Proposal of Nano-satellite IoT Constellation Mission by International Collaboration - 10th UNISEC-GLOBAL Meeting

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Contents

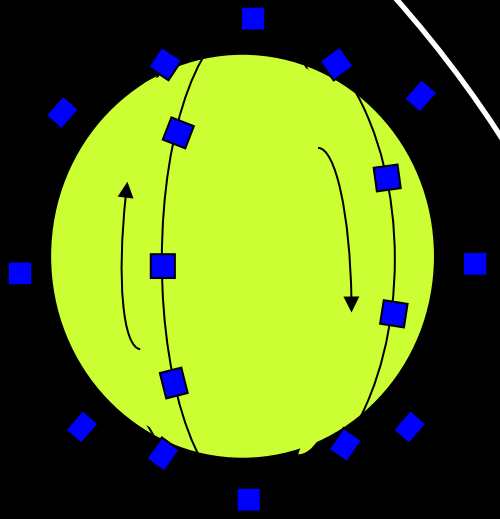
How about developing nano-sat constellation as UNISEC-GLOBAL Joint mission?

Assumptions:

- Jointly design satellite bus (3-6U) with online guidance (education)
- Each satellite will be developed by each country with its own funding or if difficult, we will jointly search for international funds.
- All the satellites have the **same mission payload** to contribute to solving global problems or local problems, etc., as **a constellation**.
- Each country can have **one specific mission payload** for its own interest

Why Constellation is Required ?
- Earth observation case -

LEO (500-800km alt.)
Almost all remote sensing sat.
- High spatial resolution 0.3m – 30m
- Time resolution is several - 40 days
- Several hundreds sats required for less than 1 hour time resolution



Constellation of many LEO satellites

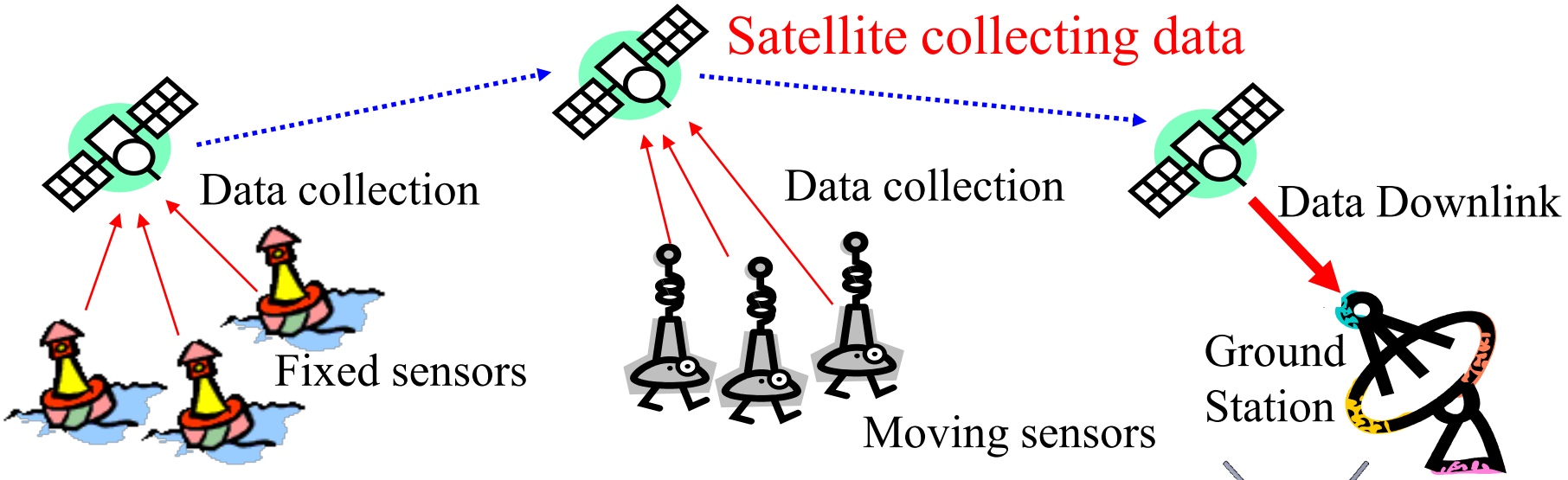
GEO (36000km alt.)
Himawari and a few satellites.
- Low spatial resolution (18m – 2 km)
- Continuous monitoring possible
- High time resolution achieved by quick scanning (even 10 minutes)

Merits of LEO Constellation

- Earth Observation
  - Higher time resolution: from once per 20-40 days to once/twice per day
  - Robust to one satellite failure
- Communication
  - 24 hours' service possible with many satellites
  - Short delay of communication
  - Cross link between satellites can improve the service in future
- In-situ Monitoring or Sensing in/from Space
  - Multi-site, simultaneous monitoring in/from space
  - Aims at scientific or environmental observations

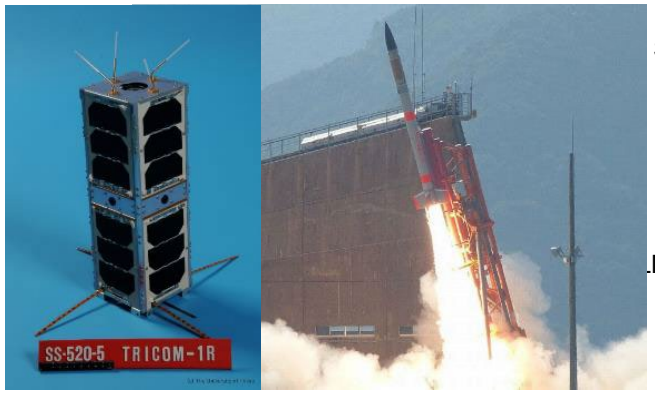
What kind of mission would be suitable for common mission and specific missions ?

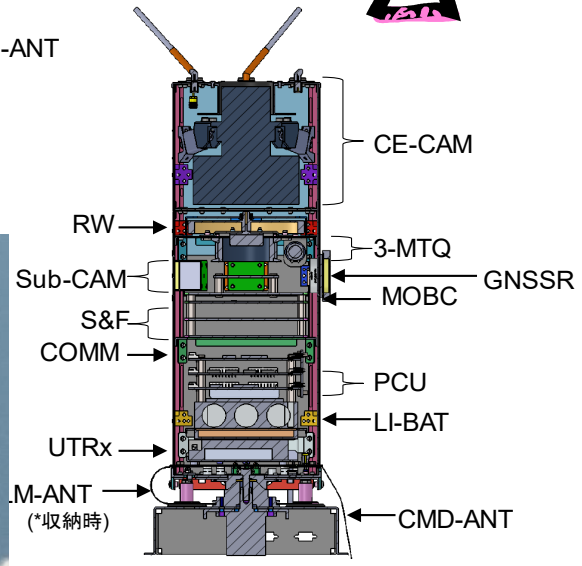
Common Mission: “Store & Forward (IoT)”



Application areas: disaster prediction, water level monitoring, soil moisture, PH…..

Low power transmission is key: 8 -130 mW RF power, low data rate (300bps) transmission was successful. (2018)



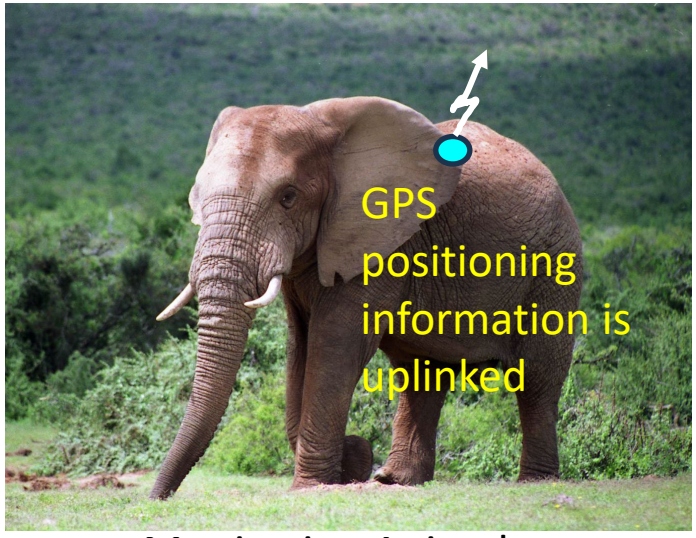


3kg TRICOM-1R

Merit of “IoT” as Common Mission

- IoT satellite can be developed in 3U-6U size and does not require so high level satellite-bus
  - Even not so high data rate (300-500bps) can send important ground information (idea is important !)
  - One satellite can receive data for 40 min per day
- If the number of satellites increases, service time increases (launch orbit coordination will further increase the service time)
- Ground sensors can be invented/improved even after the satellites are launched
  - You can develop new sensors suitable for problem solving in your countries
  - Sensors can be shared between member countries

Use case of “Store and Forward”



Monitoring Animal
Movements over wide area

Wild Fire Detection and Monitoring
(temperature sensor network)

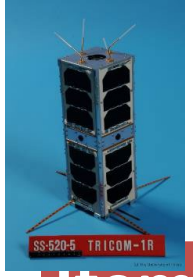
Flood Detection and Monitoring
(Water Leven Sensor Network)

Agriculture Field Monitoring
(PH, moisture level sensors)

Global Problems on the Earth are Becoming Severer

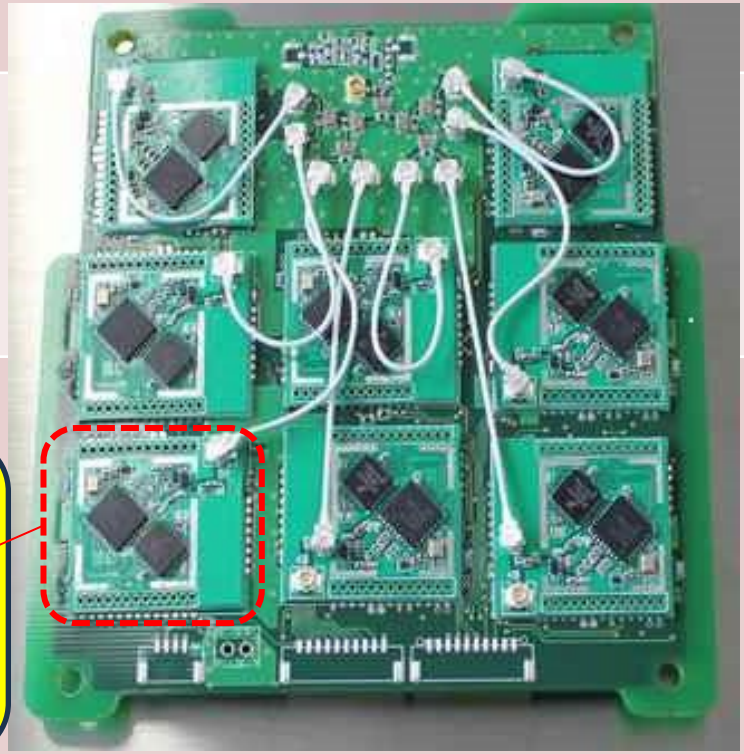
- Global problems on the Earth
  - Global Warming
  - Wildfire
  - Deforestation
  - Desertification
  - Flood and Drought
  - Earthquake
  - Tsunami
  - Volcano explosion, etc.
- The situation seems to be getting worse

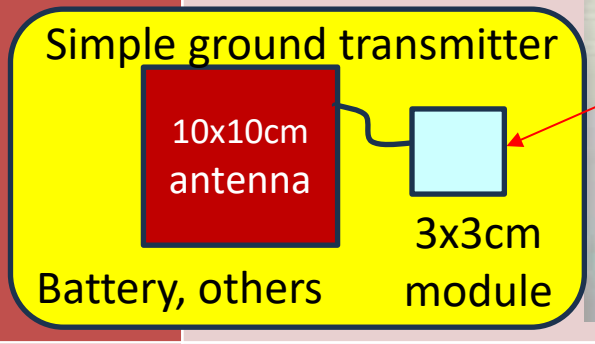
What information should be collected from wide area to mitigate such problems ?



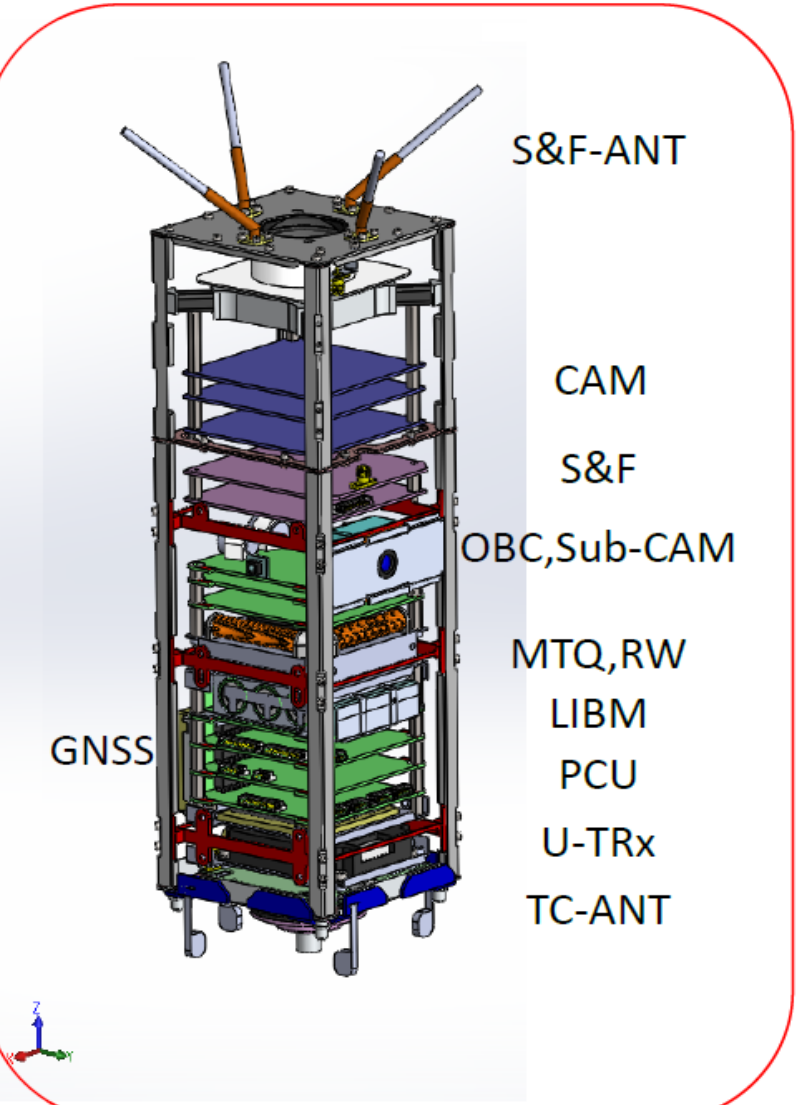
TRICOM-1R Weak Signal Receiver for Data Collection Capability

Item	Specification
bit rate	300 bps, maximum 8 channels in parallel
Transmission duration	< 300 sec
Transmission power from ground	20 mW
Frequency band	920 MHz (no license of usage is required if using 20mW power)

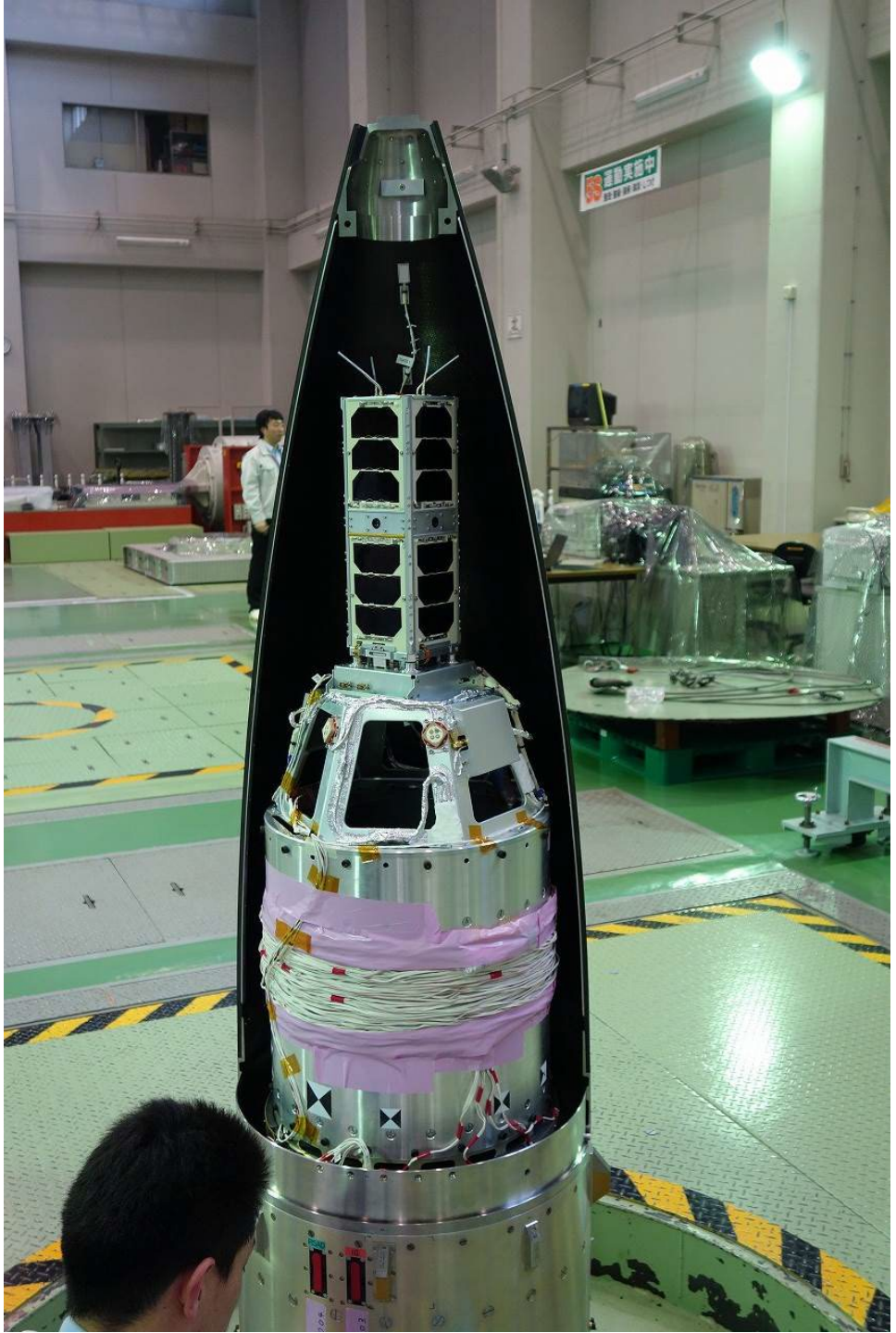




3U CubeSat “TriCom-1R”
- S&F Test Satellite (2018.1) -



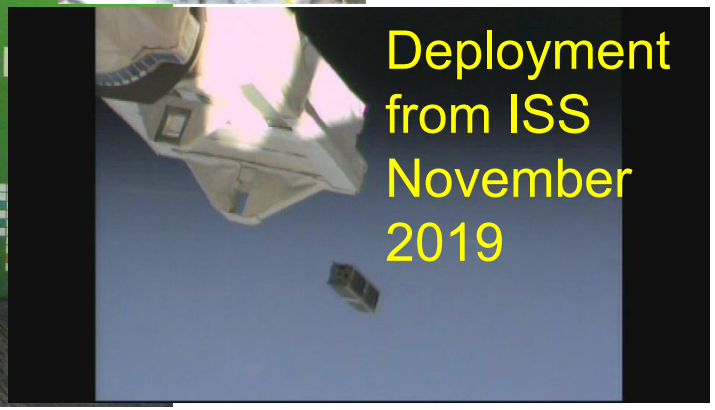
Items	Values	Miscellaneous
Size	10x10x30cm	3U size
Weight	< 3kg	
OBC	"Bocchan"board	Internal made
Power (average)	4W	AZUR GaAs cell
Battery	Li-Ion 41 wh	LIBM
Downlink (H/K&data)	W 1.2kbps	460MHz AFSK "U-TRx"
Uplink(H/K)	50W 9600bps	401MHz
Attitude	Simple 3 axis	B-dot law only
Sensor	magnetic sensor, gyro GPS receiver	"GNSS"
Actuators	magnet torquer despun wheel	"MTQ" "RW"
Camera	GSD 314 m VGA @180km	"CAM"
Sub-Camera	GSD 67 m @600km	"Sub-CAM"



"Modified SS520-5"

Dedicated rocket for CubeSat by JAXA

H-IIB launch September 25, 2019



MOU to develop 3U CubeSat to be deployed from ISS

Rwanda's first satellite "RWASAT-1" (launched in 2019)

News from Africa (09/05/2018)

Smart Africa, Rwanda Sign Deal With Tokyo University For Satellite Technology

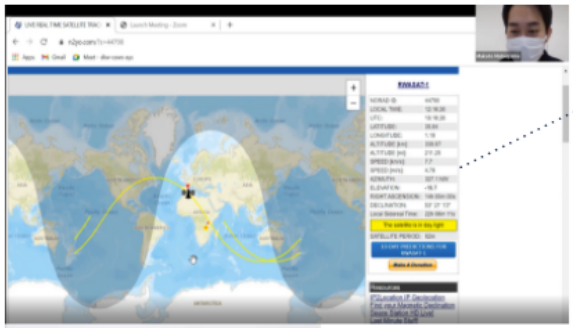
Taarifa
We Give You The Facts, You Connect The Dots

Satellite Development and S&F Experiment in Rwanda

- Development in Japan
- Sending data to RWASAT-1 from rooftop of RSA's office
- Possible applications:
  - PH or moisture level of land
  - Flood or water level
  - Water quality
  - Emergent/health information

ArkEdgeSpace

Remote instruction from Japan



Remote co-operation

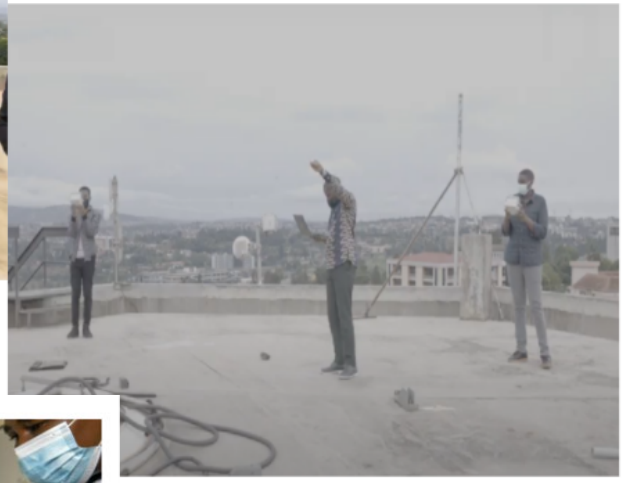
-Rwasat-1 appeared from the direction XX, please start

-OK

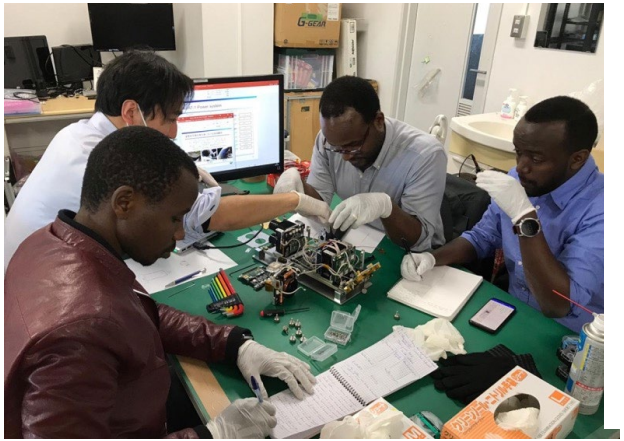
-Its elevation is XX, please keep tracking

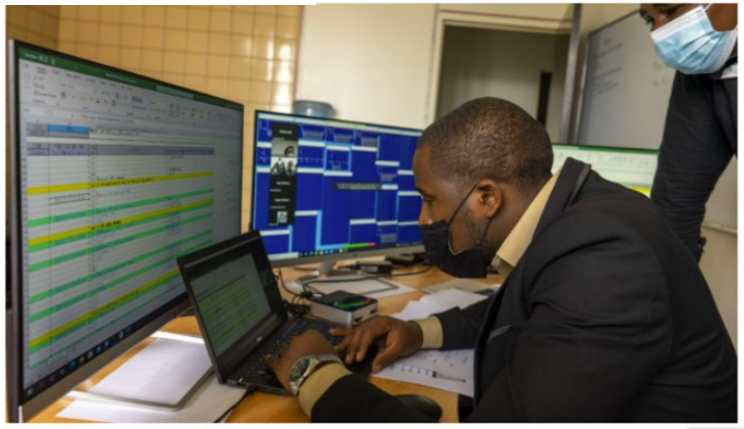
-OK

Ground test on the rooftop in Rwanda



Satellite development and test in Fukui prefecture





Ground operation in Rwanda

Merits of “Constellation” for IoT

- One satellites only provide 4 x 10 min (SSO case) chance to receive data from ground
- Even if urgent data is sent to the satellite, some delay occurs until the data is downlinked to ground
- If a satellite fails, no backup is provided

- Constellation is important !
- The country who provides one satellite can use all the satellites for data collection
- We, university community may be able to contribute to the world by obtaining world-wide data (to solve global warming, flood, desertification, etc.)

What kind of mission payload you can develop for your specific mission ?

It would be difficult to accommodate so many varied payloads in the common satellite bus, so it is better to assume some payloads so that you can select from them, such as:

- cameras (several levels of resolution, wave lengths, etc.)
- in-situ measurement (such as magnetic or other field, particle, etc.)
- additional communication payload
- etc.

Please discuss within your country team

- As to “store and forward (IoT mission),” what kind of ground sensors you want to put on the ground of your country.
  - What information can be obtained with simple sensors?
  - How frequently you want to get the data from sensors?
  - How much data should be sent to the satellite?
- Specific mission payload suitable for your country’s interest
  - Each country should pick up one mission and develop and/or install to the satellite
  - This payload should be installed in 1U size, requiring not so large power, downlink service, precise attitude control, etc.

Fund Raising Chance in Japan

- NewSpace Africa Conference in Egypt: April 2025
- TICAD9 in Japan: August 2025

"Africa-Japan collaboration" has a chance to get big fund

- Japanese Space Strategic Fund: $7B (for 10 years)

"Data utilization network" in foreign countries

Development Items (1)

- IoT Receiver in 1U size
  - License free frequency is different by countries
    - 400MHz or 900MHz, two antennae(?), SDR receiver
    - Jointly apply for ITU for license-free frequency (?)
  - Standard interface with satellite bus
  - Data rate, transmission power, BER, etc. (depends on what kind of data to be downlinked)
  - Capability to decode multiply incoming signals
- IoT transmitter on ground
  - Data rate, transmission power, etc
  - Standard interface with ground sensors (mini-satellite)
- Current situation
  - Technology base exists in Arkedge Space and UT

Development Items (2)

- Common satellite bus to accommodate IoT module
  - Jointly design one common satellite (3U or 6U)
  - 3U: simple IoT satellite
  - 6U: IoT + specialized mission by country
- You can also develop your own satellite having the interface to the developed IoT module
- IoT module can also be installed on your satellite having different missions ("Parasite-Sat" concept)
  - Want to increase the quantity of IoT receivers in orbit
- Ground Sensors
  - With power system and interface to IoT transmitter
- Ground Stations
  - Uplink/downlink frequency search (VHF/UHF/S/X ?)
  - Amateur or experimental frequency ?
  - Ground information system accessible by members

Tentative Schedule

- Misson Conceptualization Phase
  - 12/2024-3/2025: Each country studies IoT mission and its own specific mission ⇒ requirement for IoT/specific payloads
- Conceptual design phase (incl. education)
  - 4/2025-8/2025: Collaboratively design one satellite bus, guided by Japanese team
- Fund raising (from now on)
  - We will seek Japanese governmental fund
  - Each country team contacts its own government/university to seek for funding
  - One idea is to formulate one “fund raising team” in UNIGLO to seek for more international funding source
- If we obtain enough funding, we can really start developing satellites one by one !

First Thing for you to do

- Please indicate how you want to contribute to this joint project (to UNISEC secretariat)
  1. Design of IoT module (transmitter/receiver)
  2. Join common satellite design/development project
  3. Want to develop your own satellite with the IoT module
  4. Want to install the IoT module to your satellite
  5. Want to develop ground sensor module
  6. Provide a ground station
  7. Develop ground data system
  8. Fund raising internationally

We need signs (non legal binding) from participants so that we can apply for Japanese government fund (later)

- Mission Definition 12/2024 - 3/2025 (All participants)
  - Each country's preferred IoT mission to define requirements
  - If you want specialized mission, your payload should be defined
- Conceptual design phase 4/2025 - 8/2025
  - Design of IoT module and its common interface
  - Design of common satellite bus (through online discussion)

Future Research Themes

- Two-way IoT communication method
  - Uplink only when downlink triggering signal comes
    - requiring less power
  - Can mitigate double reception of upcoming signals
- Ground information system design over the world
  - Connection of ground stations via internet and server to store data
- Research using the IoT data
  - Interested members can take IoT data all over the world by asking other countries to support their research
  - Research as to global problem solving with obtained data
- More effective IoT module concept
- ------ many other themes

Please send e-mail to

einfo@unisec.jp

Name, Organization, Country, intension from among:

1. Design of IoT module (transmitter/receiver)
2. Join common satellite design/development project
3. Want to develop your own satellite with the IoT module
4. Want to install the IoT module to your satellite
5. Want to develop ground sensor module
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