CubeSat-Based Low-Cost Communication Network and its Utilisation for Capacity Building in Developing Countries

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Back Ground:
Forester, Conservation & Rural Development Projects
LEAN SPACE technologies and Spatial Information Science make it possible for all developing countries to LEAPFROG towards the accomplishment of SDGs.
Primarily by university/venture companies, but governmental projects are also appearing, which begin to replace mid-large sized satellites.
University of Tokyo’s (UT’s) History
- 10 satellites developed (8 launched) -

<table>
<thead>
<tr>
<th>Year</th>
<th>Satellite</th>
<th>Launch Vehicle</th>
<th>Mission Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>CubeSat XI-IV</td>
<td>ROCKOT</td>
<td>World First CubeSat! Education, Camera test</td>
</tr>
<tr>
<td>2003</td>
<td>CubeSat XI-V</td>
<td>COSMOS</td>
<td>Education, CIGS solar cells</td>
</tr>
<tr>
<td>2009/1</td>
<td>PRISM</td>
<td>H-IIA</td>
<td>30m GSD Remote sensing, Astrometry (top-science)</td>
</tr>
<tr>
<td>2005/10</td>
<td>NANO-JASMINE</td>
<td>ROCKOT</td>
<td>Remote sensing, S&amp;F</td>
</tr>
<tr>
<td>2014/6,11</td>
<td>HODOYOSHI-1,3,4</td>
<td>DNEPR</td>
<td>Deep space exploration</td>
</tr>
<tr>
<td>2014/12</td>
<td>PROCYON</td>
<td>H-IIA</td>
<td>Deep space exploration</td>
</tr>
</tbody>
</table>

3 x 3U CubeSat EQUULEUS (14kg, deep space) are being developed.

[1]-[8]: Launched  [9]: Waiting for launch
“Store & Forward” collects ground information

8mW low RF power (LoRA), low data rate (300 bps) transmission is tested in TRICOM-1R.

1. Measurements by ground stations
2. Data stored in satellite
3. Data forwarded by satellite
4. Data analyzed in headquarters

3kg TRICOM-1R
Launch of TRICOM-1R by SS-520-5

• Launched on 3/2/2018 by the world smallest orbital rocket by JAXA/ISAS

• S&F and camera experiments successful
  • 8mW transmission from Japan, RWANDA, etc

• Plan to develop low cost/quick development version to support foreign countries
Mobile devices and
Connected Vehicles

Geospatial big-data
analytics

Space system

Remote sensing

Satellite communication

TRIANGLE

driving positive cycle of technology
development and service development
“High level data processing” using Satellite data and in situ data is necessary.
Geostationary Communication Satellite:

Low Earth Orbit Small Satellite:
Space Inclusion
Boot Camp
Next Generation of Cubesat

- Towards the constellation of cubesats
  - Based on heritage design and experience
  - Renewed architecture to easy build and test
  - Industry partnership for better quality and mass production
- 1st Deployment of two satellites will be 20th Nov. 2019
Launch (deployment) from ISS with **Kibo** Unique Exposed Facility

- Unique Exposed Facility
- Exposed Experiment Handrail Attachment Mechanism (ExHAM)
- JEM Small Satellite Orbital Deployer (J-SSOD)
Collaboration Options

• Any Collaboration : Your Idea × Our Experience
• All options can include capability building programs

Your Mission × Our 2U/1U S&F BUS

Your Members × Our 3U/2U S&F Cubesat (build Together!)

Your Bus × Our S&F Mission Board

Your Bus × Our Heritage Components
New Tricom : 3U-Satellite

Nano Thruster
0.3U - 0.5U

Onboard Deep Machine Learning
MOU to develop 3U CubeSat to be launched in 2019

News from Africa (09/05/2018)
Smart Africa, Rwanda Sign Deal With Tokyo University For Satellite Technology
Today: 22 Smart Africa Member States

- 22 Member States have joined the alliance
- Market: 560+ Millions people

Member States:
- Angola
- Benin
- Burkina Faso
- Cameroon
- Chad
- Congo (D.R. of)
- Côte d'Ivoire
- Djibouti
- Egypt
- Gabon
- Guinea
- Kenya
- Mali
- Niger
- Rwanda
- Sao Tome & Principe
- Senegal
- South Africa
- South Sudan
- Togo.
- Tunisia
- Uganda
Keynote Address by Mr. Shinzo Abe, Prime Minister of Japan

「Let us raise our eyes now to a place beyond the earth. Soon, up there, a small-sized satellite built by Rwanda together with the University of Tokyo will emerge. From space, the satellite will observe crop harvests and the state of water resources in Rwanda. ーsnipー

And so I will say it again: the Japanese government -- New TICAD -- will do its utmost to support Japanese enterprises that are betting on the future of Africa.」

Yokohama Action Plan-TICAD7(2019)
AU flagship initiatives:Africa Outer Space Strategy

Support human capital development and harness STI to achieve the SDGs
- Capacity building through development, operation and utilization of small satellites, including small satellites deployment from the Japanese Experiment Module ”Kibo”of ISS and satellite data utilization to solve social issues.
Capacity building for emerging countries

**Capacity Building**
- E-learning system available for overseas universities in space emerging countries
- Education program with cansat/model rocket composition and its launch for invited foreign university students
- Training program on remote sensing technology for senior engineers in space emerging countries

**Utilization of ISS “KIBO” Module**
- Exposure test of components developed by emerging countries using JAXA’s KIBO module of ISS
- Deployment of cubesat developed by emerging countries from robot arm of JAXA’s KIBO module of ISS

**Application of QZSS**
- Demonstration experiments of commercial GNSS applications in Asia-Pacific region where QZSS signals is available

**Dispatch of Japanese experts**
- Overseas dispatch of Japanese experts to give a lecture in seminar/workshops and/or university classes

▲ E-learning system
▲ Cansat/model rocket program
▲ Cubesats to be released from ISS “KIBO” module
▲ Autonomous driving of a tractor in Australia
▲ Demonstration of i-Construction in Thailand
▲ JASTIP symposium in Thailand
▲ Space technology seminar in UAE
Capacity building programs using Japan’s assets

【Cansat/Model Rocket Hands-on】
- Provide foreign students with opportunity to manufacture and launch can-size satellites and model rockets

【Space Experiment Ideathon】
- Divide students into several groups, and then each group comes up with ideas and present the outcomes for experiment in space environment.
- Japanese experts may advise when necessary.

【Parabolic Fright】
- Invite the winner of Space Experiment Ideathon to the real experience of zero gravity by parabolic flight.
“UNISEC-Global” activities

40+ regions/countries are interested to start UNISEC in their countries: South Africa, Angola, Namibia, Egypt, Ghana, Kenya, Nigeria, Tunisia, Bangladesh, Korea, Mongolia, the Philippines, Singapore, Taiwan, Thailand, Turkey, Australia, Indonesia, Saudi Arabia, Canada, USA, Guatemala, Mexico, Peru, Brazil, Bulgaria, Italy, Samara (Russia), Switzerland, India, Germany, Slovenia, Lithuania and Japan.

15 Local Chapters and 1 Association of Local Chapters have been acknowledged. (red part)
“MicroDragon” for Vietnam

<table>
<thead>
<tr>
<th>Size</th>
<th>approx. 0.5 m × 0.5 m × 0.5 m (stowed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>approx. 1.4 m (SAP deployed)</td>
</tr>
<tr>
<td>Mass</td>
<td>approx. 50 kg</td>
</tr>
<tr>
<td>Orbit (Planned)</td>
<td>SSO 500 km</td>
</tr>
<tr>
<td></td>
<td>LTDN 9:30</td>
</tr>
<tr>
<td>ADCS</td>
<td>Three-axis Earth Pointing</td>
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<tr>
<td>EPS</td>
<td>Solar Cells</td>
</tr>
<tr>
<td></td>
<td>2x Solar Array Paddles (SAPs) + 5x Body</td>
</tr>
<tr>
<td></td>
<td>Mount Cells</td>
</tr>
<tr>
<td>Generation Consumption</td>
<td>Generation 100 W (max)</td>
</tr>
<tr>
<td></td>
<td>Consumption 50 W (avg)</td>
</tr>
<tr>
<td>Bus Voltage</td>
<td>Bus Voltage 28V (unreg) + 5V (reg)</td>
</tr>
<tr>
<td>Battery</td>
<td>Battery 5.8AH Li-ion</td>
</tr>
<tr>
<td>COM</td>
<td>S-band 4kbps (CMD)</td>
</tr>
<tr>
<td></td>
<td>S-band 4/32/64kbps (TLM)</td>
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<tr>
<td></td>
<td>X-band 10Mbps (Mission)</td>
</tr>
</tbody>
</table>
Hodoyoshi PJ ("First Program," 2010-2014)

Development Process

- Low cost supply chain network
- Hodoyoshi-reliability

Satellites, components, infrastructure with high competitiveness

- Low-cost, Quick, Practical level
- Human Resource Training
- Promotion
- Ground Station
- Ground Testing

New Paradigm of Space Development and Utilization

- Space science mission
- Mission creation

Four satellite development

- Optical system, Image processing
- Advanced components
- Miniature components

Infrastructure

- Novel Missions Demo.
- Personal use Novel missions
- Foreign Customers

New utilizations

New Players
Hodoyoshi-3 (left) and Hodoyoshi-4 before Shipment (April, 2014)

Target: 50kg class satellite to be developed within $3M and 2 years

Size: 50x50x80cm 60kg  Downlink: 10Mbps  Power: max 100W  average 50W
Attitude Control Capability:
- Stability 0.08 deg/s (Roll, Pitch)  0.8 deg/s (Yaw)
- Pointing accuracy 0.2 deg  2 deg
- Determination accuracy 0.0048 deg  0.048 deg
AXELGLOBE

microsats constellation

Monitoring whole world, every day
Small SAR Satellite Constellation

- Small SAR (Synthetic Aperture Radar) satellite constellation for frequent and persistent information gathering from Earth
- Six satellite constellation until 2021, 20 sats are the goal to achieve daily to hourly revisit
- The launch of the first demo satellite will be in late 2019 and now in EM development phase
  - Demo satellite: 3m ground resolution, 140kg, 0.7m cubic size, designed based on Hodoyoshi outcomes
- The mission part is developed in ImPACT (Impulsing Paradigm Change through Disruptive Technologies) program, funded by Cabinet Office, Government of Japan
Big Data for development: preventing the spread of epidemics

"The use of Information and Communication Technologies (ICTs) plays an important role to break the chain of health-related emergencies such as Ebola virus transmission" (Resolution 202, PP-2014).

Big data derived from the use of ICTs holds great promises to help address global development challenges. Digital footprints left through the use of online services, phones and other digital transactions, can be gathered, analyzed and used to develop better policies, and provide more individualized services and critical information. Because of the near ubiquity of the mobile-cellular network and since a growing number of people are using mobile phones, data from mobile phone operators are particularly valuable, including in the case of emergencies.

As part of ITU’s efforts to support its Members States in the area of emergency telecommunications, a big data project was launched in 2015. The project showcased the potential of big data to facilitate the timely exchange of information to combat the Ebola epidemic - which had gripped West Africa in 2014 - and future health crises. The project used Call Detail Record (CRD) data, which includes information on the use of the mobile phone, including the location, from mobile network operators in Liberia, Guinea and Sierra Leone. The project demonstrated how analyzed CDR data can provide information on human mobility, including cross-border movement, and the spatiotemporal distribution of people, while safeguarding individual privacy. In the case of the outbreak of a disease this information is critical for governments as well as for humanitarian aid agencies, for effective intervention, and to tackle the disease. It can further be used to build models of population flow patterns over time, and at specific events, and to combine these data with other information.
キャプションを入力してください。