in FY2019 (520kg)

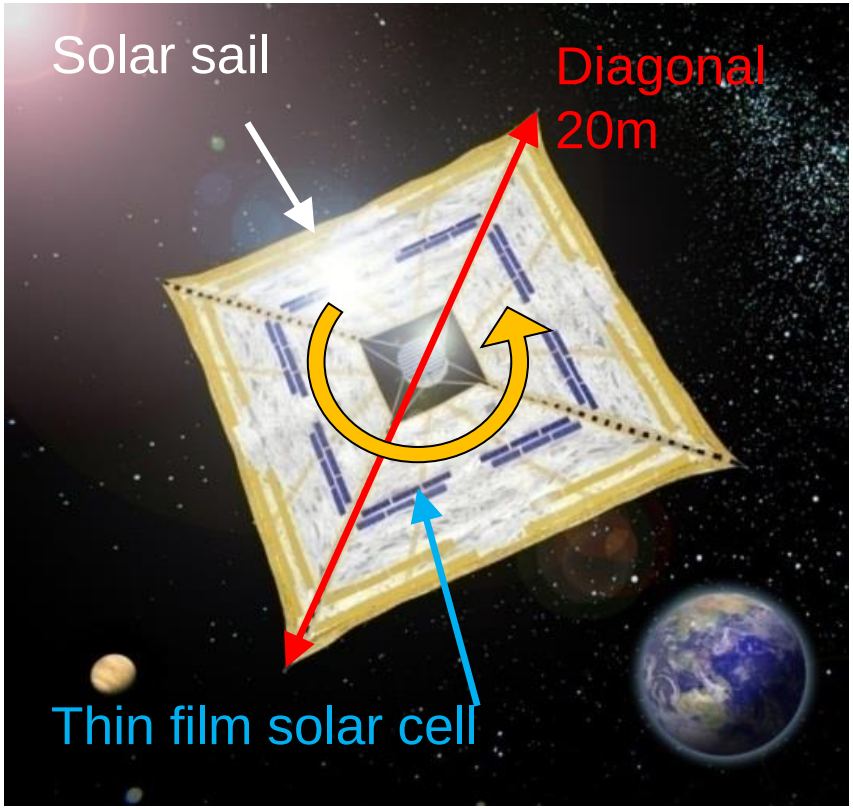
SLIM is a mission to demonstrate the technology for pin-point (about 100m accuracy) soft landing on lunar surface.

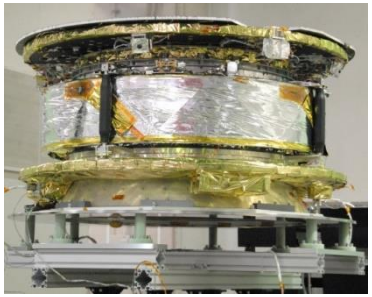
- Technology demonstration with Small Spacecraft
  - Image-based Navigation utilizing Lunar Terrain
  - Autonomous Obstacle Detection
  - Robust Pin-point Guidance
  - Landing Shock Absorber
  - High-performance Propulsion
  - Exploration using Spectrimeter or Tiny Rovers (option)
- Frequent trials of lunar/planetary surface exploration technology
- Precursor of future full-scale lunar or planetary missions

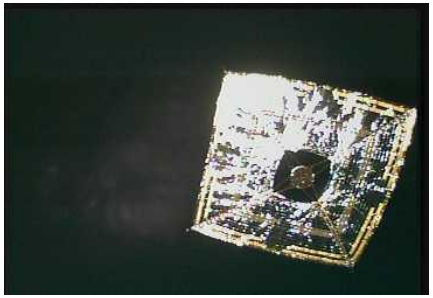
(Piggy-back) IKAROS: A Solar Sail Demonstrator

IKAROS (= Interplanetary Kite-craft Accelerated by Radiation Of the Sun) is the world's first interplanetary solar sail craft which demonstrated its photon sailing and thin film solar power generation

- (**310kg**, launch in 2010 as piggyback of Akatsuki)



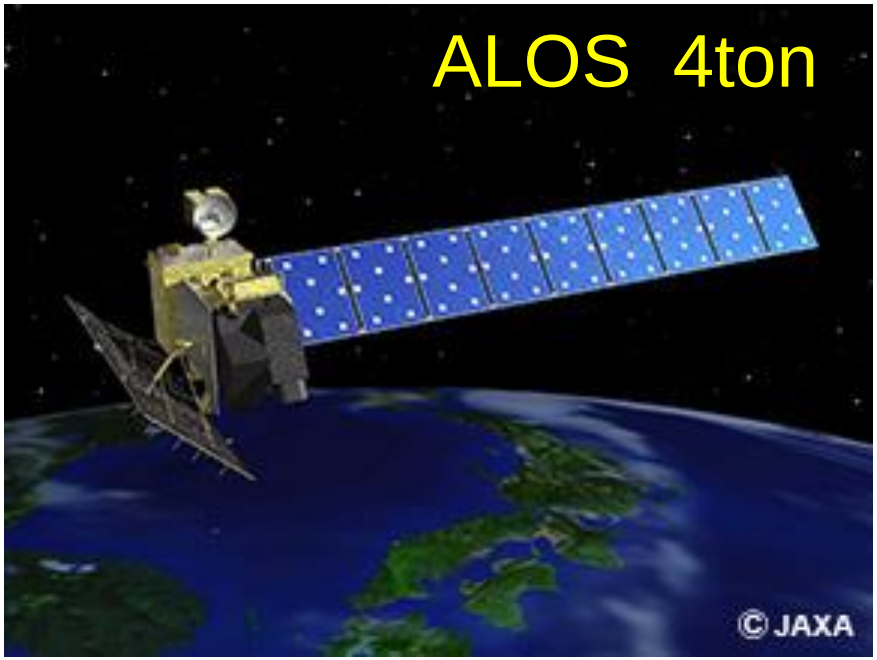


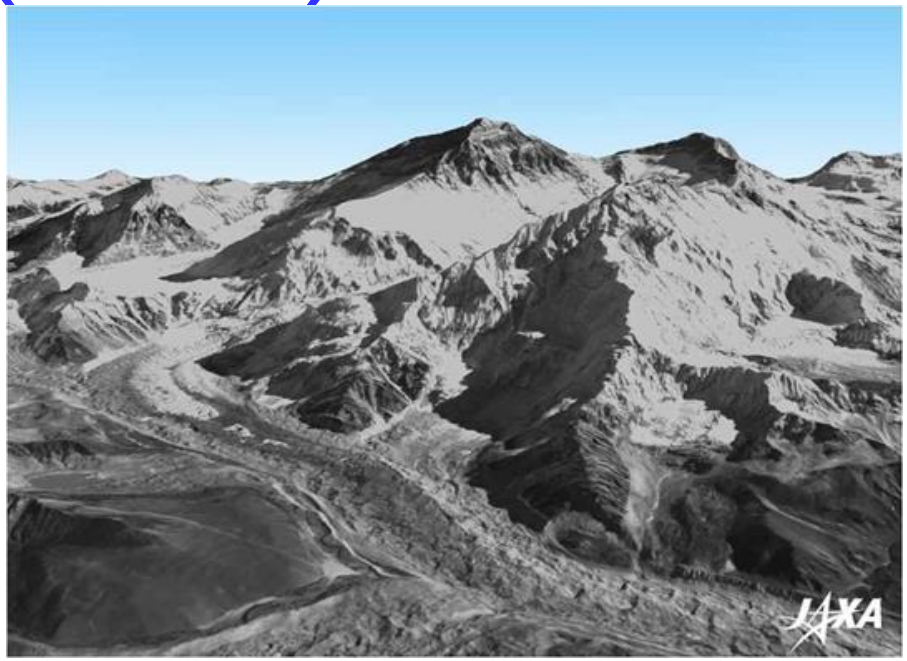


DCAM(Camera-craft) captured solar-sailing IKAROS June 14, 2010

Governmental Satellites for Life on Earth

Optical Remote Sensing Satellite
- Daichi (ALOS) -





DEM (Digital Elevation Map)

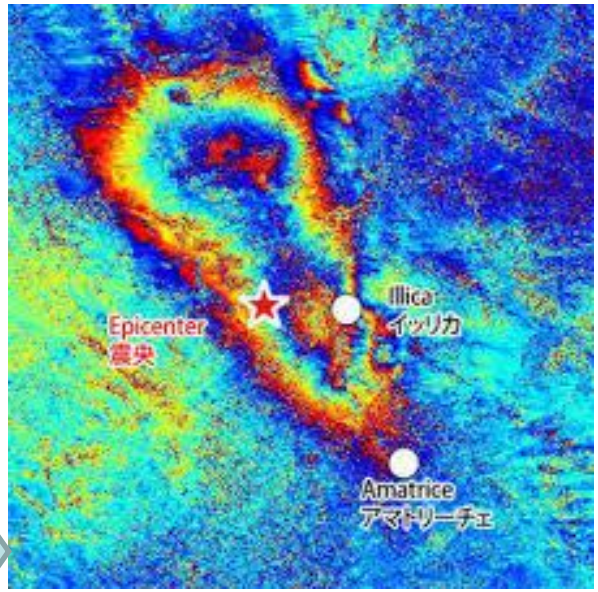
2.5m GSD “PRISM” Image

ALOS-2 Synthetic Aperture Radar(SAR)

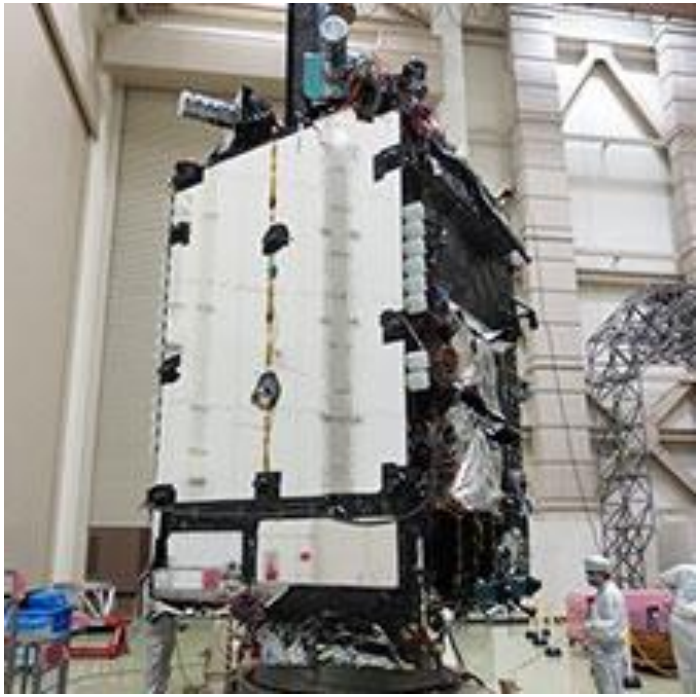
ALOS-2 2 ton

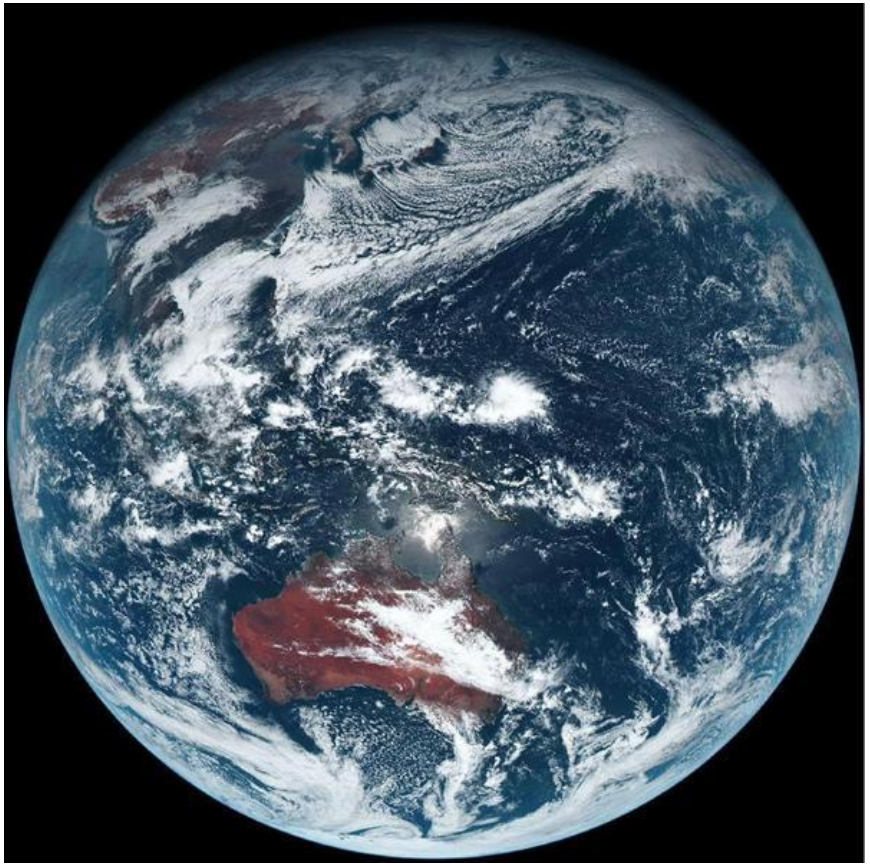
Ground info. can be captured under night or cloudy conditions

cm movement can be detected



Meteorological/ATC Satellite



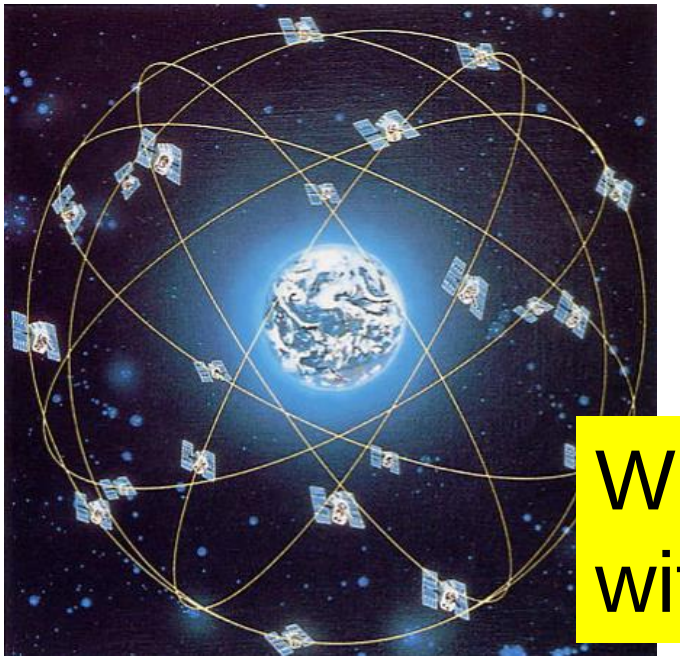


“HIMAWARI-8”
(3.5 ton)

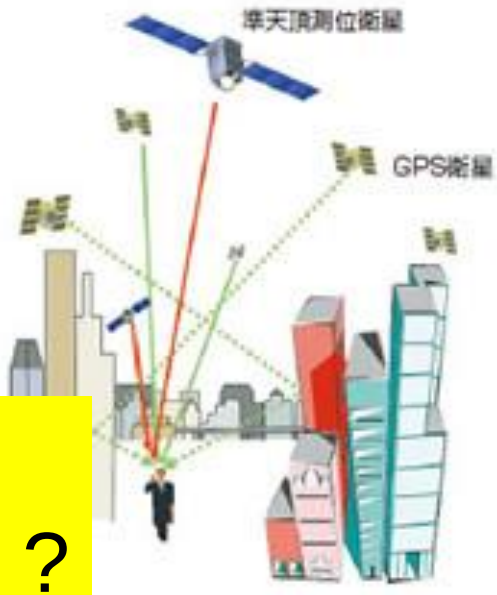
Navigation Satellite (GPS, QZS)

←GPS
Accuracy
3-5m

QZS→
accuracy：
6cm
- 1m
(2018)



4ton



What you can do
with 6 cm accuracy ?