CanSat & Rocket Experiment('99〜)

Hodoyoshi-1 '14

# What you can and SHOULD learn from CanSat ?

**Shinichi Nakasuka**
**University of Tokyo**
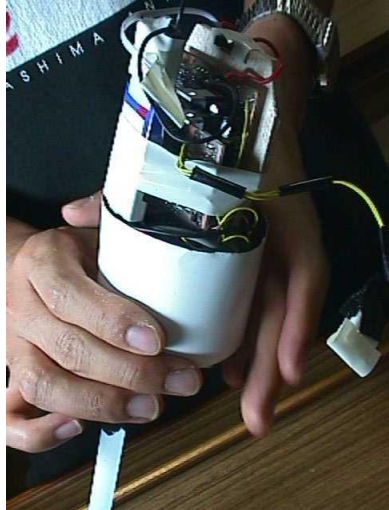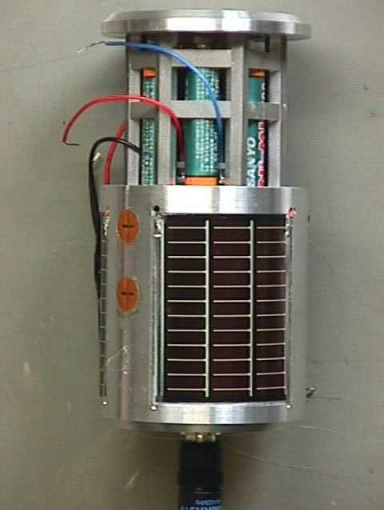
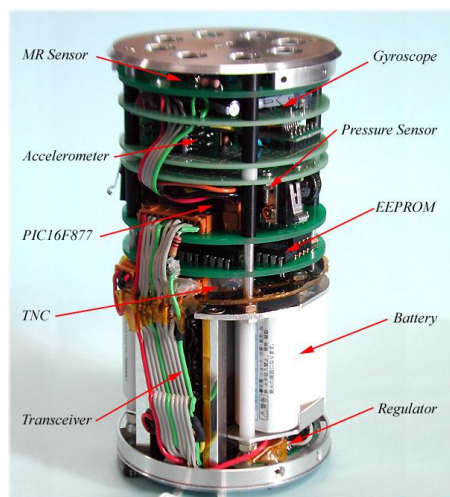CubeSat 03,05

PRISM '09

Nano-JASMINE (TBD)

**Initial Training for satellite development CanSats 1999 - now**

MR Sensor

Gyroscope

Accelerometer

Pressure Sensor

PIC16F877

EEPROM

TNC

Battery

Transceiver

Regulator

# ARLISS (A Rocket Launch for International Student Satellites)
## - Annual suborbital launch experiment in USA -

- ARLISS 1999：Sept. 11 (Japan:2, USA:2)
  - Univ.of Tokyo, Titech, Arizona State, etc.
- ARLISS 2000: July 28-29  (Japan:4, USA:3)
- ARLISS 2001: August 24-25 (Japan:5, USA:2)
- ARLISS 2002: August 2-3 (Japan:6, USA:3)
- ARLISS 2003: Sept.26-27 (Japan:6, USA:3)
- ARLISS 2004: Sept.24-25 (Japan:6, USA:3)
- ARLISS 2005: Sept.21-23 (Japan:7, USA:3)
- ARLISS 2006 Sept.20-22 (Japan:8 USA:3 Europe:1)
- ARLISS 2007 Sept.12-15 (Japan:10 USA:3 Korea:1)
- ARLISS 2008 Sept.15-20: 10th Memorial ARLISS !

- ARLISS 2016 18th （Japan:12, USA:2, Korea, Egypt)
- ARLISS 2017 19th Sept.13-17 (Japan:13 USA:2 Kore
- ARLISS 2018 20th Memorial !!

# 2001～ Comeback Competition in ARLISS
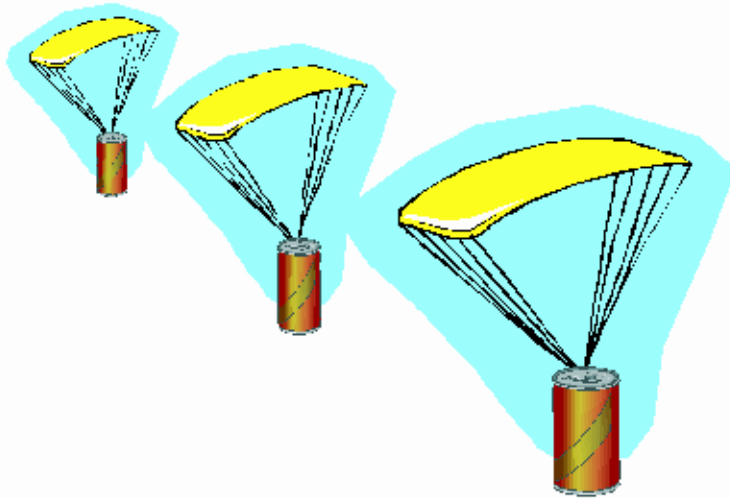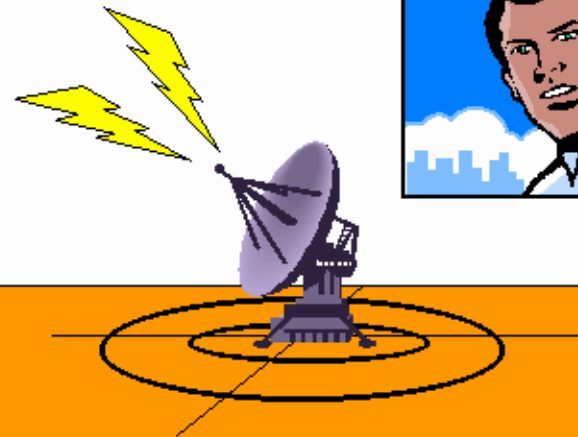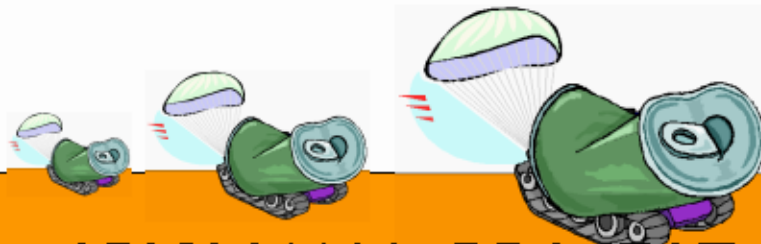
Each year, winner was decided who came back nearest to the target!



University of Tokyo's CanSat reach the target

# 2018, Students Challenge "Flyback"



Result was 900m and was awarded Best Comeback Technology Award

# History of Flyback vs. Rover

Competition Winner Results (2008-2017)
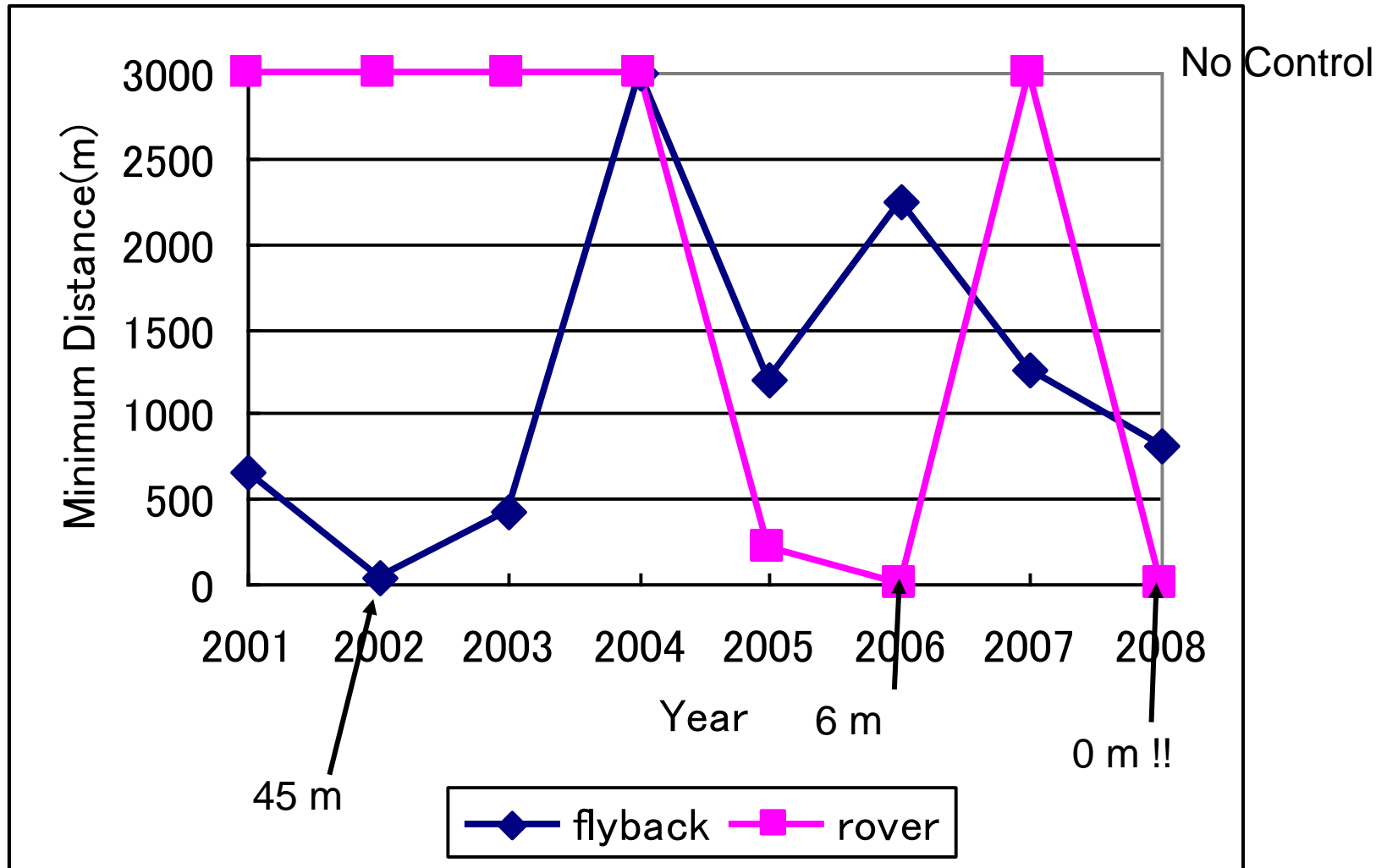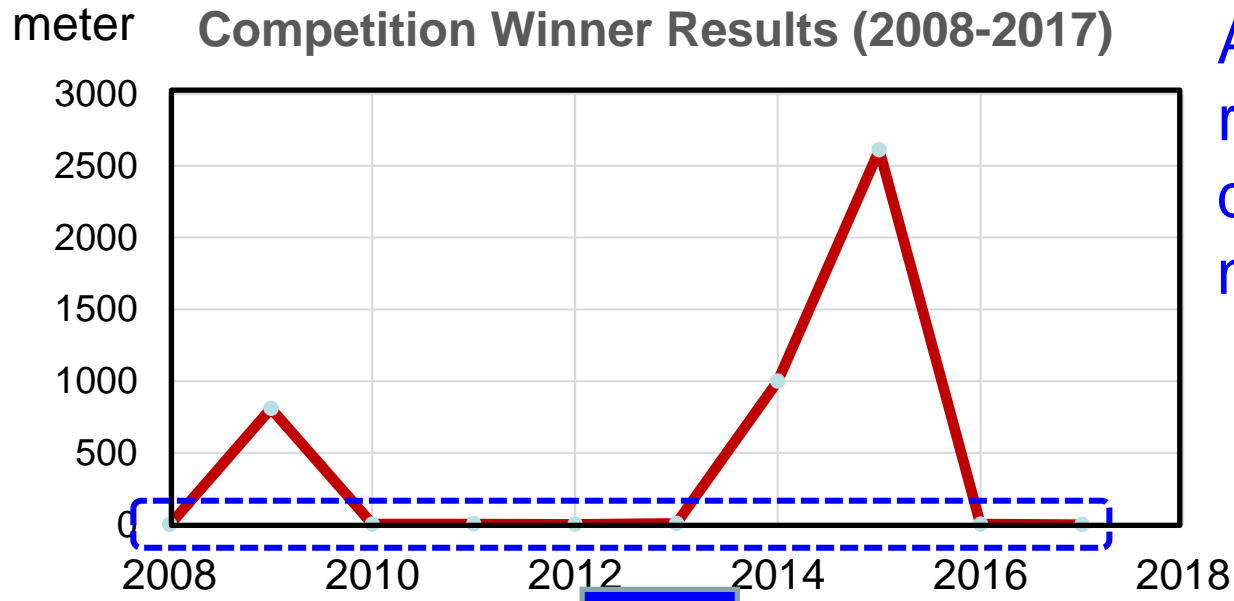
After 2008, rover has been dominating until now

Detail

2016 UT won with 3.8m
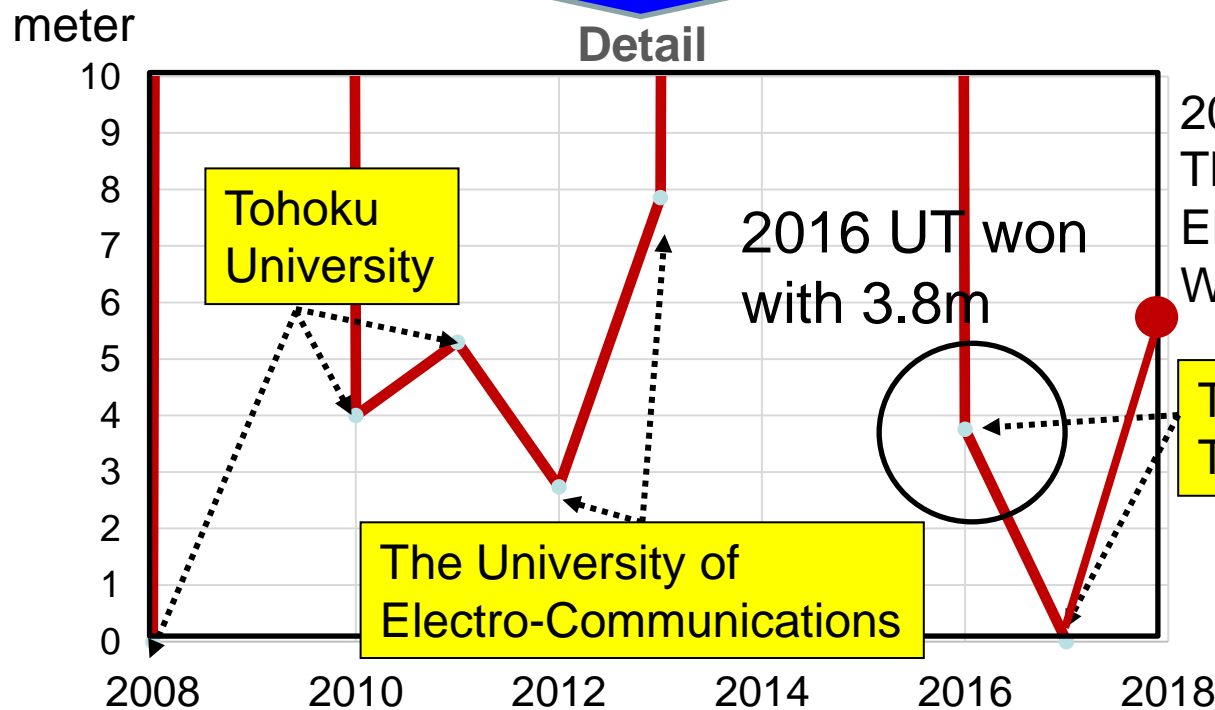
2018
The University of Electro-Communications
Won with 5.8m

Tohoku University

The University of Electro-Communications

The University of Tokyo

# 20ᵗʰ Anniversary
# Participating Comeback CanSats

# Balloon Experiment in Japan

- Itakura Competition 2002 (Thermal balloon)
- Noshiro Space Event 2005～

Drone or UAV are also used recently

100-200m

**Helium Balloon**

**CANSAT Gondora**

**Tether**

**CANSAT Drop（20 sec）**

# CanSat lead to "University Satellites"
## 53 university satellites launched in 2003-2019 in Japan

MicroDragon
Univ. of Tokyo
Jan 18, 2019

FREEDOM
Tohoku Univ.
Nakashimada Engineering Works, Ltd.
Dec 9, 2016 (Launched)
Jan 16, 2017 (Deployed from ISS)

NEXUS
Nihon Univ.
Jan 18, 2019

RWASAT-1
Univ. of Tokyo
Sep 24, 2019 (Launched)
Nov 20, 2019 (Deployed from ISS)

AOVA-Velox III
Kyushu Inst. of Tech.
Dec 9, 2016 (Launched)
Jan 16, 2017 (Deployed from ISS)

Sters-AO
Shizuoka Univ.
Oct 29, 2018

WASEDA-SAT3
Waseda Univ.
Dec 9, 2016 (Launched)
Jan 16, 2017 (Deployed from ISS)

ITF-2
Tsukuba Univ.
Dec 9, 2016 (Launched)
Jan 16, 2017 (Deployed from ISS)

TRICOM-1
Univ. of Tokyo
Jan 15, 2017

TRICOM-1R
Univ. of Tokyo
Feb 3, 2018

STARS-C
Shizuoka Univ.
Dec 9, 2016 (Launched)
Dec 19, 2016 (Deployed from ISS)

PROCYON
Univ. of Tokyo
Dec 3, 2014

SHIN-EN2
Kyushu Inst. of Tech.
Dec 3, 2014

ARTSAT2:DESPATCH
Tama Art Univ. and
Univ. of Tokyo
Dec 3, 2014
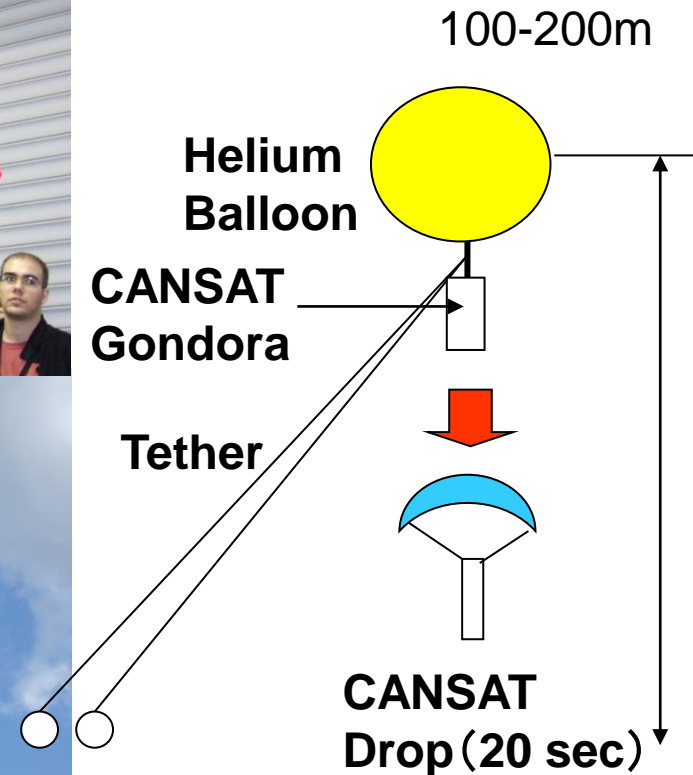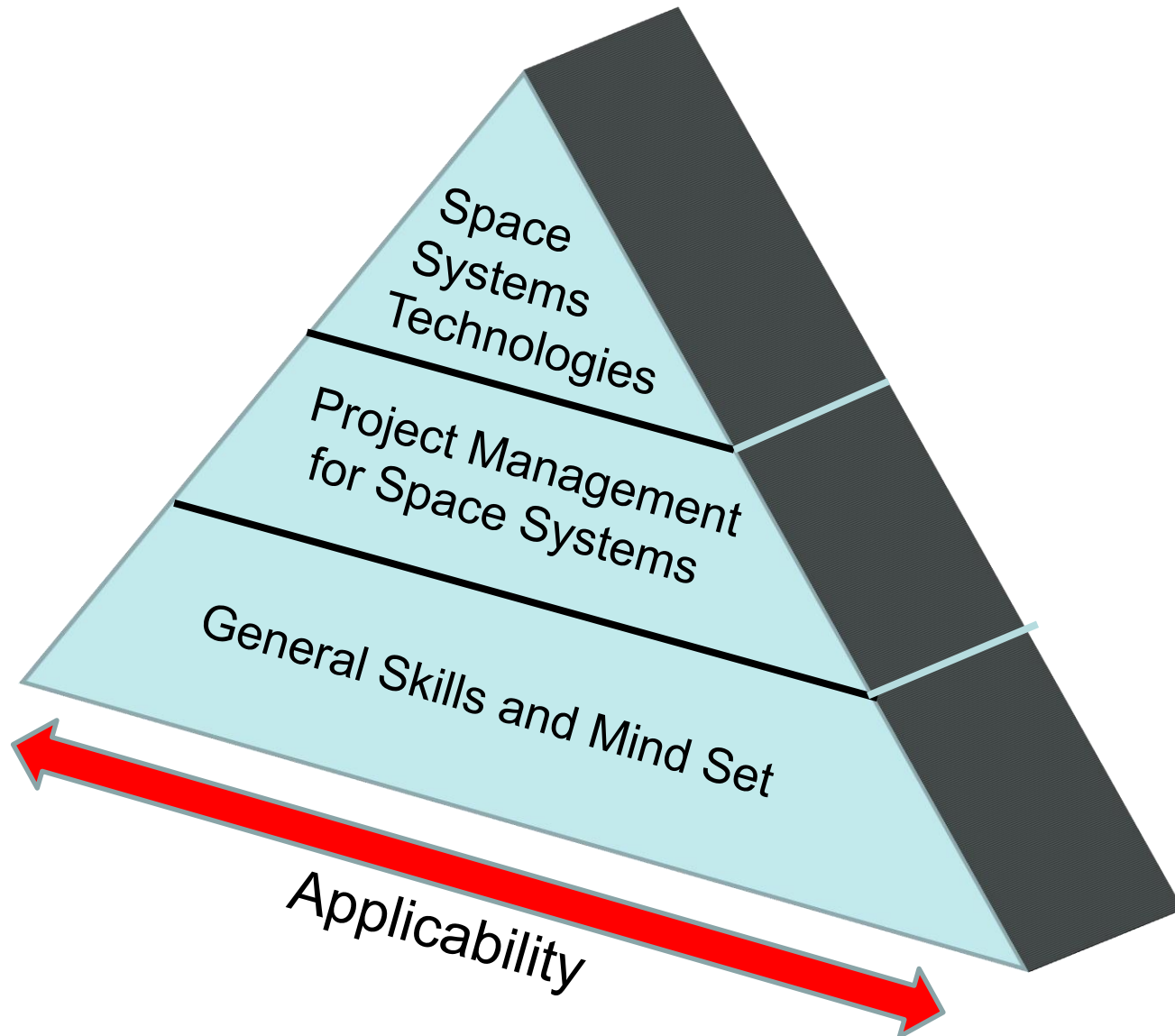
STARS-Me
Shizuoka Univ.
Sep 23, 2018

ChubuSat-1
Nagoya Univ. et al.
Nov 6, 2014

QSAT-EOS
Kyushu Univ.
Nov 6, 2014

S-CUBE
Chiba Inst. of Tech.
and Tohoku Univ.
Sep 17, 2015

ChubuSat-2
Nagoya Univ. et al.
Feb 17, 2016

TSUBAME
Tokyo Inst. of Tech
Nov 6, 2014

HODOYOSHI 1
Univ. of Tokyo
Nov 6, 2014

TeikyoSat-3
Teikyo Univ.
Feb 28, 2014

SPROUT
Nihon Univ.
May 24, 2014

RISING2
Tohoku Univ.
May 24, 2014

HORYU-IV
Kyushu Inst. of Tech.
Feb 17, 2016

ITF-1
Tsukuba Univ.
Feb 28, 2014

UNIFORM-1
Wakayama Univ. et al.
June 19, 2014

OPUSAT
Osaka Prefecture Univ.
Feb 28, 2014

ARTSAT1:INVADER
Tama Art Univ. and Univ. of Tokyo
Feb 28, 2014

KSAT-II
Kagoshima Univ.
Feb 28, 2014

HODOYOSHI 3
Univ. of Tokyo
June 19, 2014

HODOYOSHI 4
Univ. of Tokyo
June 19, 2014

START-II
Kagoshima Univ.
Feb 28, 2014

KKS-1
Tokyo Met. College Of Industrial Tech.
Jan 23, 2009

UNITEC-1
UNISEC
May 21, 2010

WASEDA-SAT2
Waseda Univ.
May 21, 2010

Negai☆"
Soka Univ.
May 21, 2010

KSAT
Kagoshima Univ.
May 21, 2010

HORYU-II
Kyushu Inst. of Tech.
May 18, 2012

PROITERES
Osaka Inst. of Tech.
Sep 9, 2012

RAIKO
Tohoku Univ. and
Wakayama Univ.
July 21, 2012 (Launched)
Oct 5, 2012 (Deployed from ISS)

SPRITE-SAT
Tohoku Univ.
Jan 23, 2009

PRISM
Univ. of Tokyo
Jan 23, 2009

XI-V
Univ. of Tokyo
Oct 27, 2005

Cute-1.7+APD
Tokyo Inst. of Tech.
Feb 22, 2006

SEEDS (FM1)
Nihon Univ.
Jul 27, 2006

HIT-SAT
Hokkaido Inst. of Tech.
Hokkaido University
Sep 23, 2006

FITSAT-1
Fukuoka Inst. of Tech.
Oct 5, 2012

STARS (KUKAI)
Kagawa Univ.
Jan 23, 2009

CUTE-I
Tokyo Inst. of Tech.
June 30, 2003

XI-IV
Univ. of Tokyo
June 30, 2003

SEEDS (FM2)
Nihon Univ.
Apr 28, 2008

Cute-1.7+APD II
Tokyo Inst. of Tech.
Apr 28, 2008

UNISEC
University Space Engineering Consortium

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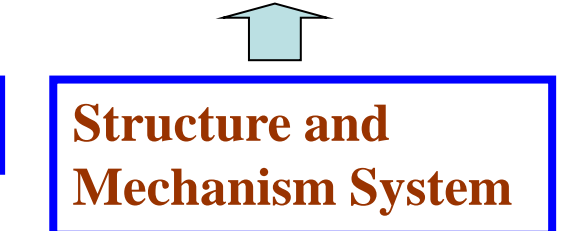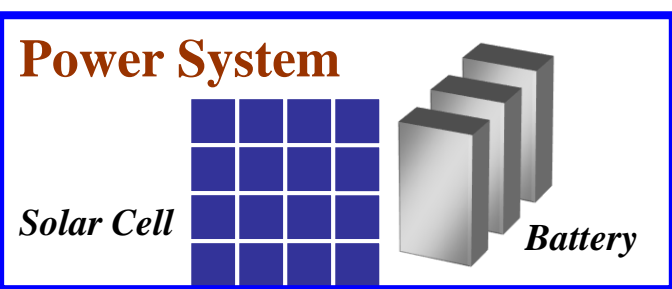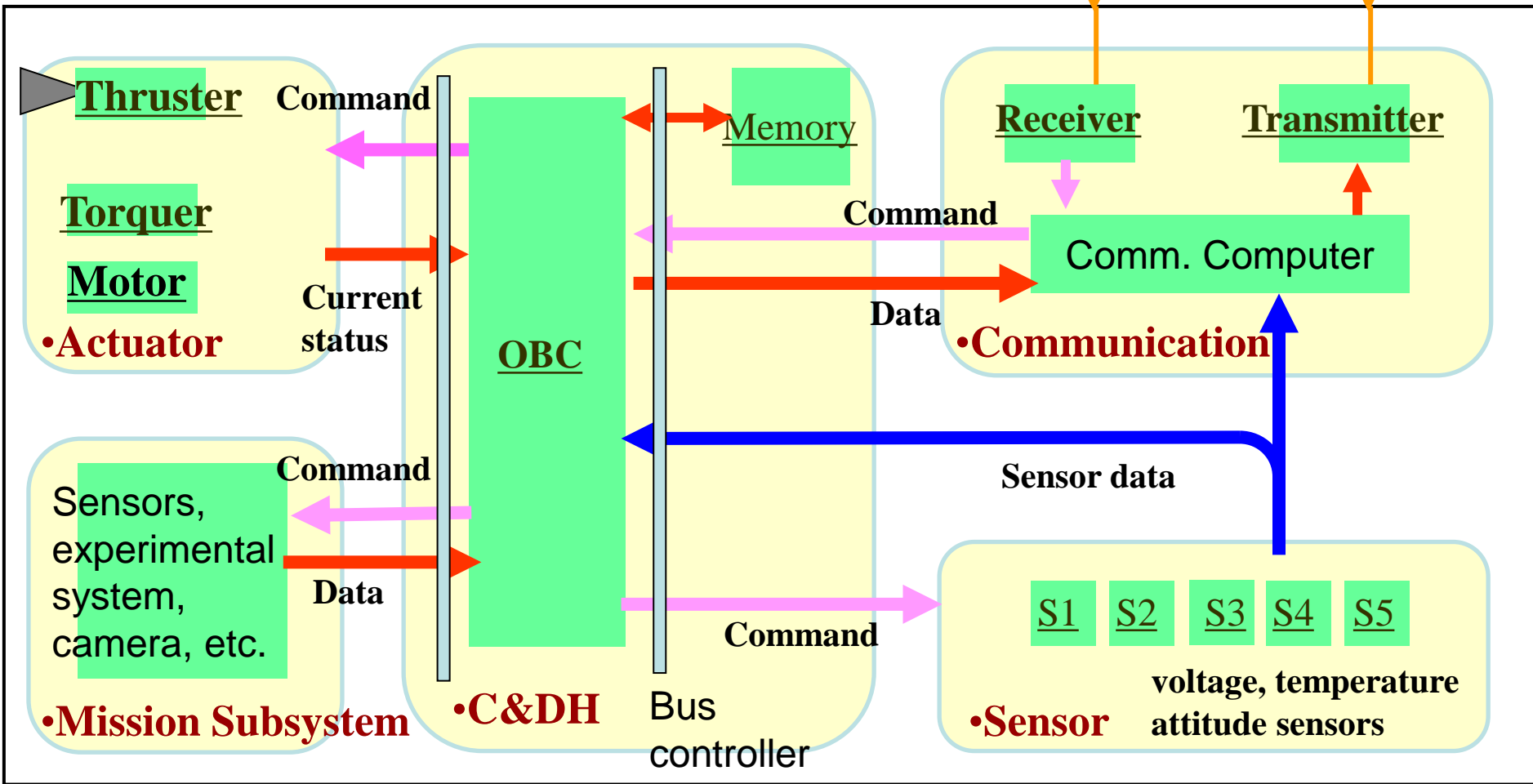
**Almost all the universities experienced CanSat.**
**CanSat's experiences became good base !**

# Three Important Levels to be Learned

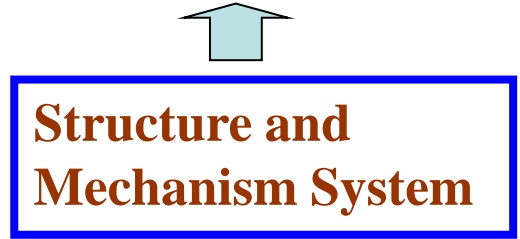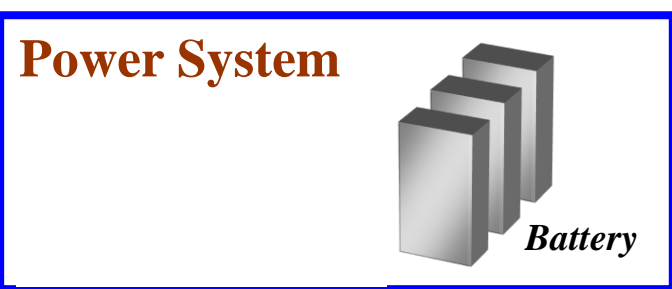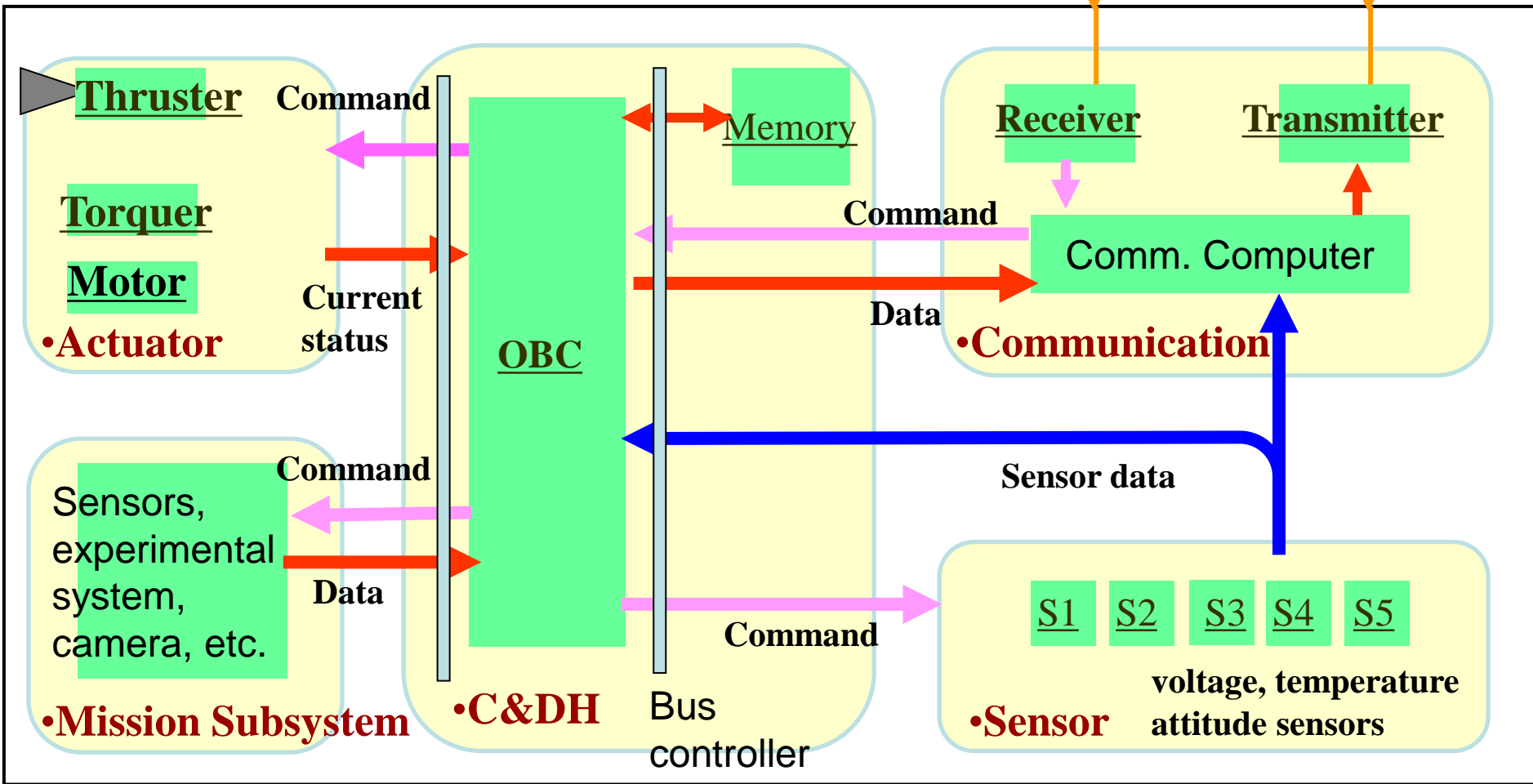# Satellite Systems



uplink    downlink

**Thruster**    **Command**

**Torquer**

**Motor**

•**Actuator**

**Current status**

Memory

**Receiver**    **Transmitter**

**Command**

Comm. Computer

•**Communication**

**Data**

OBC

Sensors, experimental system, camera, etc.

**Command**

**Data**

•**Mission Subsystem**

•**C&DH**

Bus controller

**Command**

**Sensor data**

S1  S2  S3  S4  S5

•**Sensor**    **voltage, temperature attitude sensors**

Power System

Solar Cell    Battery

Thermal Control System

Structure and Mechanism System

# CanSat Systems



uplink    downlink

**Thruster**    **Command**

**Torquer**
**Motor**

•**Actuator**

**Current status**

**OBC**

Memory

**Receiver**    **Transmitter**

**Command**

Comm. Computer

•**Communication**

**Data**

Sensors, experimental system, camera, etc.

**Command**

**Data**

•**Mission Subsystem**

•**C&DH**    Bus controller

**Command**

**Sensor data**

S1  S2  S3  S4  S5

•**Sensor**    **voltage, temperature attitude sensors**

**Power System**

*Battery*

**Structure and Mechanism System**

# Space Systems Technologies

- *Even in small scale, the following important technologies and skills can be learnt:*
  - System analysis and design (weight, power budgeting)
  - Ground tests to assure reliable system
  - Imagine what may happen and countermeasures
- *We should develop from parts, not by buying components, by which we could learn:*
  - How to make components from parts or by modifying the COTS components
- **Systems usually do not work as expected. Try many many many "test + refine" processes !**
  - If you succeed <u>10 times</u> consecutively, then the system will work in the real environment

# Project Management for Space Systems

- ***Practical Training of Whole Cycle of Space Project***
  - Mission conceptualization, satellite design, fabrication, ground test, modification, launch and operation
  - Know <u>what is important</u> and what is not.

- ***Importance for Engineering Education***
  - Synthesis (not Analysis) of an really working system
  - <u>Feedbacks from the real world</u> to evaluate design, test, etc.
  - Learning from failures (while project cost is small)

- ***Education of Project Management***
  - Four Managements: "*Time, human resource, cost and risk*"
  - Team work, conflict resolution, discussion, documentation
  - International cooperation, negotiation, mutual understanding

# General Skills and Mind Set

- ***"Problem Setting"***
  - Appropriate setting of the target mission
  - Not too high and not too low targets (with priorities)
  - Considering your own technological level
- ***"Problem Solving"***
  - Utilizing anything, asking people from outside
  - Discussion withing your team to create ideas
- ***Strong will and "Never give up" Mind***
  - Many "trial and errors" to find a solution: "tenacity"
  - Team spirits to tackle difficult problems together
- ***Think up what you can do within limited resources***
  - Idea on how to drop a CanSat from high position
  - Even without electronics, you can do a CanSat contest

# Simple CanSat Contest without electronics for mid-high school students

- **<u>Flight time</u>:** how to make the flight time from release to ground be (for example) 15 seconds ?
    - Each team can try three or four times.
    - Gradually modifying parachute size and weight of CanSat
- **<u>Standing up:</u> If it stands-up at landing, add point**
- **<u>Breaking a Balloon:</u>**
  If it breaks a balloon at landing with any mechanism, add point
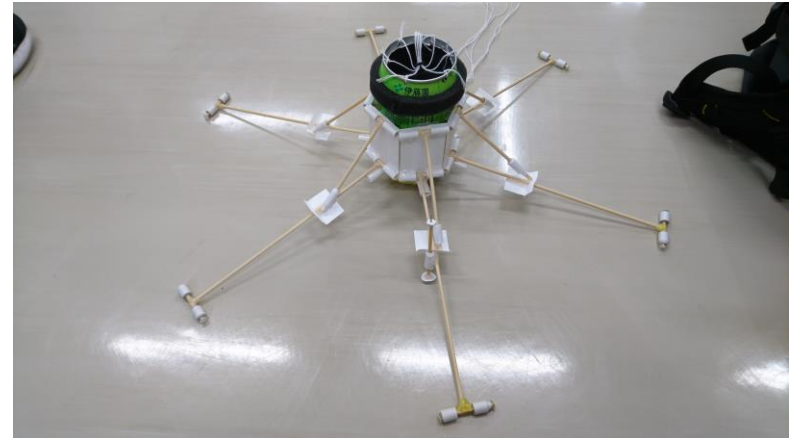


- You can learn "problem solving" with only structure parts. (cheap and easy for younger generation!)

# Middle-High School CanSat Contest in Fukui Prefecture ('16-'19)

# CubeSat/Micro-Sat Fleet
## by The University of Tokyo

Capacity Building
Support Projects

**11**
Satellites Launched

**4**
Satellites will be launched soon

**16**
Years of In-orbit Satellite Operations

**104**
Students Graduated

**XI-IV (2003)**
In operation (16 years)

**Education Experiment**

**XI-V (2005)**
In operation (14 years)

**PRISM (2009)**
In operation (10 years)

**Earth Observation**

**HODOYOSHI 1, 3, 4 (2014)**
In operation (5 years)   Collaborator: Axelspace, NESTRA

**MicroDragon (2019)**
In operation (0.5 years)
Collaborator: VNSC

**Nano-JASMINE**
Awaiting launch
Collaborator: NAOJ

**Space Science**

**Deep Space Missions**

**TRICOM-1R (2018)**
End of operation (0.5 years)
Collaborator: JAXA

**RWASAT-1 (2019)**
Will be launched in 2019
Collaborator: Rwanda

**PROCYON (2014)**
End of operation (3 years)
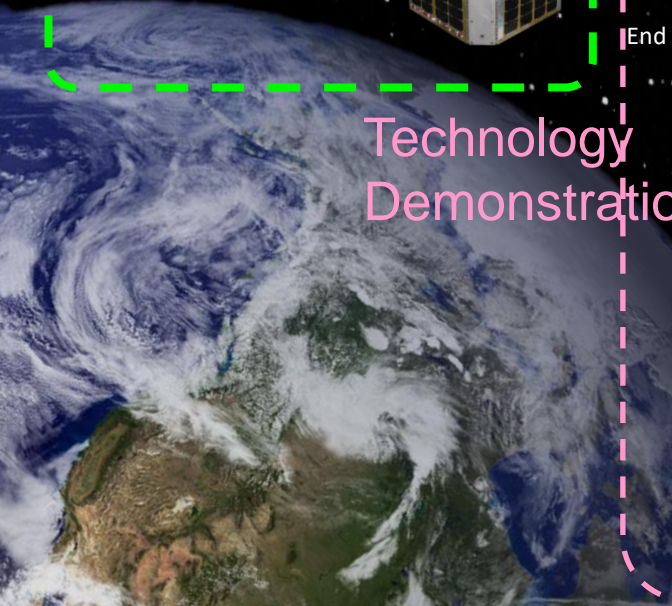Collaborator: JAXA

**Technology Demonstration**

**AQT-D(2019)**
Will be launched in 2019
Collaborator: UT-SPL

**G-Satellite**
Will be launched in 2020
Collaborator: TOCOG, JAXA

**EQUULEUS**
In development
Collaborator: JAXA

**Entertainment**

CanSat – A Gateway to Space !
- Technologies for Satellite
- Project Management
- Problem Solving
- Never Give-up Mind !!

20th Memorial ARLISS
Black Rock, Nevada, USA 2018

# Reference
UNISEC 12 important Rules

# (1) Technology, Procedure

1. Be honest regarding project feasibility – openly recognize technology and schedule risks that may impact success.

2. Build a system which can work as designed in the environment where fixing is impossible.

3. Do your best to avoid failing. Only in that case, you can learn from failure.

4. Remember that there are rules that you must follow - from Outer Space Treaty to internal rules in your project.

# (2) Management

5. Refer to the <span style="color:red">other's achievements in the past</span>, and accumulate your own achievement on that basis.

6. Setup <span style="color:red">appropriate and realistic targets</span> considering your capability and capacity.

7. Recognize the pressure in <span style="color:red">other team members</span> working to demanding deadlines on challenging projects; support and help reduce their stress wherever possible.

8. <span style="color:red">Evaluate your results</span> realistically and reflect them to your subsequent activities.

# (3) Fundamental Spirits

9.  Use imaginative and innovative ways of achieving the maximum using available personnel, technical and financial capabilities even if they are limited.

10. Identify and work with your rivals and compete with each other to stimulate innovation & mutual growth. Recognize other people's successes and use these to stimulate yourself further.

11. Respect a spirit of mutual assistance. Seek ways to contribute to others, not only seeking help for yourself.

12. Be careful not to be misled by the "bewitching nature and allure of space" or by flattering words. Be modest and sincere.