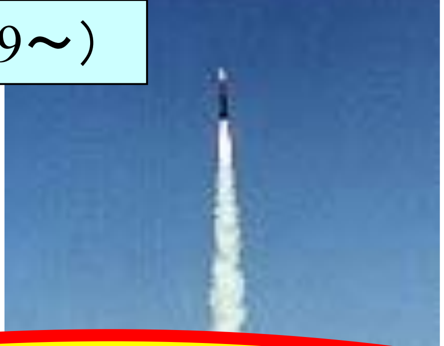
CanSat & Rocket Experiment('99～)

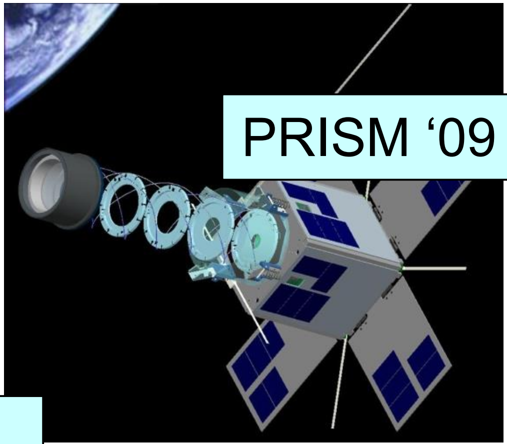


Hodoyoshi-1 '14

Introduction to Mission Idea Contest 7 - Deep Space Mission Challenge -

Shinichi Nakasuka
University of Tokyo

CubeSat 03,05



PRISM '09

Nano-JASMINE (TBD)

Mission Idea Contest：Background

- Mission Idea Contest was launched in 2010 to encourage innovative exploitation of micro/nano-satellites to provide useful capabilities and services.
- It provides aerospace engineers, college students, consultants, and anybody interested in space with opportunities to present their creative ideas and gain international attention.
- Four books were published as IAA book series.

MIC3 finalists and reviewers, Nov 19, 2014, Kitakyushu, Japan

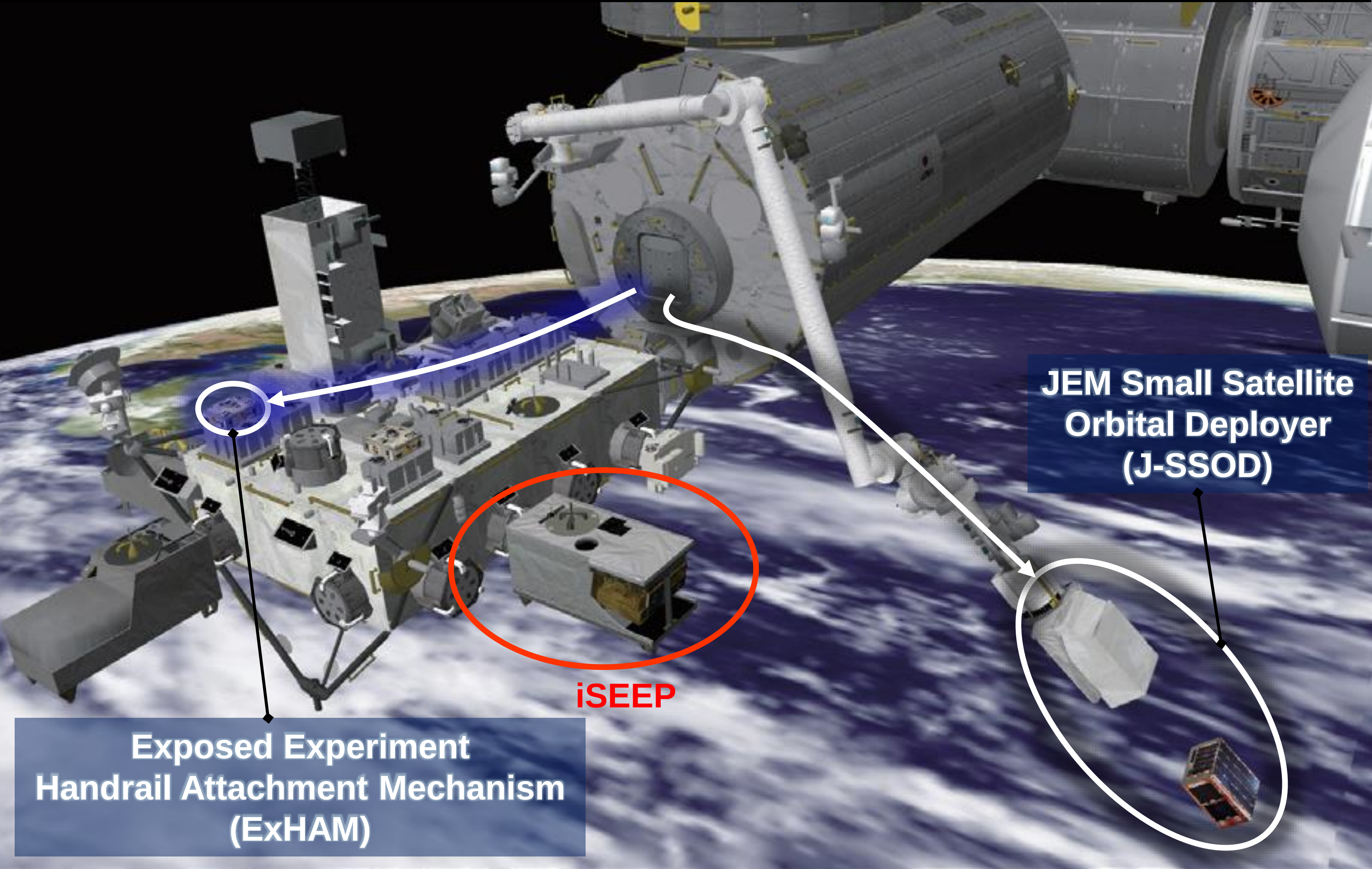
MIC4 finalists and reviewers, Oct. 21, 2016, Verna, Bulgaria

IAA book series (MIC1-4)

MIC Winners' Mission Ideas

	Proposed idea	Country
MIC 1 (constellation)	Integrated Meteorological / Precise Positioning Mission Utilizing Nano-Satellite Constellation	Japan (professional)
MIC 2 (Satellite Design)	SOLARA/SARA:Solar Observing Low-frequency Array for Radio Astronomy/ Separated Antennas Reconfigurable Array	USA (student)
MIC 2 (Business model)	Underground and surface water detection and monitoring using a microsatellite	South Africa (student)
MIC 3	Clouds Height Mission	Germany, Italy, Slovenia (professional)
MIC 4	CubeSat constellation for monitoring and detection of bushfires in Australia	Australia (student)
MIC 5	Smallsat Ionosphere Exploration at Several Times and Altitudes,	Taiwan, USA, India (student)
MIC 6 (ISS-IceCube)	MUSA: An ISS Experiment for research of a dual culture for Panama Disease	Costa Rica (student)
MIC6 (ISS-iSEEP)	Spectrum Monitoring from Space with i-SEEP (SMoSiS)	Philippines (professional)

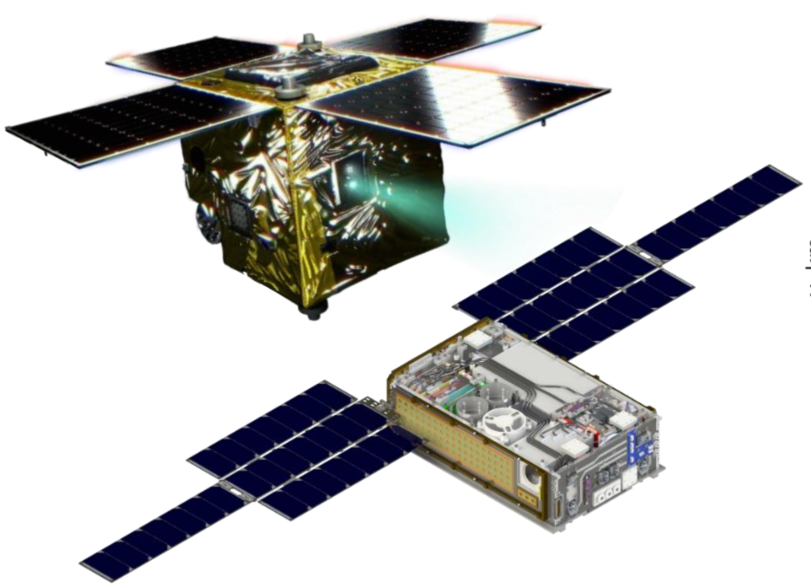
MIC6-iSEEP
ISS with Kibo Unique Exposed Facility

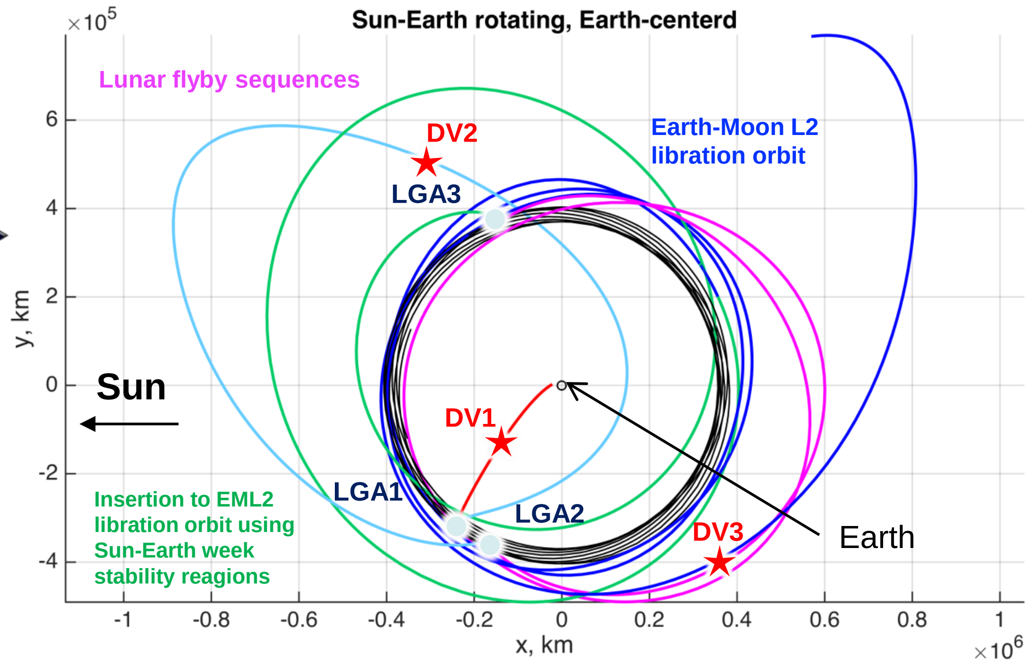


Now it's time to go to "Deep Space" - MIC7 Overview -

- **Requirement:** Propose deep space science and exploration mission with micro/nano satellites
- **Constraints:** Realistic constraints shown later

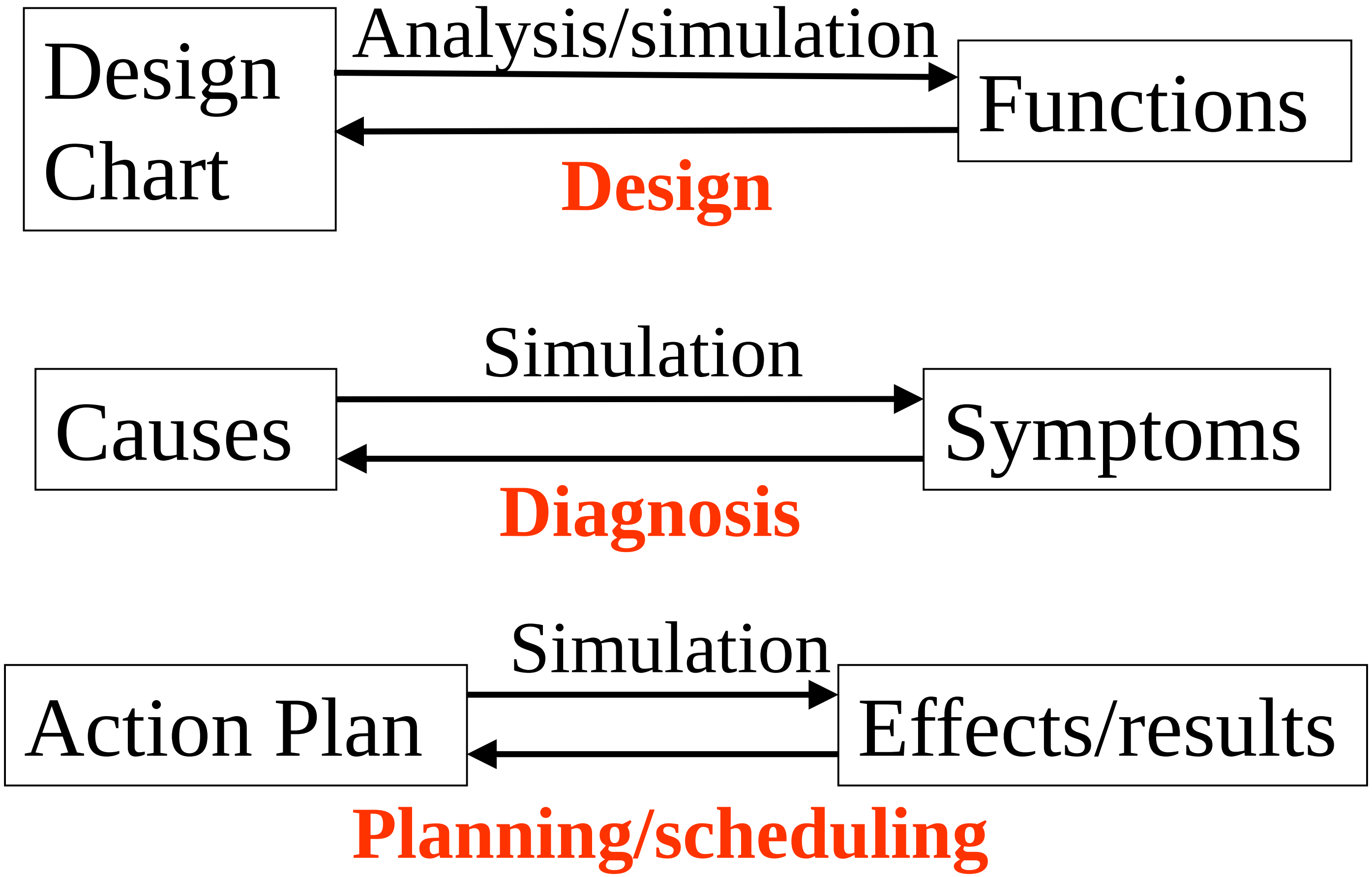
http://www.spacemic.net





Importance of Satellite Design and Mission Idea Contest

Importance of “Problem Solving”



Important Engineering Skills: “backward reasoning,” or “Inverse problem”

Everyday life requires "problem solving" skills

- Life is full of problem solving
  - We cannot tell whether answer exists or not
  - You should answer with knowledge and skills on various fields (not only engineering and mathematics, but also economics, culture, ethics, laws, etc.)
  - Frequently you should solve the problem as a team
- Problem solving skills can be trained only if you really want to solve the problem.
  - Strong motivation is essentially required !

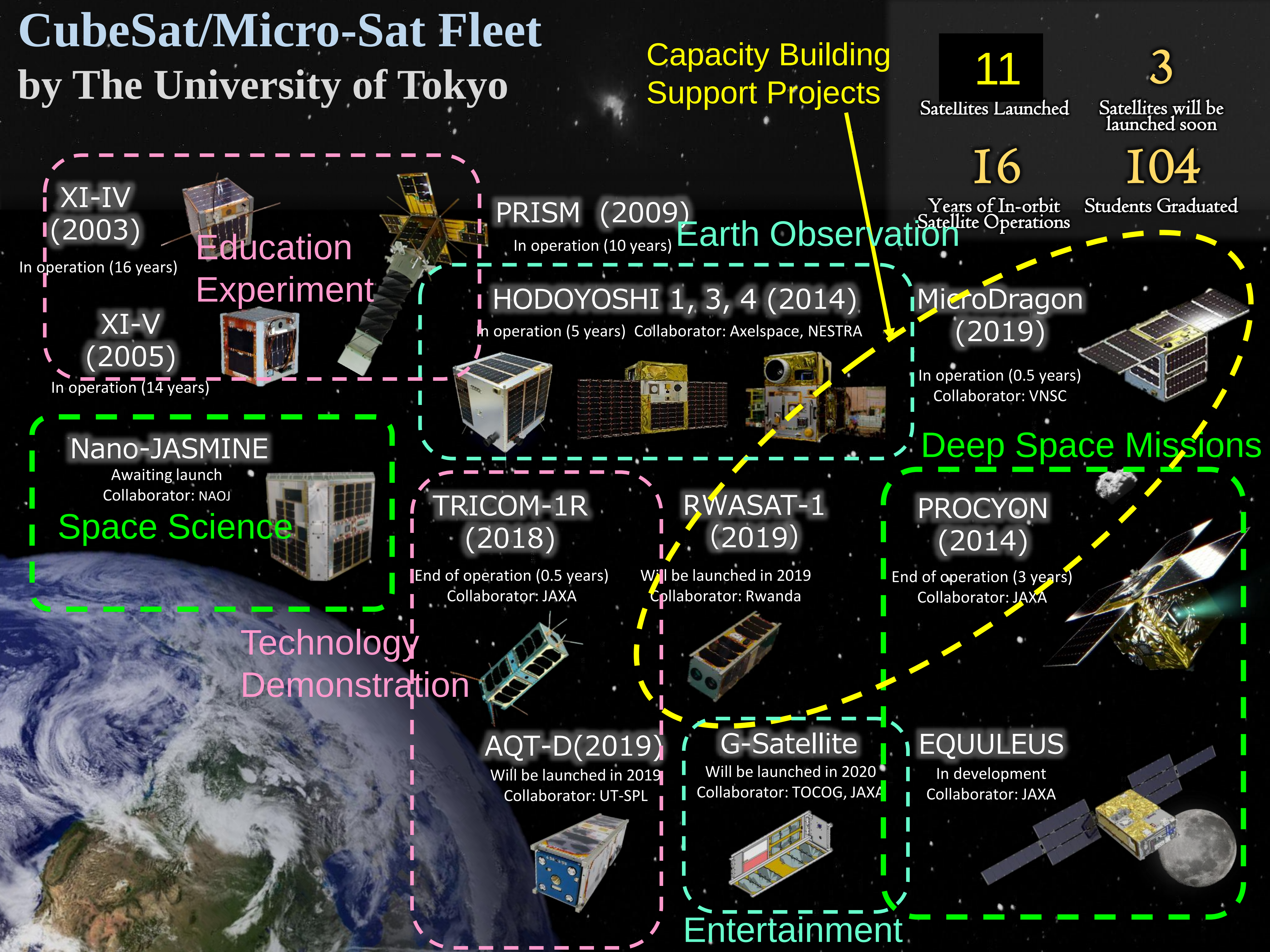
Satellite project/design contest is….

- Problem solving of "mission success"
  - Scientific goal → mission scenario design → orbit and spacecraft design
  - Not a academic paper. System should behave correctly in the real world !
- Requiring integration of multiple fields knowledge and skills, people with various background and expertise
  - If you don't know, search for someone who know
  - Example of "Open innovation"
- Giving you very strong motivation to solve the problem, which provide excellent training

Why deep space missions ?

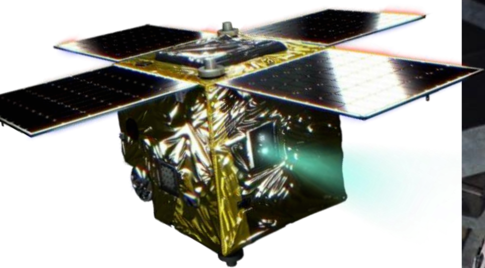
MIC7 Focus on Deep Space Missions

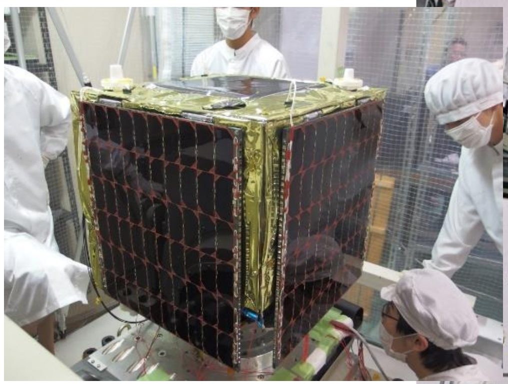
- Theme of MIC7 is **"Deep Space Mission."**
- This is because technological field of LEO satellites are already almost established, and we consider that creation of deep space mission will give young generation more motivations towards "Frontier."
- Deep space missions require more variety of knowledge and skills, which will give additional areas for teaching and learning
- Because of technological development of micro/ nano-satellites, deep space missions are possible within university capability and small size !

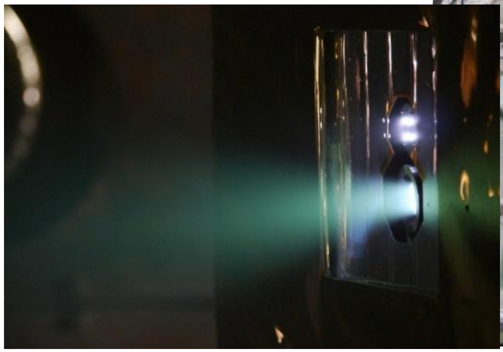

CubeSat/Micro-Sat Fleet
by The University of Tokyo
Capacity Building
Support Projects
11
Satellites Launched
3
Satellites will be launched soon
16
Years of In-orbit Satellite Operations
104
Students Graduated
XI-IV
(2003)
In operation (16 years)
Education
Experiment
XI-V
(2005)
In operation (14 years)
PRISM (2009)
In operation (10 years)
Earth Observation
HODOYOSHI 1, 3, 4 (2014)
In operation (5 years) Collaborator: Axelspace, NESTRA
MicroDragon
(2019)
In operation (0.5 years)
Collaborator: VNSC
Nano-JASMINE
Awaiting launch
Collaborator: NAOJ
Space Science
Deep Space Missions
TRICOM-1R
(2018)
End of operation (0.5 years)
Collaborator: JAXA
RWASAT-1
(2019)
Will be launched in 2019
Collaborator: Rwanda
PROCYON
(2014)
End of operation (3 years)
Collaborator: JAXA
Technology
Demonstration
AQT-D(2019)
Will be launched in 2019
Collaborator: UT-SPL
G-Satellite
Will be launched in 2020
Collaborator: TOCOG, JAXA
EQUULEUS
In development
Collaborator: JAXA
Entertainment

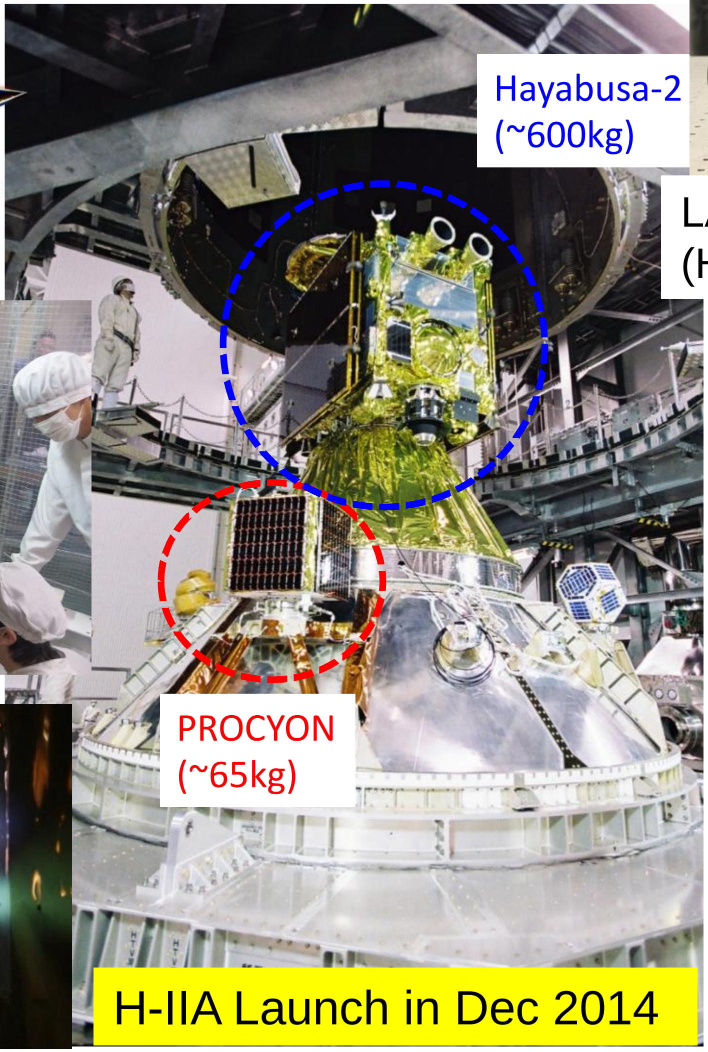
PROCYON (World first 50kg class deep space probe)

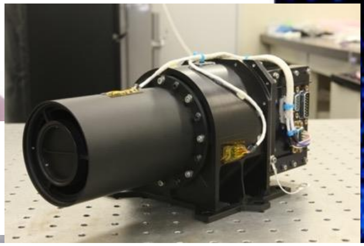
- The World First Interplanetary Micro-sat (65kg)
- Joint project with JAXA



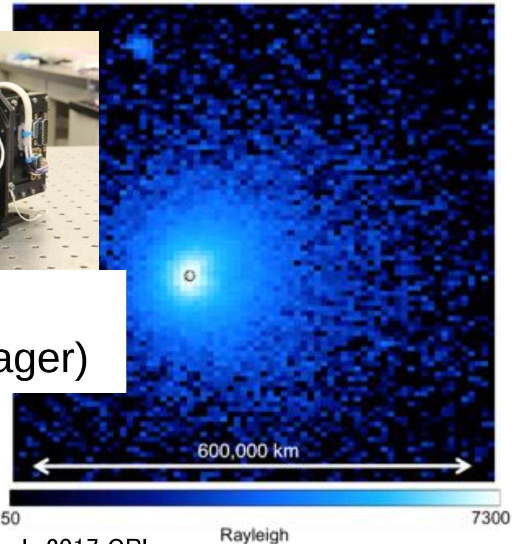




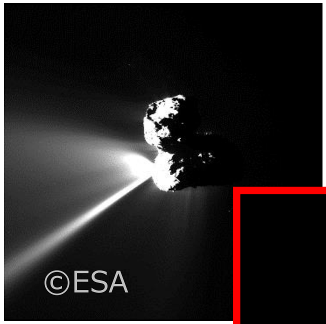




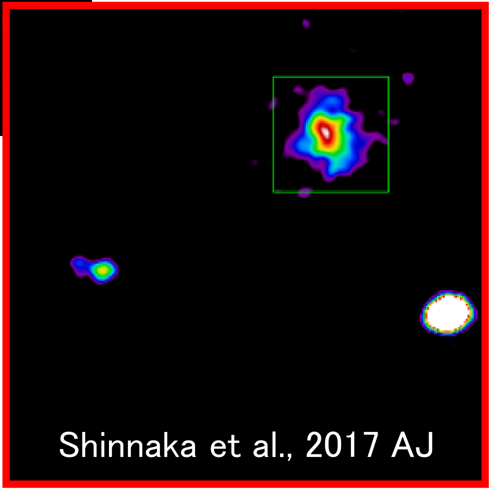
Earth's hydrogen corona



Kameda et al., 2017 GRL



Hydrogen around 67P/Churyumov–Gerasimenko



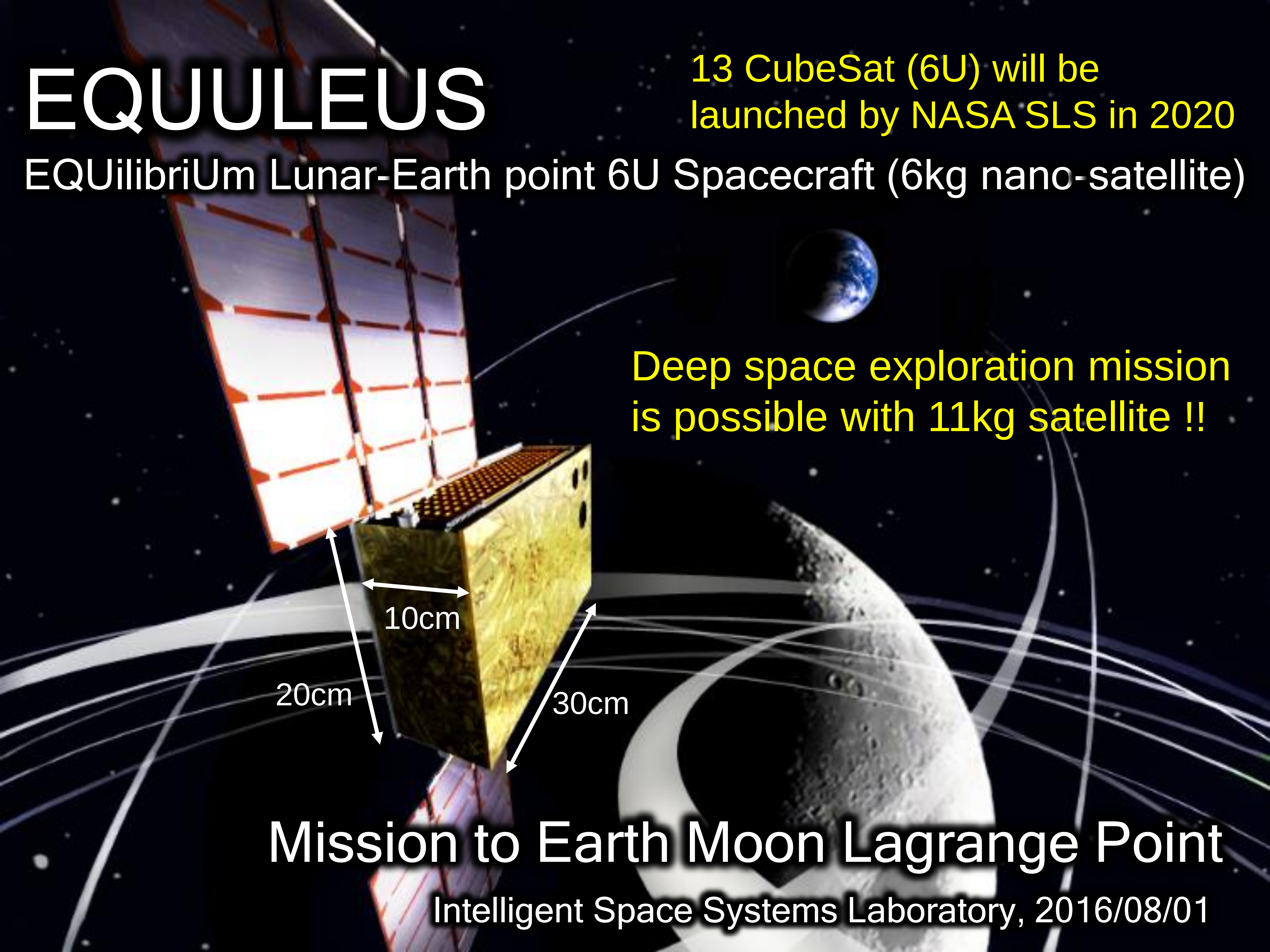
Very quick (<14 months) development

EQUULEUS

EQUilibriUm Lunar-Earth point 6U Spacecraft (6kg nano-satellite)

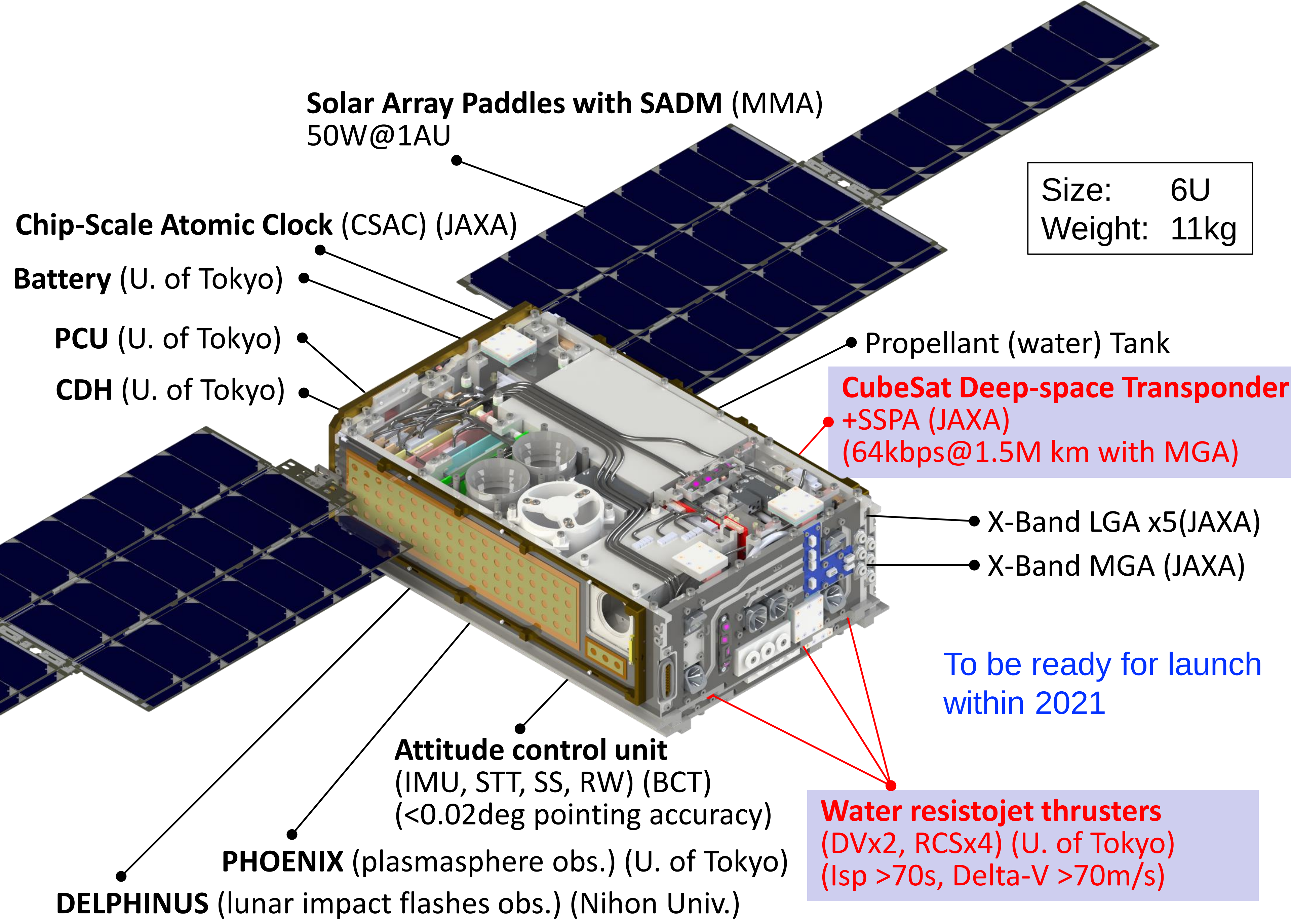
13 CubeSat (6U) will be launched by NASA SLS in 2020

Deep space exploration mission is possible with 11kg satellite !!



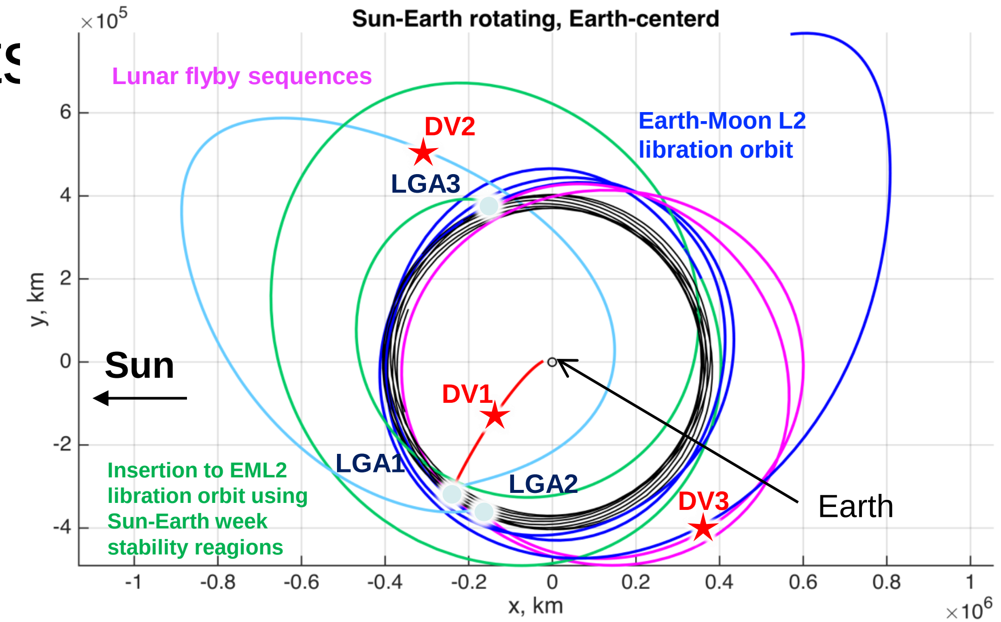
Mission to Earth Moon Lagrange Point

Intelligent Space Systems Laboratory, 2016/08/01


Solar Array Paddles with SADM (MMA)
50W@1AU
Size: 6U
Weight: 11kg
Chip-Scale Atomic Clock (CSAC) (JAXA)
Battery (U. of Tokyo)
PCU (U. of Tokyo)
CDH (U. of Tokyo)
Propellant (water) Tank
CubeSat Deep-space Transponder
+SSPA (JAXA)
(64kbps@1.5M km with MGA)
X-Band LGA x5(JAXA)
X-Band MGA (JAXA)
To be ready for launch within 2021
Attitude control unit
(IMU, STT, SS, RW) (BCT)
(<0.02deg pointing accuracy)
Water resistojet thrusters
(DVx2, RCSx4) (U. of Tokyo)
(Isp >70s, Delta-V >70m/s)
PHOENIX (plasmasphere obs.) (U. of Tokyo)
DELPHINUS (lunar impact flashes obs.) (Nihon Univ.)

Requirements and Constraints

- No specific requirements
  - You should create your own mission ideas (scientific goals) and specify the requirements for them



- "Realistic" constraints
  departure (V∞) depends on the mass of spacecraft
  - Onboard Communication System （such as PROCYON)
  - Deep Space Network（DSN) performance
  - A certain position estimation accuracy is assumed
  - Life time is arbitrary (design parameter)
  - Launch window is earlier than 2030

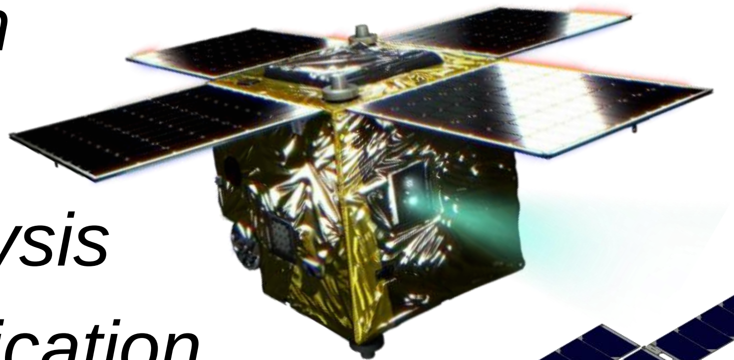
Difference from LEO missions

1) Design of the Trajectory

   1-1) Three body or multi-body problem

   1-2) Sphere of influence and patched conics

   1-3) Swing-by Mechanism



2) Design of the Explorer

   2-1) Radiation effect analysis

   2-2) Long range communication

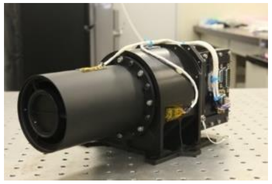
   2-3) Optical navigation

   2-4) Long lifetime

   2-5) Autonomy.

3) Ground station and operation

   3-1) Operation scenario



We are waiting for innovative and interesting idea of mission and spacecraft design !!

Join us !