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

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CanSat & Rocket Experiment ('99 ~)

Hodoyoshi-1 '14

PRISM '09

CubeSat 03,05

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

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

Exposed Experiment Handrail Attachment Mechanism (ExHAM)

JEM Small Satellite Orbital Deployer (J-SSOD)
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

- XI-IV (2003) - In operation (16 years)
- XI-V (2005) - In operation (14 years)
- Nano-JASMINE - Awaiting launch, Collaborator: NAOJ
- PRISM (2009) - In operation (10 years)
- HODOYOSHI 1, 3, 4 (2014) - In operation (5 years), Collaborator: Axelspace, NESTRA
- TRICOM-1R (2018) - End of operation (0.5 years), Collaborator: JAXA
- RWASAT-1 (2019) - Will be launched in 2019, Collaborator: Rwanda
- G-Satellite - Will be launched in 2020, Collaborator: TOCOG, JAXA
- EQUULEUS - In development, Collaborator: JAXA

Education Experiment:
- XI-IV
- HODOYOSHI 1, 3, 4
- PRISM

Space Science:
- Nano-JASMINE
- TRICOM-1R

Technology Demonstration:
- AQT-D
- G-Satellite

Earth Observation:
- HODOYOSHI 1, 3, 4

Deep Space Missions:
- RWASAT-1
- EQUULEUS

Entertainment:
- MicroDragon (2019)

Satellites Launched: 11
Satellites will be launched soon: 3
Years of In-orbit Satellite Operations: 16
Students Graduated: 104
PROCYON (World first 50kg class deep space probe)

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

Hayabusa-2 (~600kg)
LAICA (Hydrogen imager)

Earth’s hydrogen corona

PROCYON (65kg)

H-IIA Launch in Dec 2014

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

Attitude control unit
(IMU, STT, SS, RW) (BCT)
(<0.02deg pointing accuracy)

Battery (U. of Tokyo)

Chip-Scale Atomic Clock (CSAC) (JAXA)

PCU (U. of Tokyo)

CDH (U. of Tokyo)

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To be ready for launch within 2021

Size: 6U
Weight: 11kg

Water resistojet thrusters
(DVx2, RCSx4) (U. of Tokyo)
(Isp >70s, Delta-V >70m/s)

CubeSat Deep-space Transponder +SSPA (JAXA)
(64kbps@1.5M km with MGA)

Delphinus (lunar impact flashes obs.) (Nihon Univ.)

PhoeniX (plasmasphere obs.) (U. of Tokyo)

Propellant (water) Tank

X-Band LGA x5(JAXA)

X-Band MGA (JAXA)
Requirements and Constraints

- No specific requirements
  - You should create your own mission ideas (scientific goals) and specify the requirements for them
- “Realistic” constraints
  - Departure ($V_\infty$) 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 !