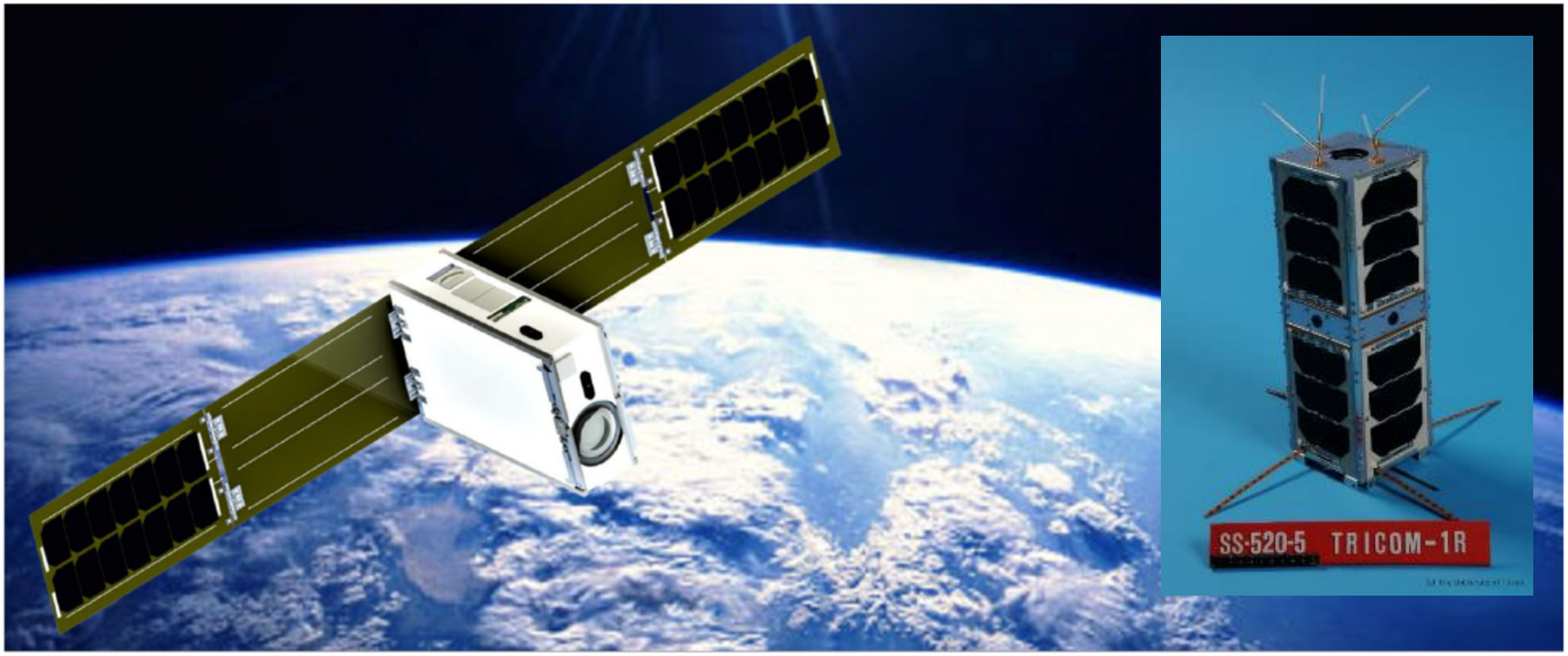
Nano-satellite IoT Constellation Program by International Collaboration

Shinichi Nakasuka, University of Tokyo

Contents

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

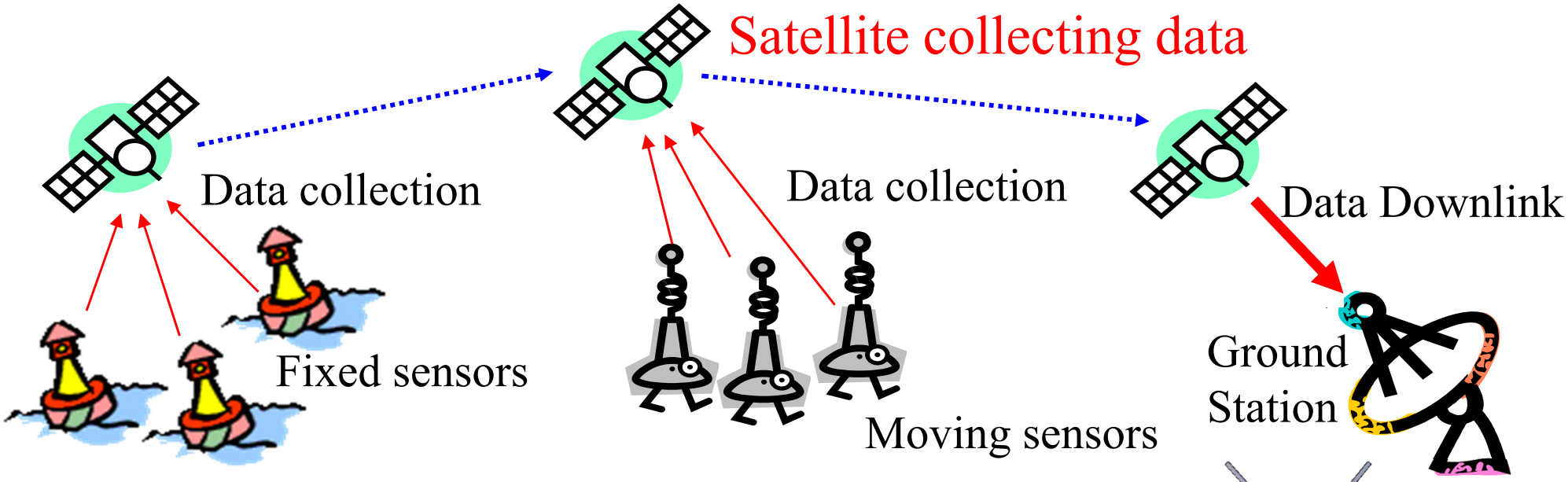


Assumptions:

- Jointly design satellite bus (3-6U) and mission payload with online guidance
- 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 **common mission payload** to contribute to solving global problems or local problems, etc., as **a constellation**.

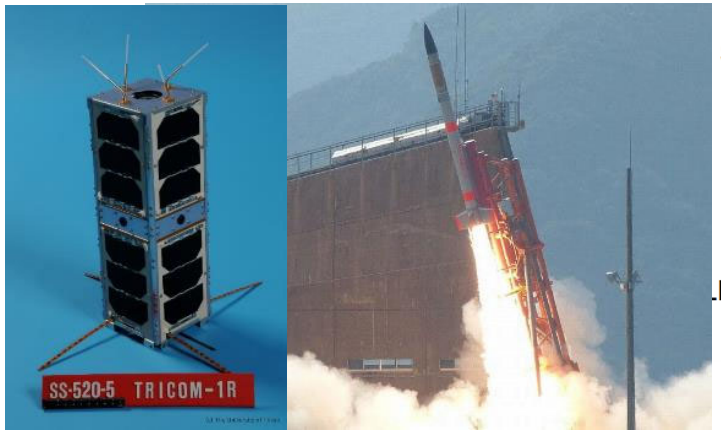
What kind of mission would be suitable for common mission ?

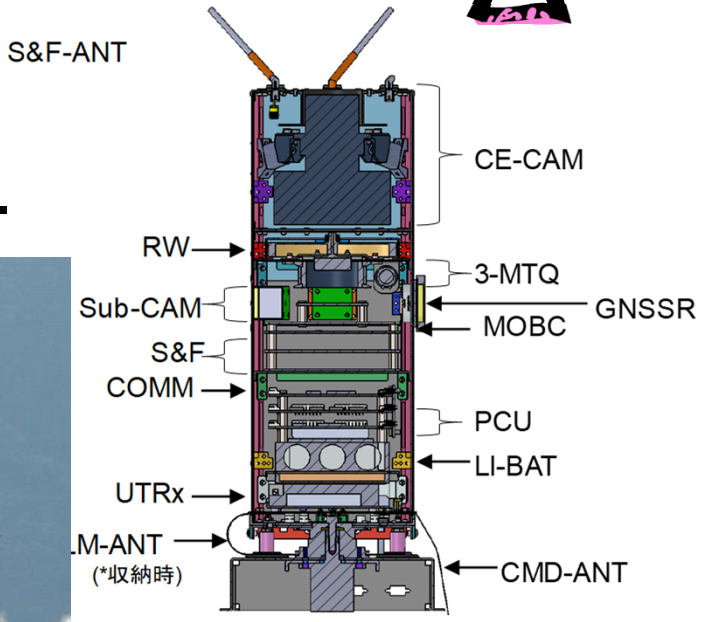
How about developing IoT Satellites?



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)



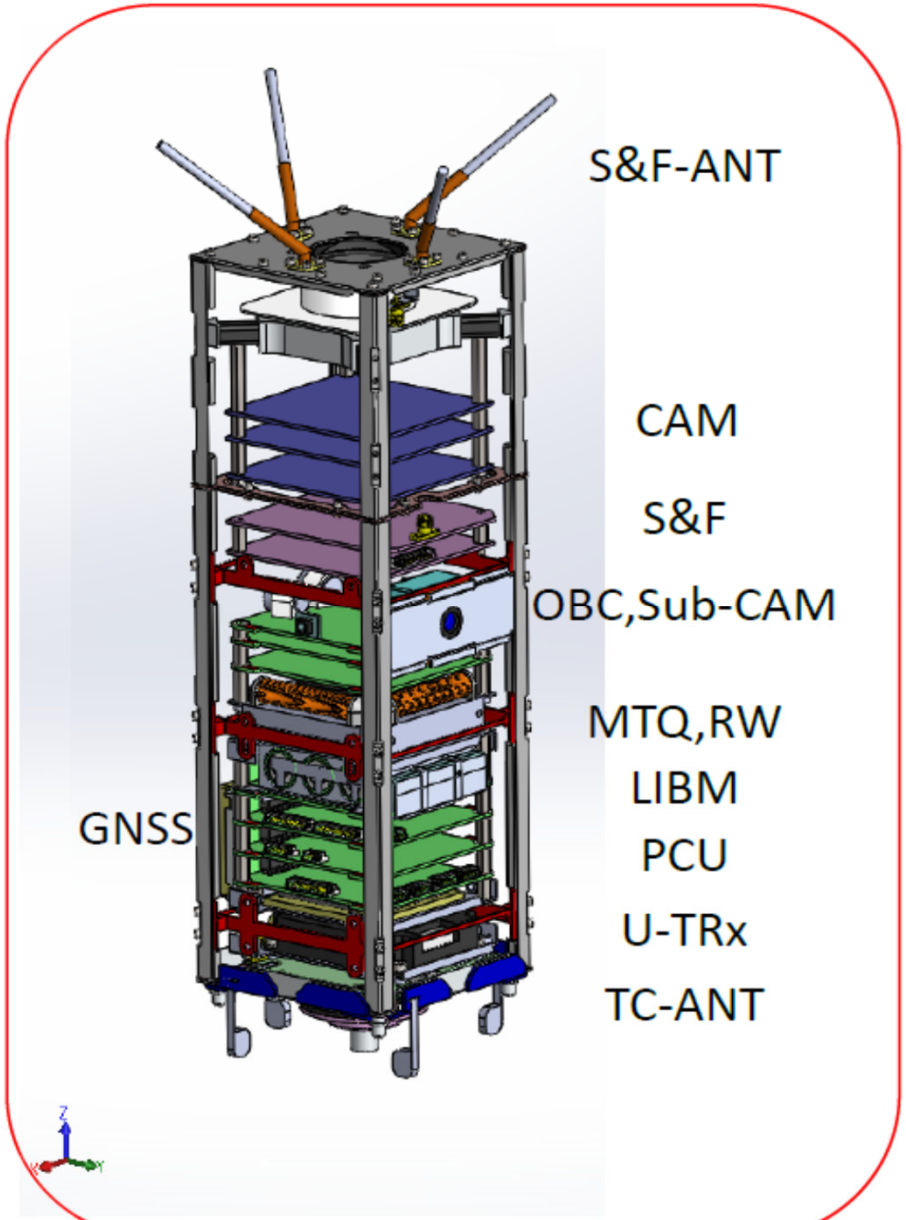


3kg TRICOM-1R

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 limited data rate (300-500bps) can send important ground information (idea is important !)
  - Communication service time using one satellite is about 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, which will appeal to your government
  - Sensors can be shared between member countries

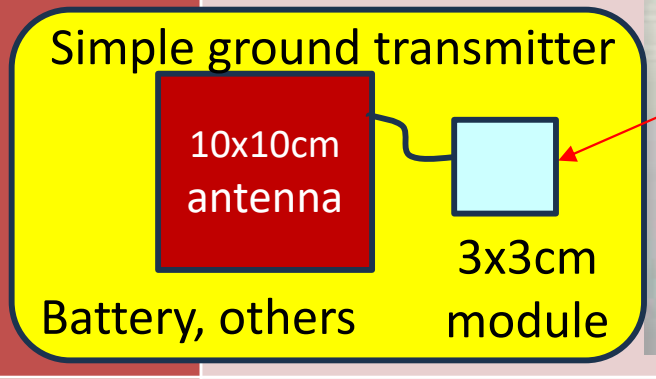
3U CubeSat “TriCom-1R”
- S&F Test Satellite (2018.1) -

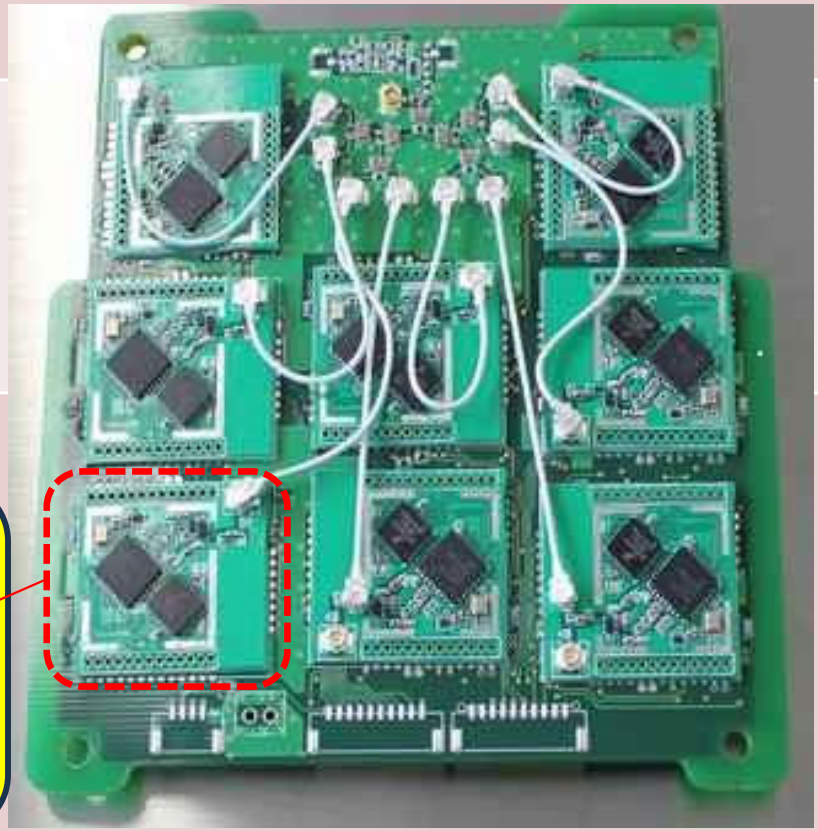


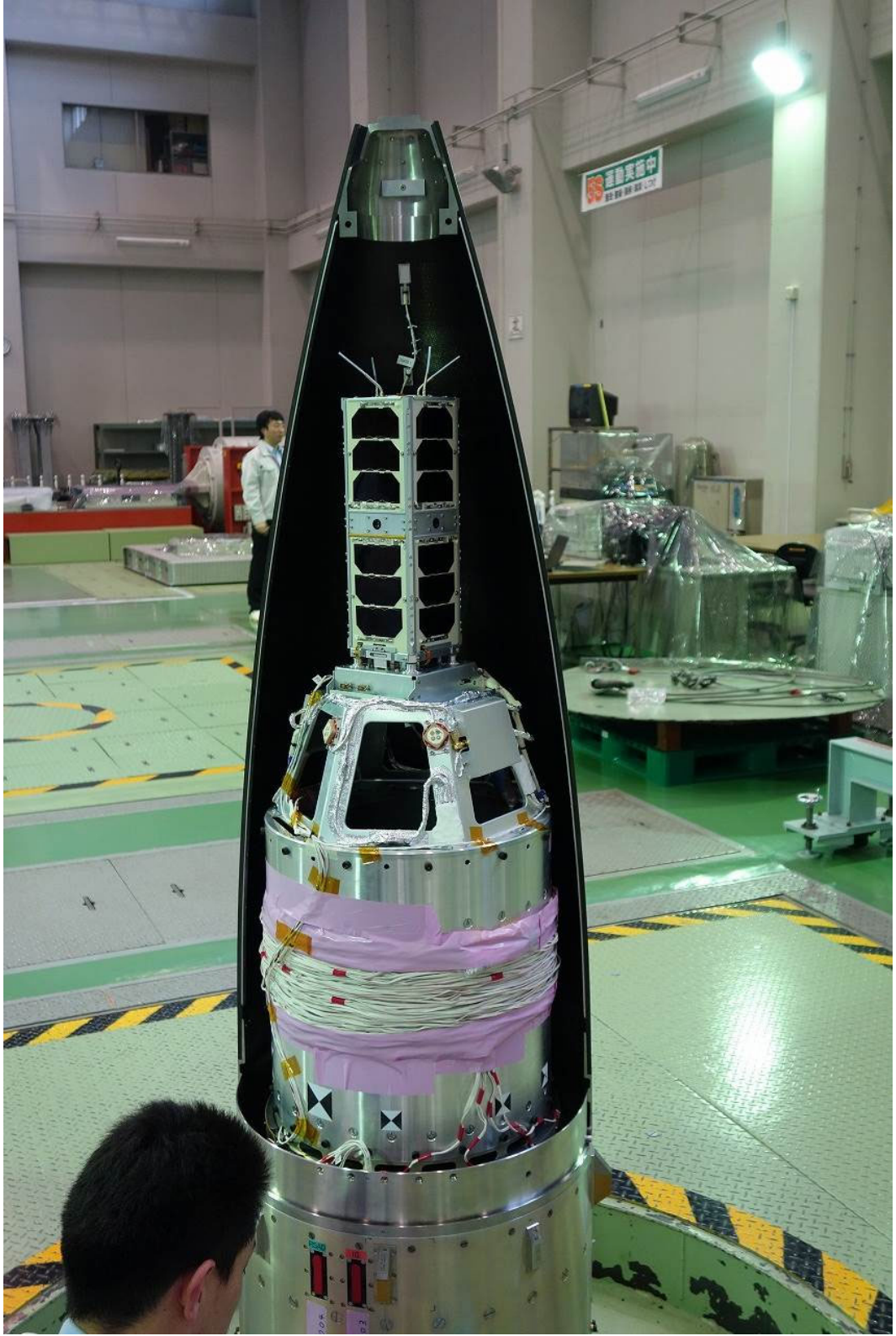
Items	Values	Miscellaneous
Size	10x10x30cm	3U size
Weight	< 3kg	
OBC	"Bocchan"board	Internal made
Power (average)	4W	AZUR GaAs cell
Battery	Li-Ion 41 wh	LIBM
Downlink (H/K&data)	W 1.2kbps	460MHz AFSK "U-TRx"
Uplink(H/K)	50W 9600bps	401MHz
Attitude	Simple 3 axis	B-dot law only
Sensor	magnetic sensor, 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"

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)







"Modified SS520-5"

Dedicated rocket for CubeSat by JAXA in 2018

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

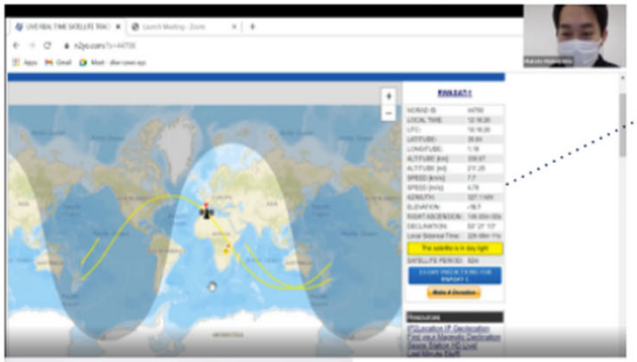
Taarifa
We Give You The Facts, You Connect The Dots

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



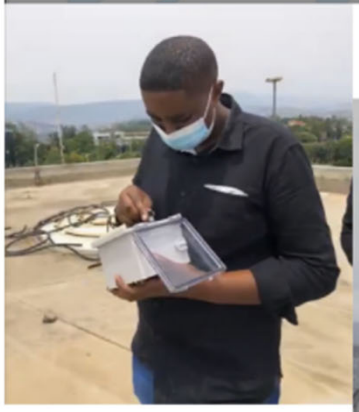
Remote co-operation

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

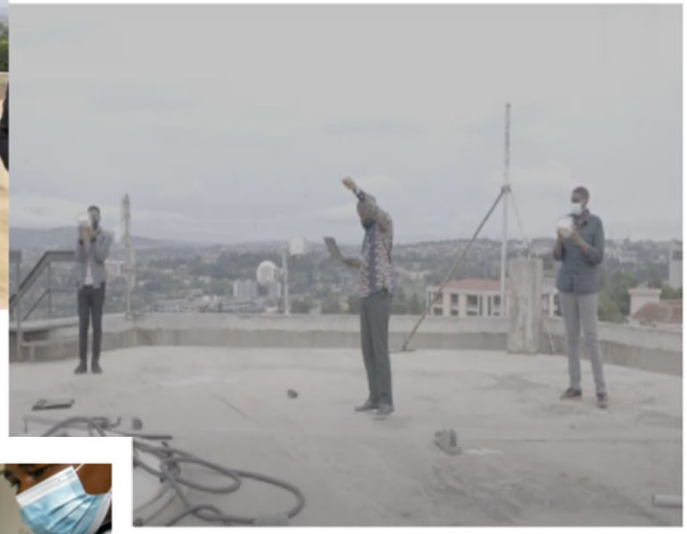
-OK

-Its elevation is XX, please keep tracking

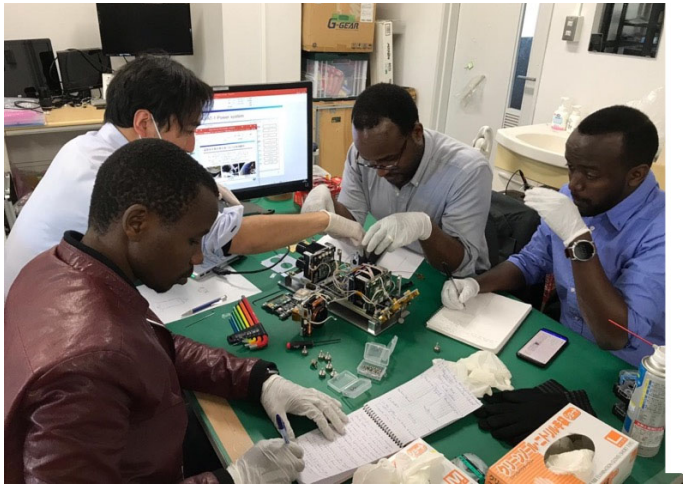
-OK

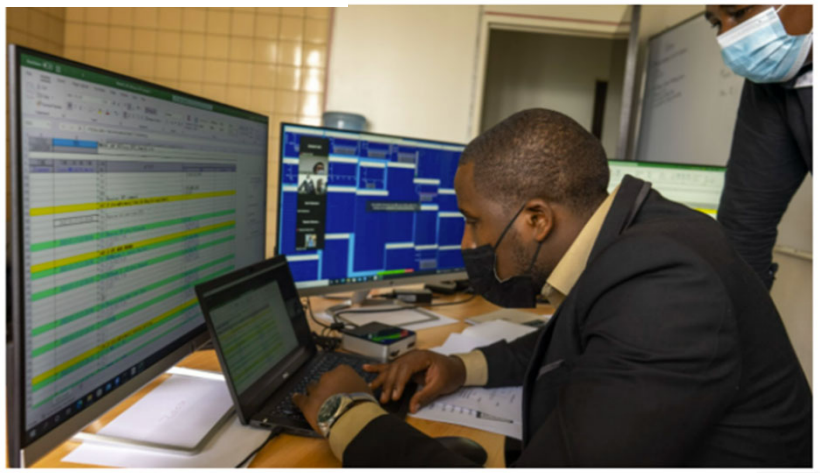


Ground test on the rooftop in Rwanda



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) chances 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

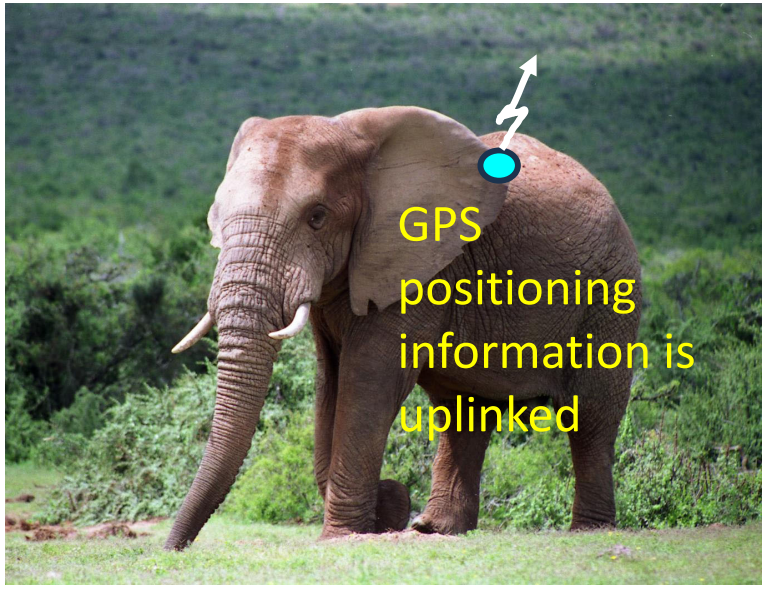
- Constellation is important !
- Participants can use all the satellites for IoT data collection
- We, university community may be able to contribute to the world by obtaining world-wide data (to solve global warming, flood, desertification, etc.)

1st Step: Definition of IoT Mission Details

1st step is to design the various parameters for our target IoT system, These parameters will be used to design the IoT transmitter and receiver systems, satellite bus system, and how many satellites are needed, etc.

1. Bit rate of transmission (bps)
2. Total amount of data per one transmission (byte)
3. Required transmission power and input power to the transmitter (W)
4. Interval of data reception from the sensor to one of the satellites (hours)
5. Allowable latency from data reception by satellites to the downlink to one of the ground stations (hours)
6. Error rate in the data transmission (%)
7. Decoding capability to correctly decode many packets which are coming to one satellite at the same time
8. Frequency for IoT data transmission (MHz)

We need to find “use cases” for IoT mission



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)

Let us create IoT missions to solve global problems on the Earth!

- 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 ?











Use Case Studies for Mission Definition

What kind of ground sensor systems are effective in addressing your country's social or environmental problems?

① How frequently should the sensor get data and send it to satellites?
ex) Once per day, at 2-hour intervals, 30-minute intervals, etc.

② How much data must be sent to the satellite in one data transmission?
ex) For example, if one data includes 8 data items each of 1 byte, then the packet size is 8 bytes.

③ How much delay is allowed from the time when a satellite receives the data from ground to the time when its data is downlinked to the ground station?
ex) If the data to be obtained is urgent data, then the allowed time may be one or two hours, but if it is agriculture-related information, one day or two days may be sufficient.

④ How many sensors will be placed in the vicinity of one another, for example, within a 10km x 10km area, to make your IoT mission meaningful?

If you come up with one idea for an IoT mission, please study more about the required sensor and the mission's impact on your society. Please specify what kind of sensor will be used in your IoT mission, who will use this data for what objective, and the mission's contribution to society.

How can you participate in this program ?

1. Show your intention by sending e-mail to the UNIGLO secretariat at iot@unisec-global.org
2. Download (or receive) the file to explain the IoT program as indicated by the secretariat.
3. Study possibilities of IoT mission in your country by thinking yourself, discussing with your colleagues or governmental officers.
4. Submit Excel file to describe your IoT mission idea to the secretariat.(as many as possible)

Excel file to be submitted (one example is shown)

Section 1: Mission overview

What kind of sensor data should be sent to satellites?	What kind of sensor is to be used for your IoT mission?	Who will use the data?	For what objectives?	Contributions to the society
Flood Detection and Monitoring	Water level sensor	Local and central governments	To mitigate disaster and save lives	We suffered from flood many times, which will be mitigated by finding the flood quickly in wide areas.

Section 2: Requirements for the IoT system

1) How frequently should the data be sent to satellites?	2) How much size of the date is to be sent to the satellite? (byte)	3) How much delay is allowed?	4) How many sensors will be put in 10km x 10km?	Priority
Once per 2 hours	One sensor requires 2 byte data. Several sensors data will be sent to a key comm station from which collected data will be sent to satellites. Total data amount will be 2 bytes x 50 sensors = 100 bytes.	The data had better be downlinked to ground in 1 hour after reception.	Along the dangerous river area, with 2km separation	5 (highest)