



Joint Global Multi-Nation Birds; Developing Nations' Testbed for Space Technology towards Sustainable Space Program

Taiwo Raphael TEJUMOLA, BIRDS Project Members,
BIRDS Partners, Mengu CHO

Laboratory of Spacecraft Environment Interaction Engineering,
Kyushu Institute of Technology,
Kitakyushu, Japan

7th Nano-Satellite Symposium, Kamchia. Bulgaria
October 18th-23rd. 2016.

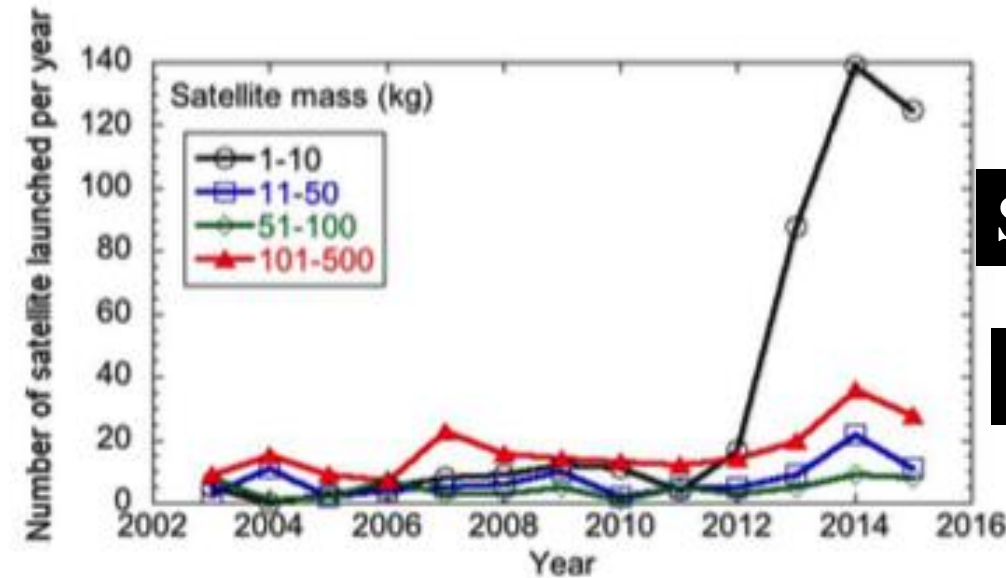


Outline



- ◎ Introduction: *Let's go Lean*
- ◎ BIRDS Satellite Project
- ◎ BIRDS System Configuration and
- ◎ Satellite Operation Strategy
- ◎ System Development Strategy
- ◎ Conclusion & Future Plans

Global participation in space activity is growing as satellite technology matures and spread due to proliferation of *Lean Satellites* (1kg -50kg)



Trend of small satellite launch

Project Cost

Delivery Time

Simplicity

Launch

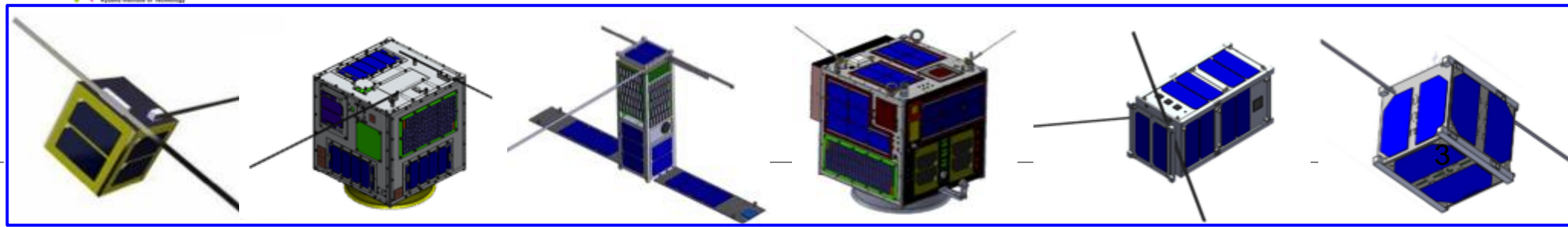
Waste Mitigation

High Risk Taking

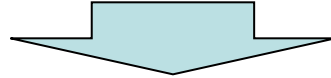
Mission Duration

Reliability Requirement

Risk Mitigation Approach



Space missions *cost too much* and *take too long* to achieve the mission objective.



Reinventing space using modern technology and *willingness to accept risk* to *do much more*, much *faster with fewer resources*.

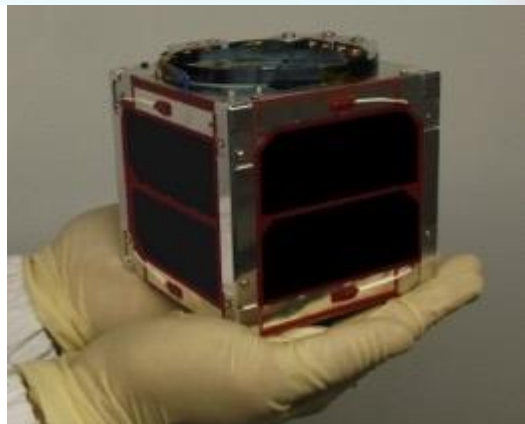


Lean satellite project

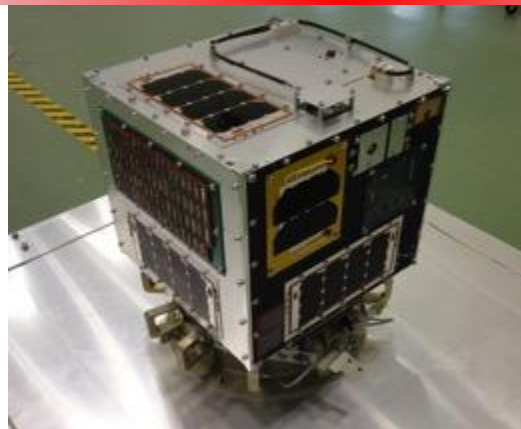
- ◎ Reduction in space mission cost and delivery time.
- ◎ Acceptance of higher mission risk and fragility.
- ◎ More responsive to world events and end user needs.
- ◎ More economical sustainable business model for space industry.
 - *Developing countries can adopt this model.*



Practical Lean Satellites at Kyutech



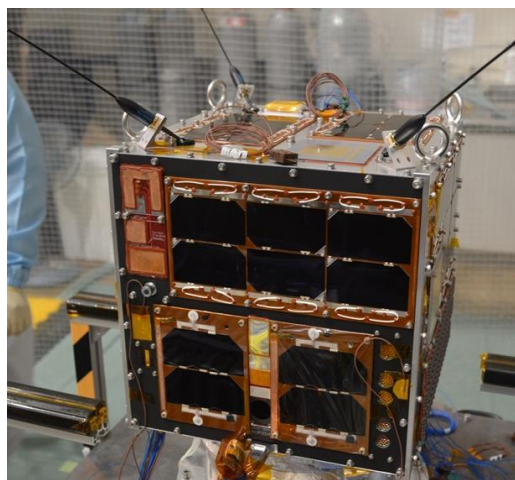
HORYU-1 (1U)
2006-2010
Not launched



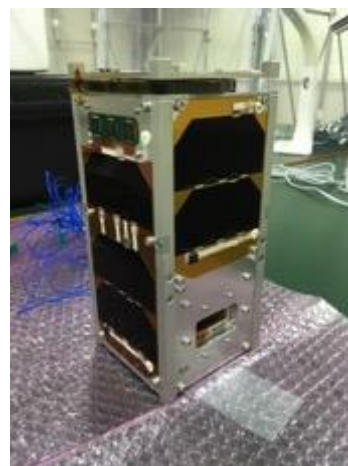
HORYU-II (30cmx30cmx30cm)
2010-2012
Launched on May 18, 2012



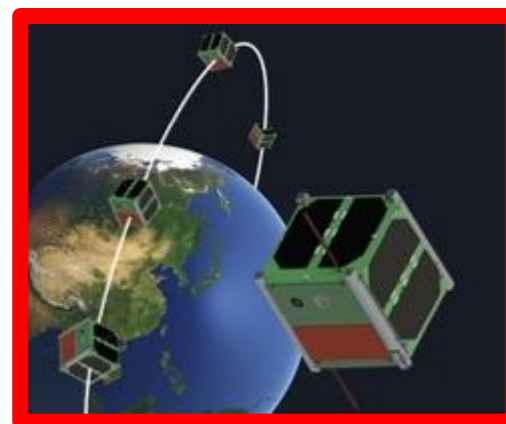
Shinen-2
2013-2014
Launched on Dec. 3, 2014



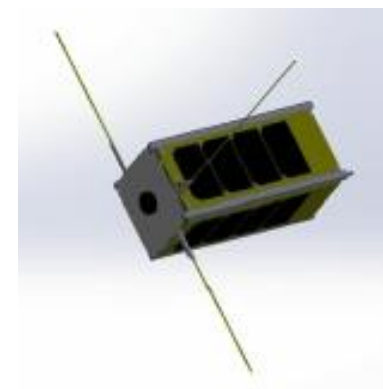
HORYU-IV
2013-2016
Launched on Feb.17, 2016



AOBA VELOX-III
2014-
To be launched in 2016



BIRDS constellation
2015-
To be launched in 2017

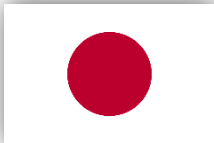


AOBA VELOX IV
2016-
To be launched in 2018

Joint **G**lobal **M**ulti-**N**ation **B**irds (JGMNB), a satellite program for non-space faring countries.

*Shortly called as “**BIRDS Project**”*

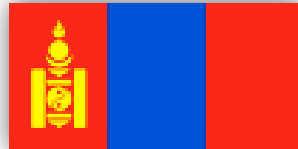
JAPAN



GHANA



MONGOLIA



NIGERIA



BANGLADESH



THAILAND



TAIWAN



Mission Statement

By successfully building and operating the first national satellite and making the foremost step toward indigenous space program at each nation.

7 Participating countries

2 years to achieve satellite Missions

4 Units of 1U CubeSats

6 Missions

4 Faculty members

Team of 15 graduate students

Operation from 7 ground stations



<http://birds.ele.kyutech.ac.jp/>





- ◎ Human network to achieve innovative System Engineering.
 - Demonstrate that a 1U CubeSats can be built and operated successfully in a **time frame shorter than 2 years** even for countries with **limited (or zero) satellite experience** with proper design and planning.
 - Starting a **sustainable and robust space program** with minimum budget at universities in emerging or developing countries.
 - **Competition and collaboration** among student members accelerate satellite development process and enhance the satellite quality.
- ◎ International Ground station network for CubeSat.
 - Obtain **key experiences regarding operation of satellite** constellation.
 - **Synergetic mission value and capability** via international operation.

- ◎ Take photograph of homeland via onboard cameras (CAM)
 Using 2 Cameras (SCAMP at 0.3MP, OV5642 at 5MP).



- ◎ Digi-singer Mission (SNG)
 Exchange of voice data from satellites to Ham Radio receivers (UHF band)



- ◎ Measure Single Event Latch-up in orbit (SEL)
 By taking log of microcontroller reset events over period of time.



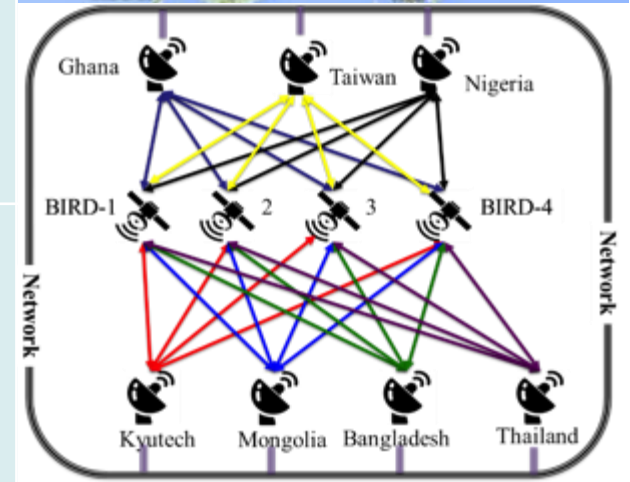
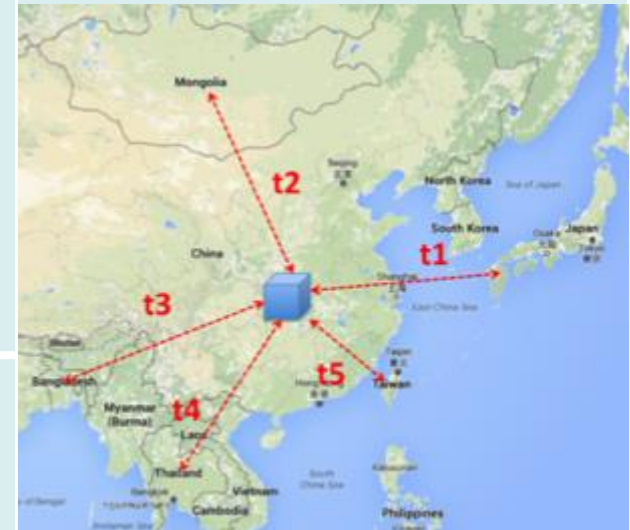
◎ Determination of Satellite Precise Location (POS) without GPS

Using analysis of TOA from time lag among multiple ground stations

◎ Atmospheric Density Measurement (ATM)

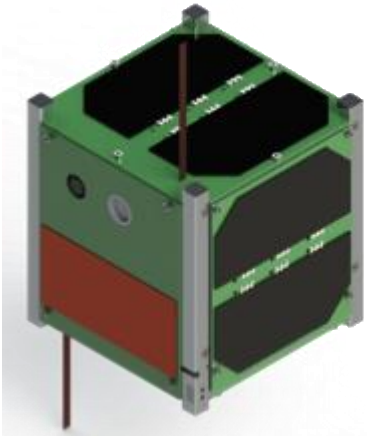
Using Orbital analysis from precise satellite tracking information (POS).

◎ Demonstrate Ground Station Network for CubeSat Constellation (NET)

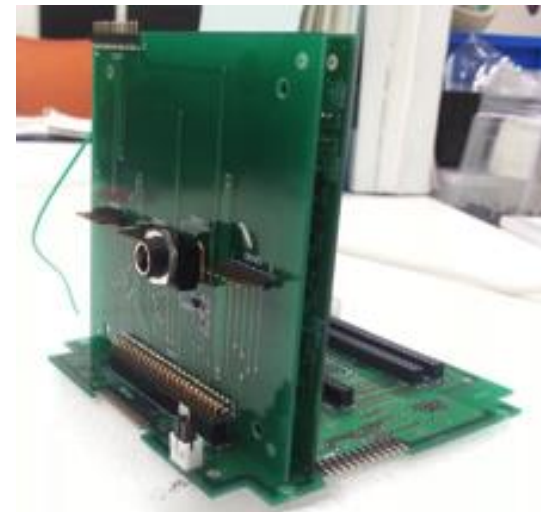


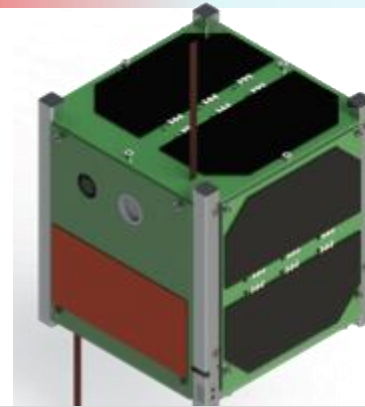
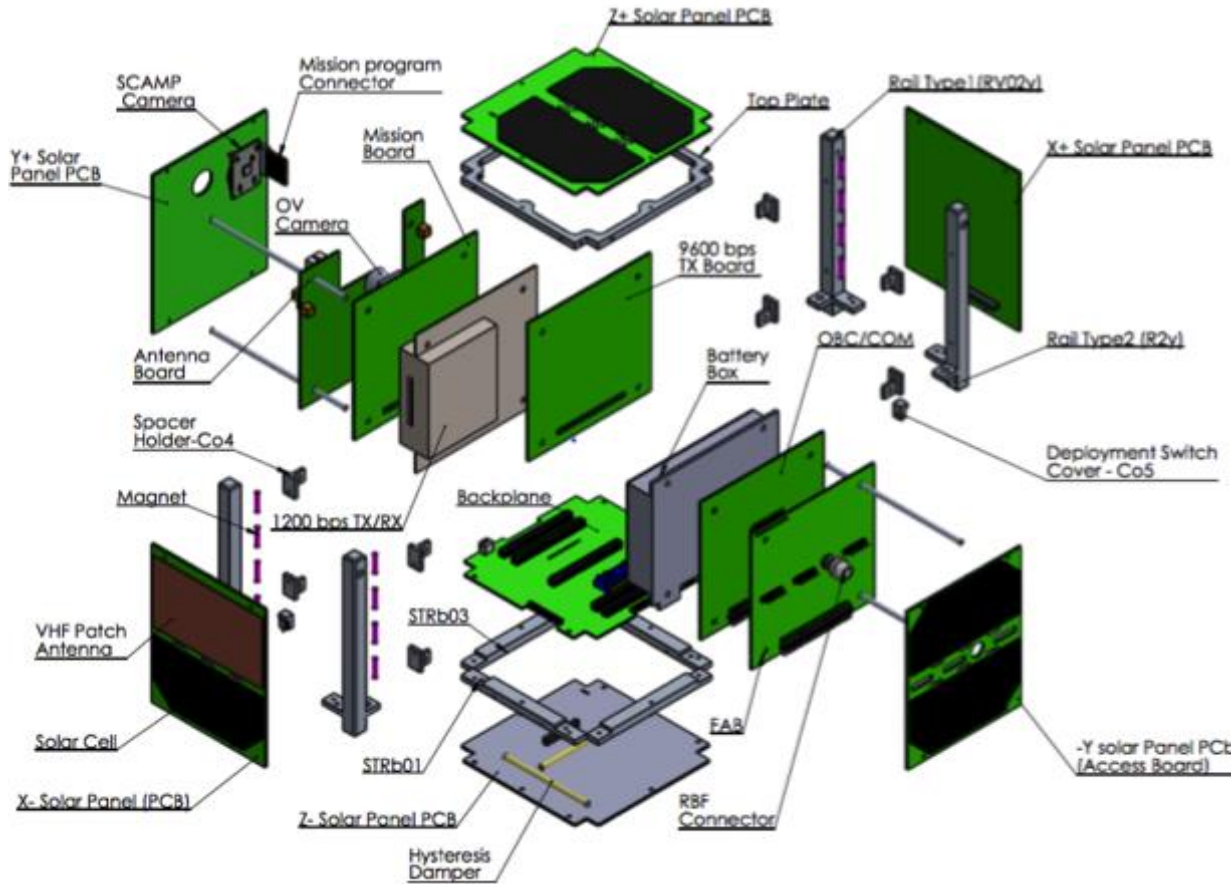
Features

- ◎ Constellation of four (4) **identical 1U CubeSats**.
- ◎ Share **same frequency** for TM & TC (UHF/VHF).
- ◎ **Modularized and Less harness** design.
- ◎ Using **Backplane style** introduced by University of Wurzburg (Germany) UWE-3.
- ◎ Only **single board** for OBC, COM and EPS.



*Main board and Backplane Designed
by Sagami Tsushin Co.,Ltd*





- ◎ Deployable UHF_9600bps
- ◎ Patch UHF_1200bps
- ◎ VHF Patch Antennas;
- ◎ Two UHF transmitters
 - (9600bps and 1200bps)
- ◎ VHF receiver;
- ◎ Battery (3 series 2 parallel)
 - Ni-MH batteries, 10 solar cells;
- ◎ Passive attitude control system
 - using hysteresis damper and
 - permanent magnet;

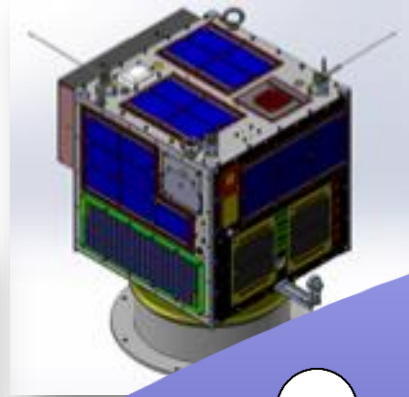
Modularized and less harness configuration

- ◎ Space proven bus system
- ◎ Modularized system



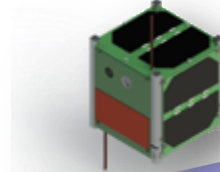
HORYU II

Launch date:
18th May 2012

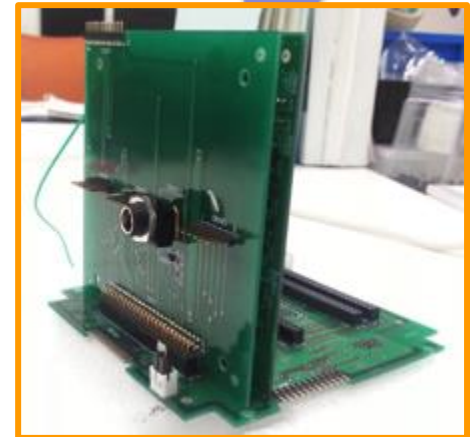


HORYU IV

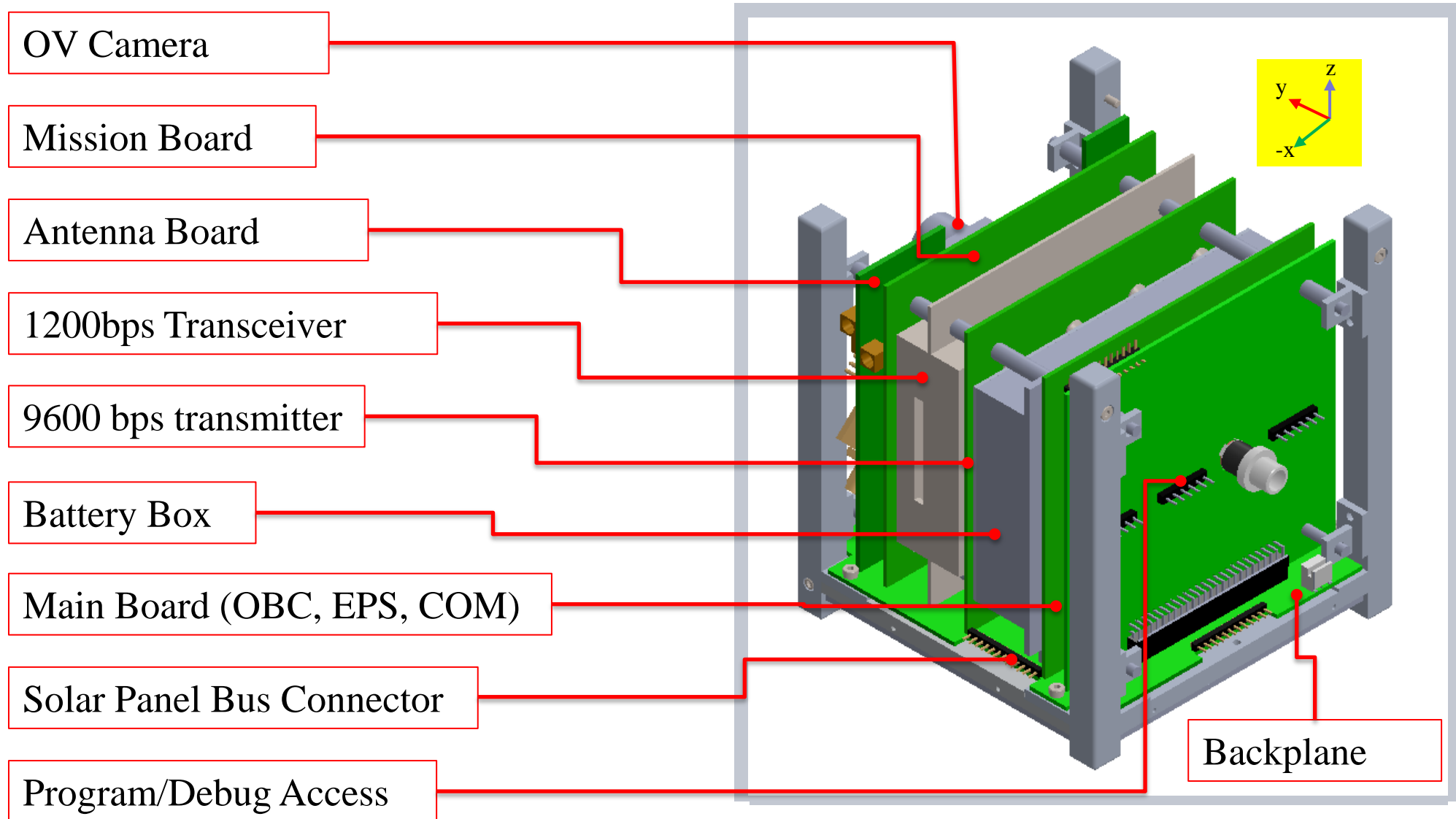
Launch date:
17th Feb. 2016

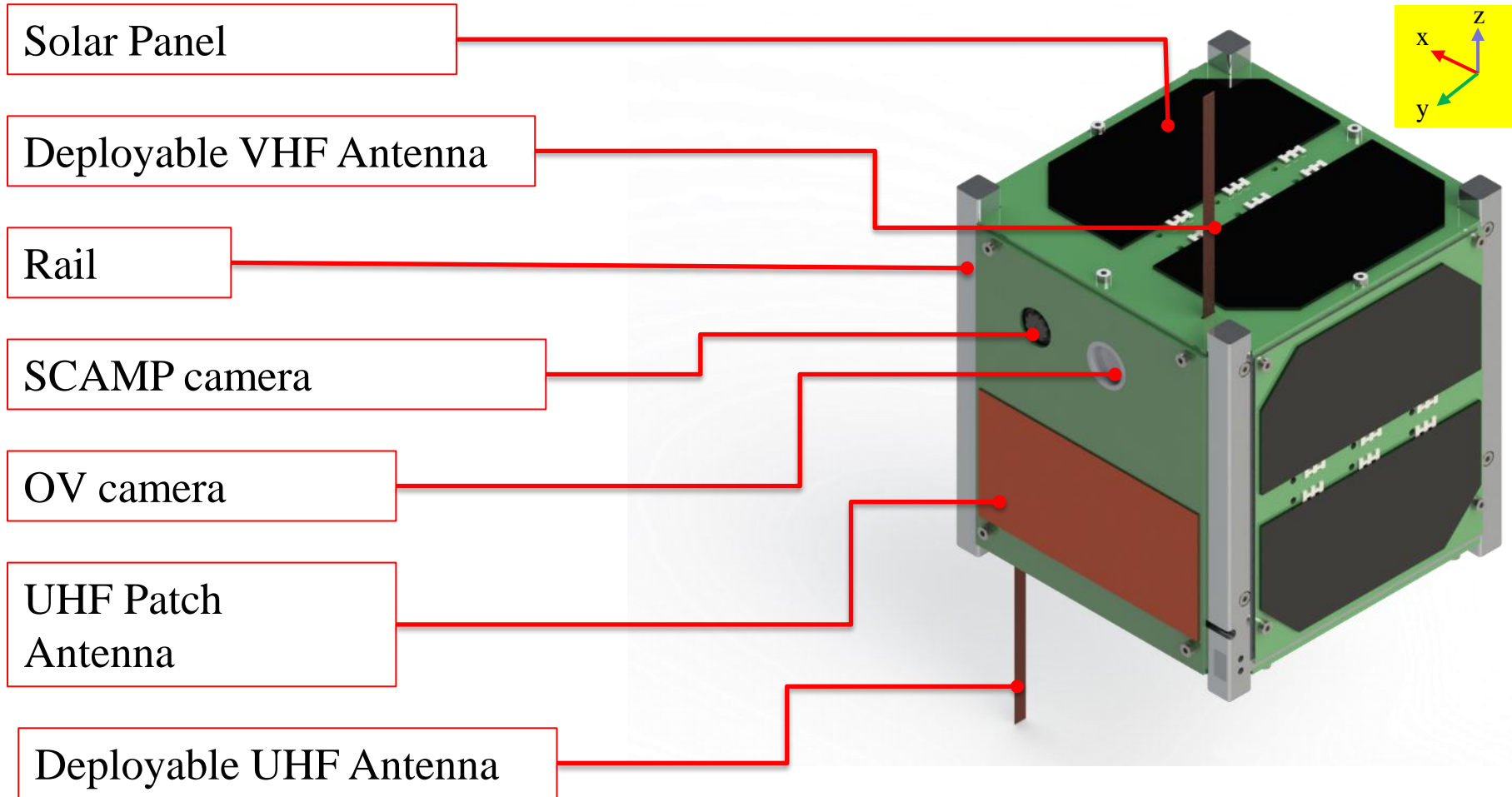


BIRDS



*Bus System of BIRDS
Designed by Sagami Tsushin Co.,Ltd. Japan*







◎ 7 Ground stations and 4 CubeSats.

◎ Innovative missions possible.

◎ Complete Mission failure unlikely.

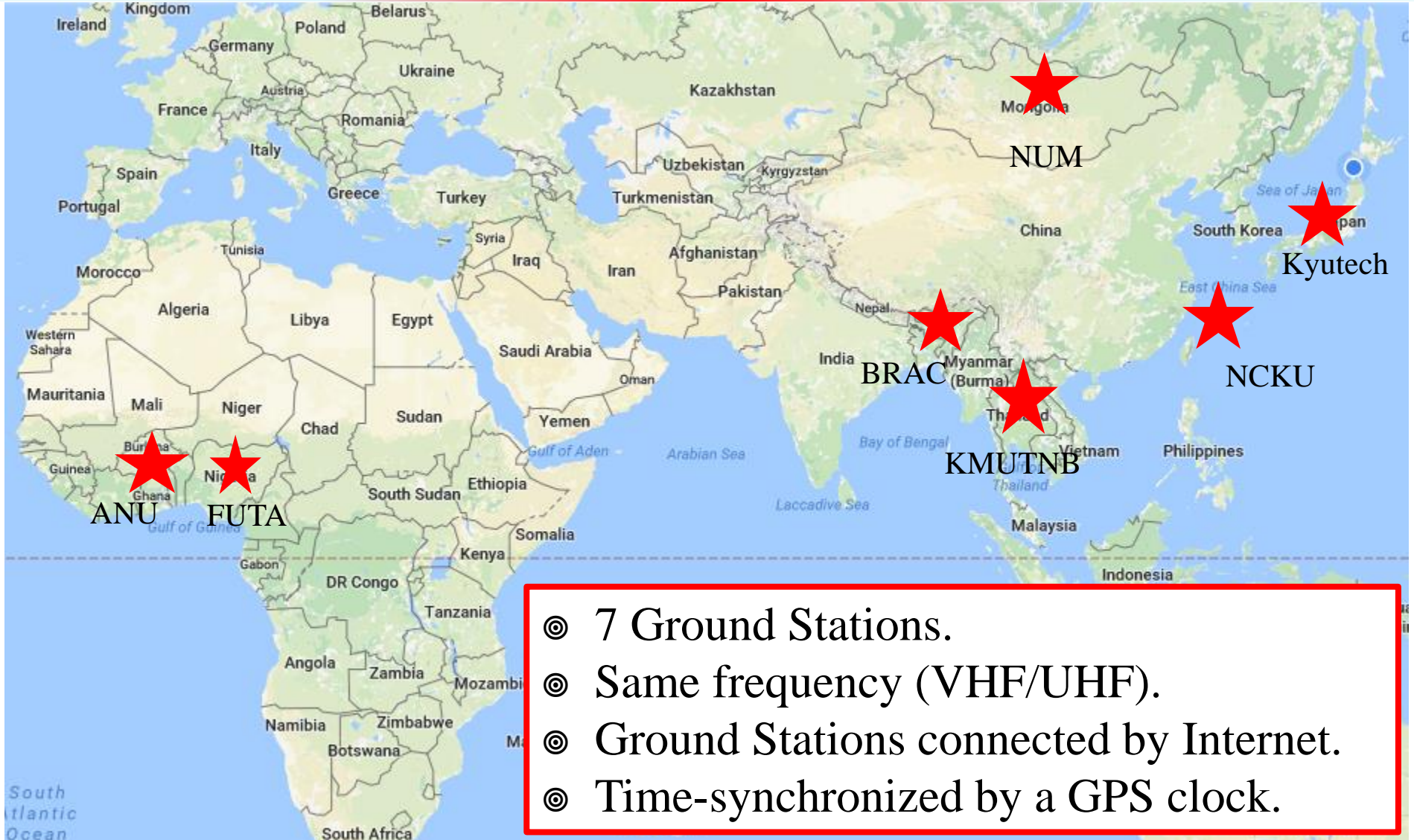
◎ Each Satellite have 2.4hour downlink time.

- 3 times more than using 1 Ground station

There are **benefits in Number**

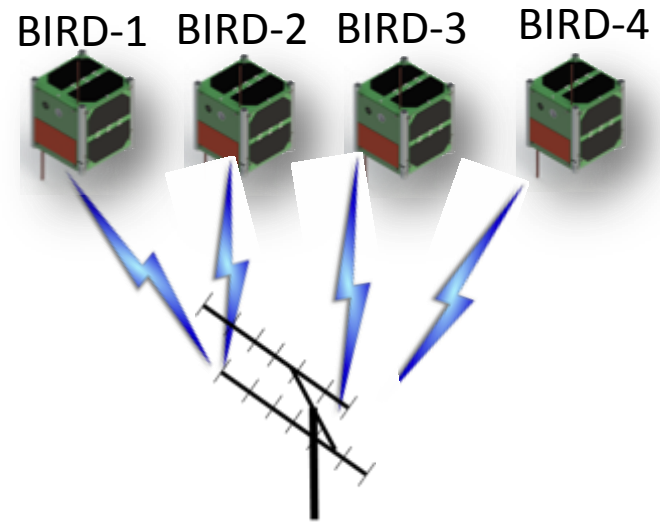
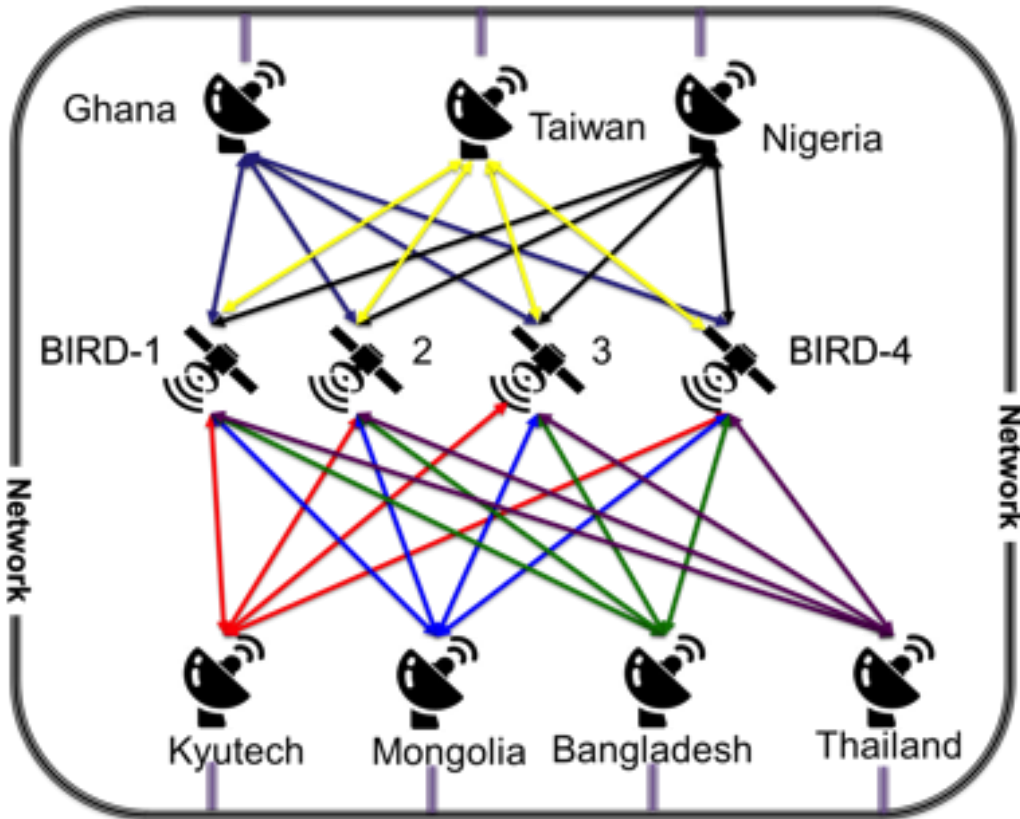


BIRDS Ground Station Network



- ◎ 7 Ground Stations.
- ◎ Same frequency (VHF/UHF).
- ◎ Ground Stations connected by Internet.
- ◎ Time-synchronized by a GPS clock.

<http://map.google.com>



High chance of RF signal interference
 ➤ Cross talk

- ◎ Uplink command contain header specifying the targeted satellite
- ◎ CW reference command is designed to halt all RF transmission

BIRDS Project
Present Stage
at October 2016



Launch

Flight Model
Fabrication

FDR; Flight Readiness Review

Engineering Model
Fabrication

● CDR; Critical Design Review

● PDR; Preliminary Design Review



Bread Board Model
Fabrication

Research and Discussion to
define CubeSat System

● SDR; System Design Review



Research and Discussion to
define CubeSat Mission

● MDR; Mission Definition Review

◎ Students carry out all system Engineering tasks.

- Making decisions and system documents.

◎ Elimination of waste

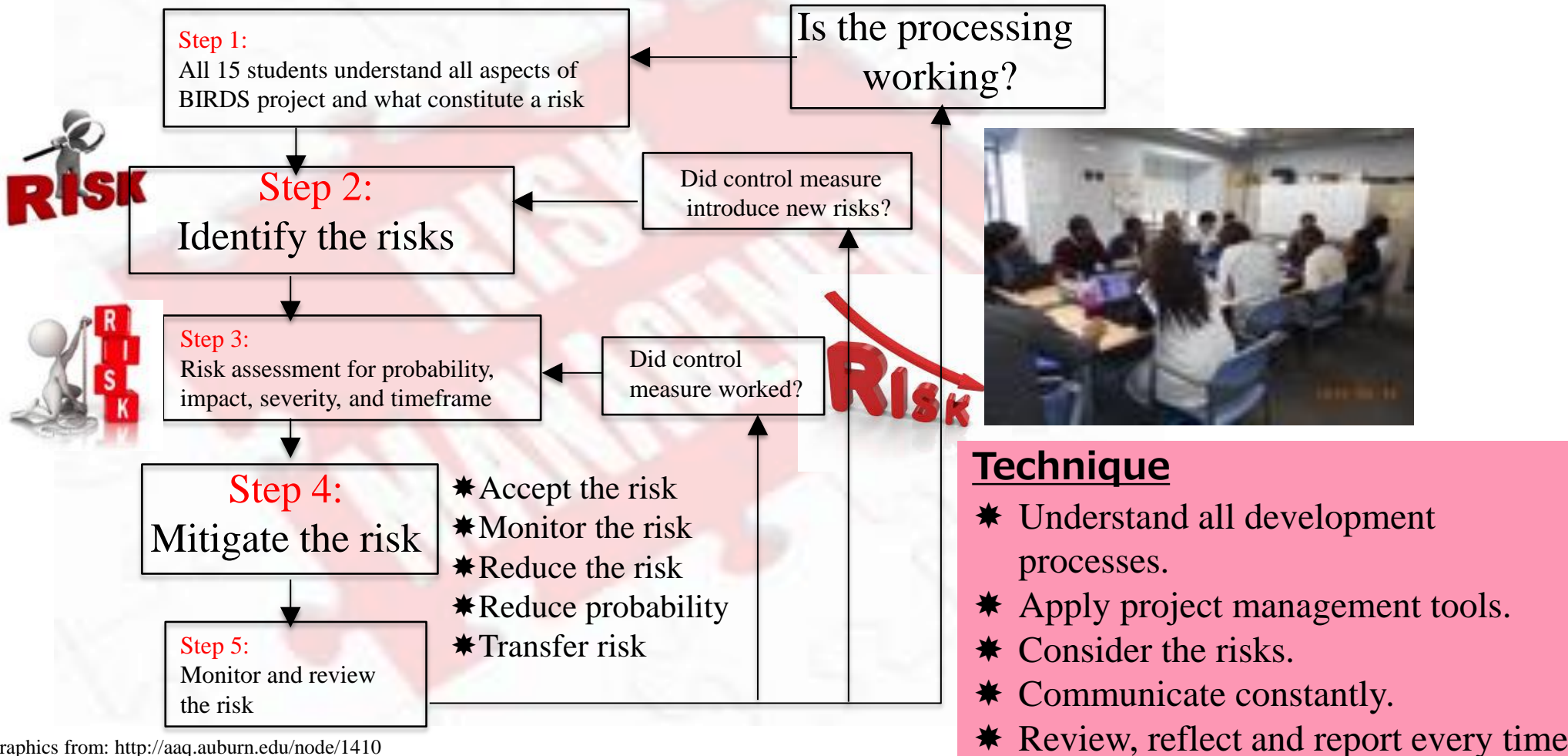
- Movement, waiting and communication.
- Colocation: All students stay in 1 room.
- All satellite development, review and testing are done in same building.



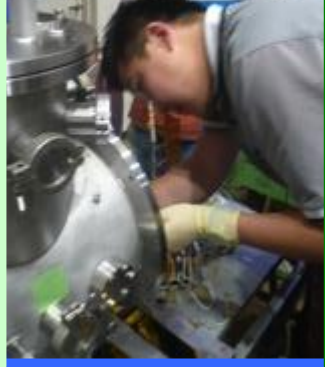
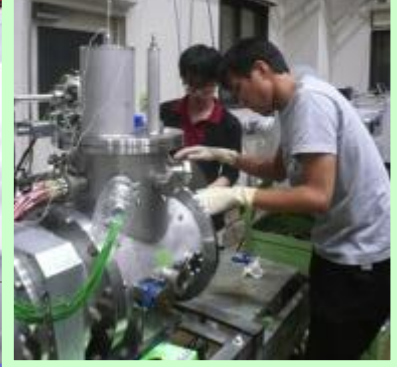
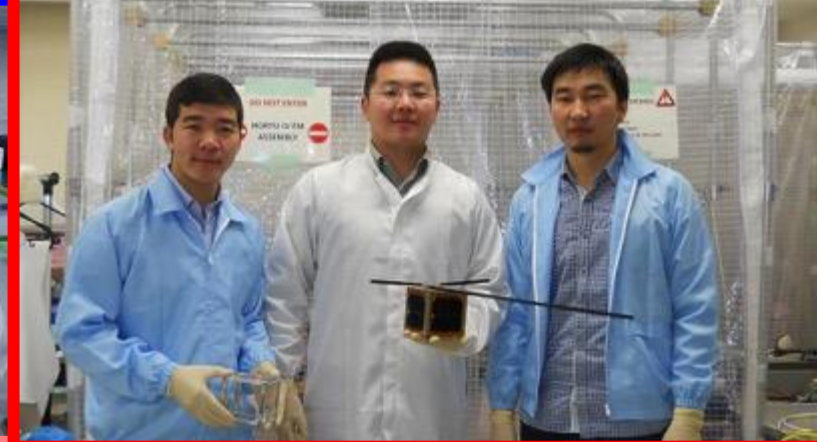
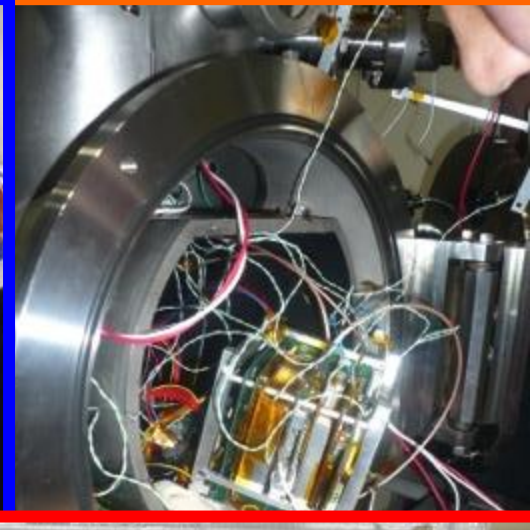
High Risk Taking

Reliability Requirement

Risk Mitigation Approach



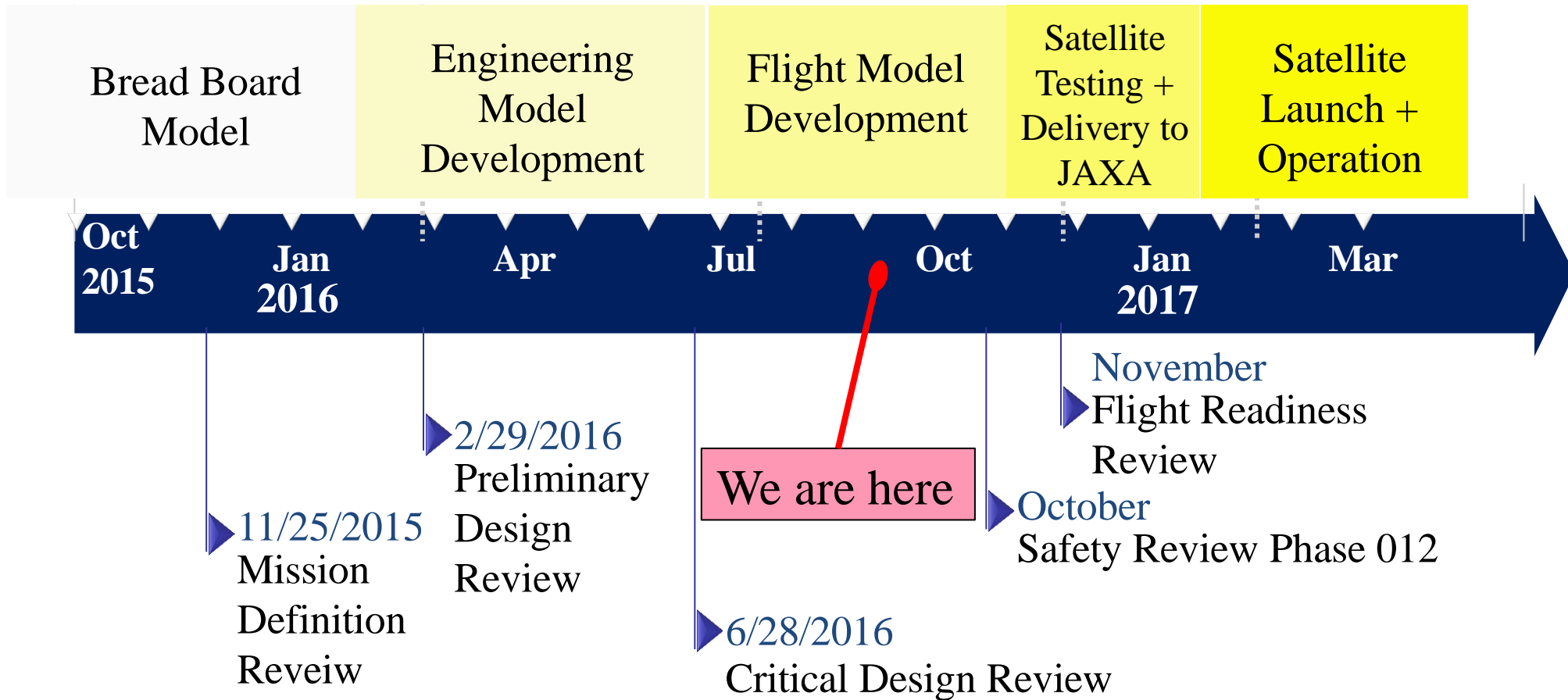
The Moments



- ◎ BIRDS Satellite Project is undertaken by **15 students from 6 countries** (Japan, Ghana, Mongolia, Nigeria, Bangladesh and Thailand).
- ◎ **Lean Satellite project** is used in the development of the CubeSats.
- ◎ BIRDS **EM environment tests have been completed** and the design shows sufficient resilience against environmental tests.
- ◎ The **project is at the Flight Model development** and safety review.
- ◎ The 4 CubeSats are expected to be **delivered to JAXA in January, 2017 for ISS deployment in April 2017 (TBD)**.
- ◎ **Students from developing countries shall return home and start a sustainable space program.**



Project schedule & Future plan

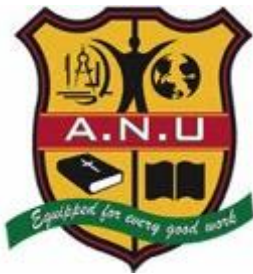




Thank you for your attention

Principal Investigator: cho@ele.kyutech.ac.jp

Project Manager: n350949r@mail.kyutech.jp



Joint Global Multi Nation Birds

<http://birds.ele.kyutech.ac.jp/>



Appendix

