

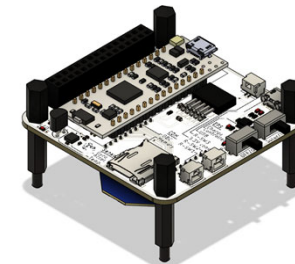
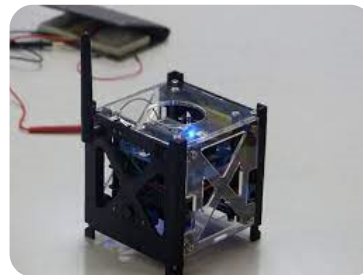
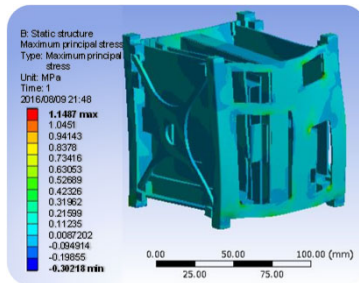
Introduction to HEPTA-Sat training

Masahiko Yamazaki, Nihon University



Challenges of CubeSat Program Knowledge Transfer

- ❖ The space industry needs **radical collaborations among more diverse sectors** (e.g., other fields such as software, disaster management, etc.) in this “new space” era.
 - ❖ It is difficult for engineers and non-engineers outside the space field to understand space systems engineering itself. Without practical experience and a common language (a common model), it is difficult to consider why and how to integrate new elements with space systems.
- ❖ Most university programs cannot sustain permanent professionals. Documentation and its handling is also not sufficient. It is difficult to pass on the concept and management methods of design development.



Project start(2012)

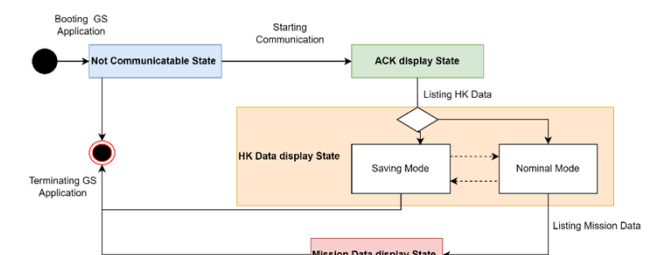
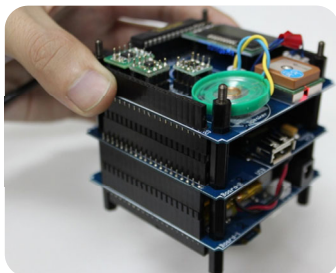
HEPTA-Sat-II(2016)

HEPTA-Sat-Lite(Online, 2021)



HEPTA-Sat-I(2012)

HEPTA-Sat-III with Model Based Systems Engineering(2019)

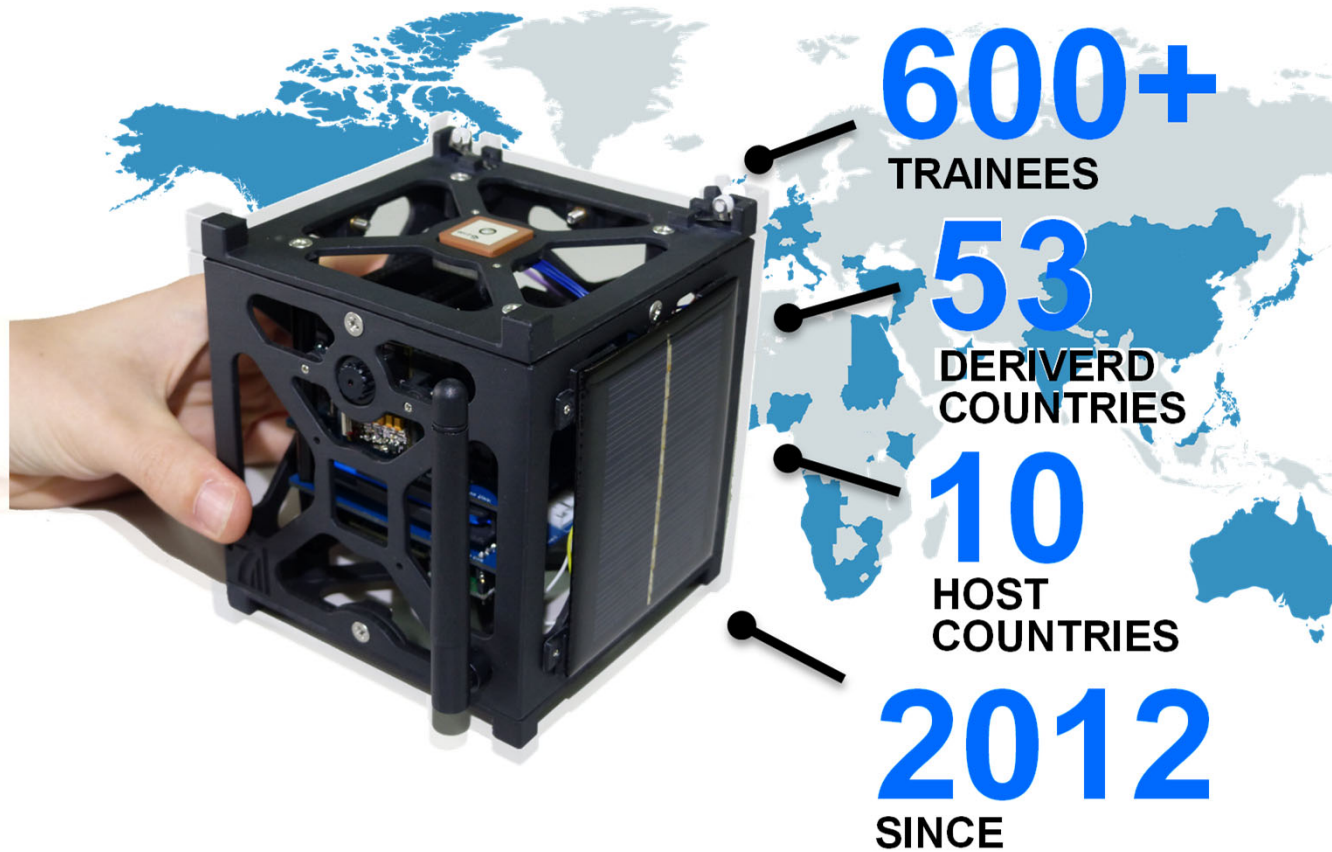


CubeSat Engineering Education by Hands-on Activity

- ❖ Education to gain the knowledge necessary to think about satellite-based services with people from various background through hands-on experience for new entrants with limited prerequisite knowledge of space systems.



CubeSat Engineering Education by Hands-on Activity



Annual Training Program (CLTP)



International Space University

- ◆ Annual Training Program for Instructors (CLTP)
- ◆ International Space University (France)
 - ◆ SHSSP (2019, 2020), SSP (2019, 2021)
- ◆ Japan International Cooperation Agency (JICA) (Japan)
- ◆ Space and Space related Agency (Kenya, Oman, etc.)
- ◆ University (UAE University, Titech, etc.)
- ◆ United Nation Workshop (South Africa)
- ◆ Online Hands-on Workshop (UNISEC Academy)

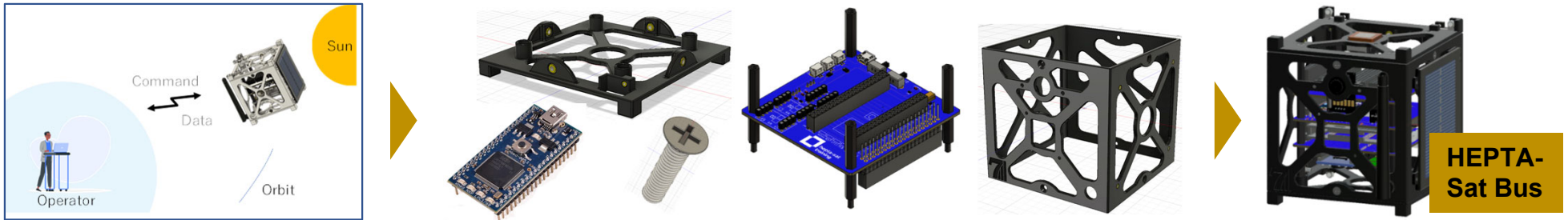


Online Workshop (UNISEC Academy)

Three Steps of HEPTA-Sat Training Program

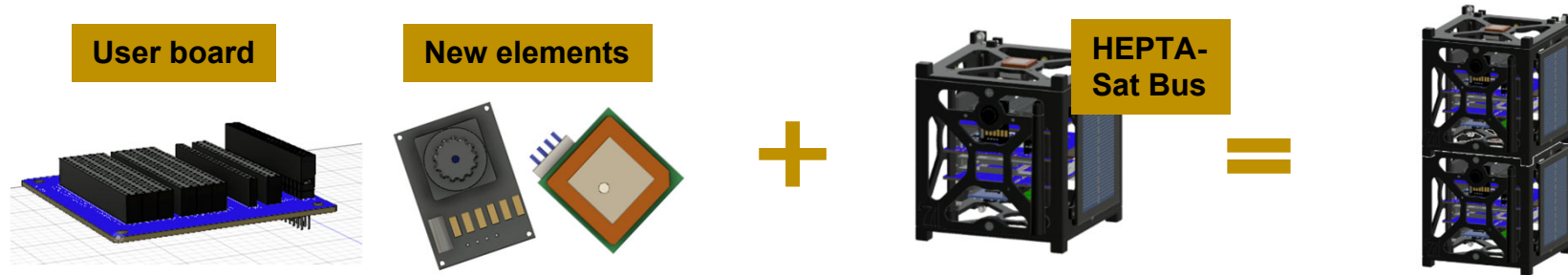
❖ Step1 : CubeSat System Assembly, Integration and Test with Textbook.

- ❖ Understand the functional and physical elements and their relationships.

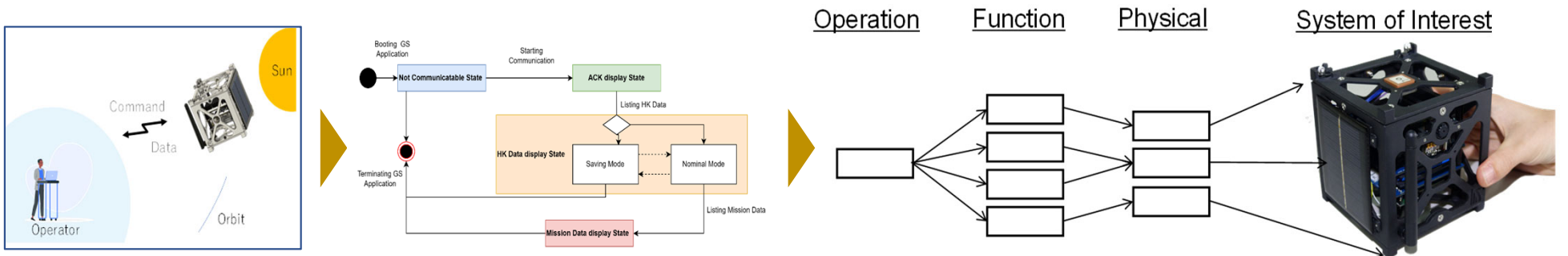


❖ Step2 : Problem and Project based learning with HEPTA-Sat Bus

- ❖ Understand the relationship between operational, functional, physical point of view and there relation with design & development.

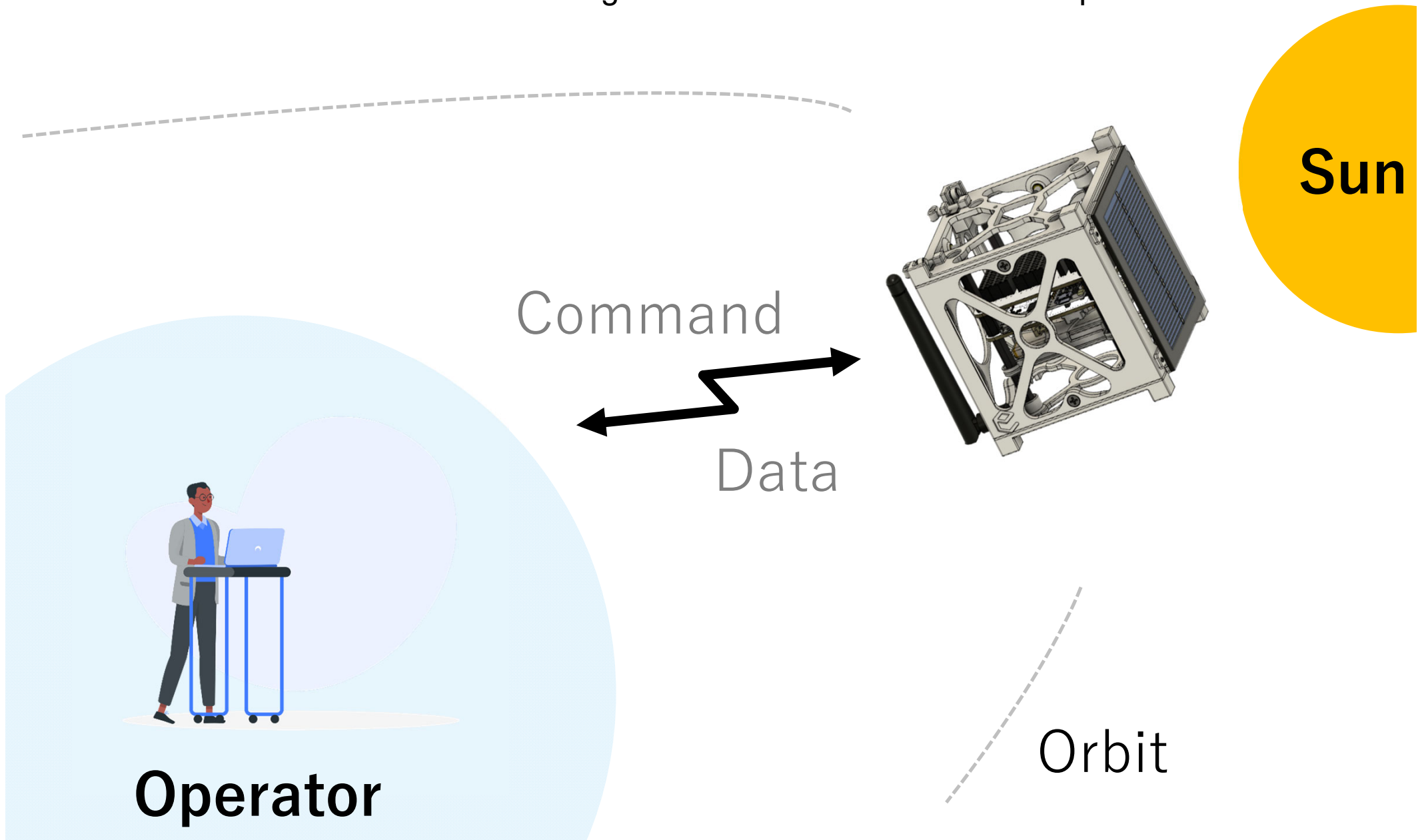


❖ Step3 : Visualization of system design and development (MBSE)



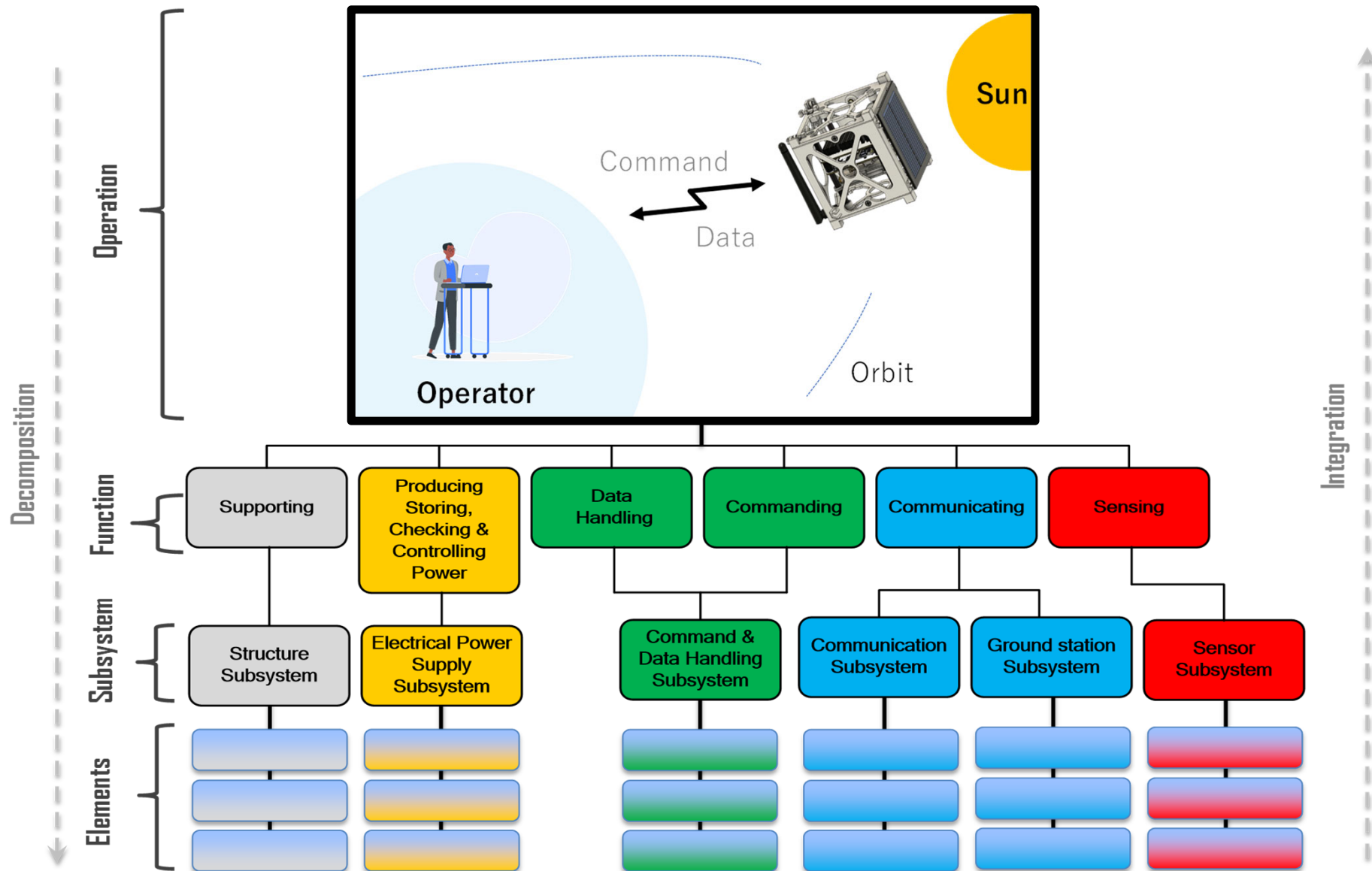
HEPTA-Sat Training Kit > HEPTA-Sat Bus

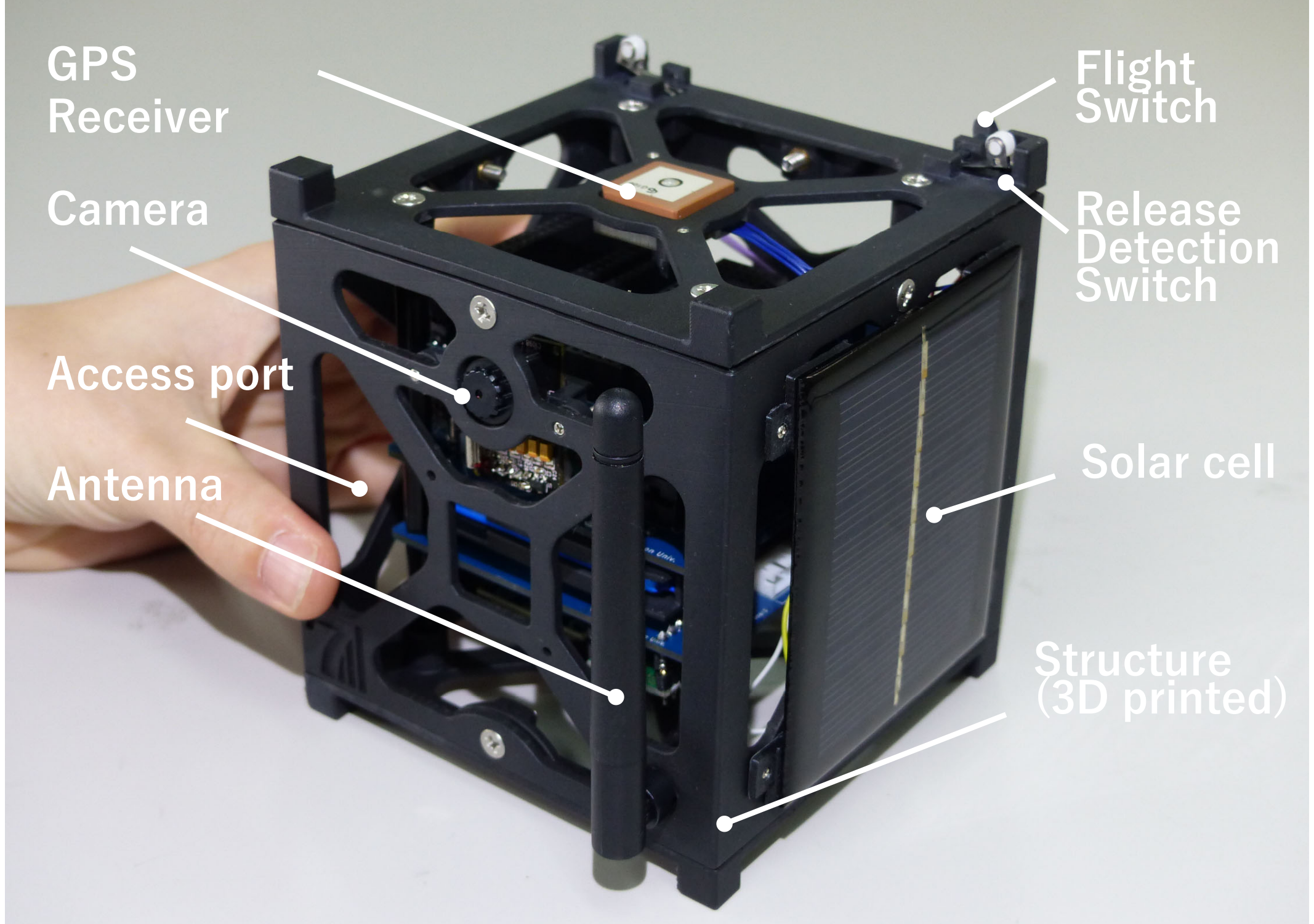
- ❖ Simulates the actual satellite-to-ground station communication experience.



HEPTA-Sat Training Kit > HEPTA-Sat Bus

- Experience how a system is composed of elements and sub-elements (understand the relationship between the whole system and the elements.)





GPS Receiver

Camera

Access port

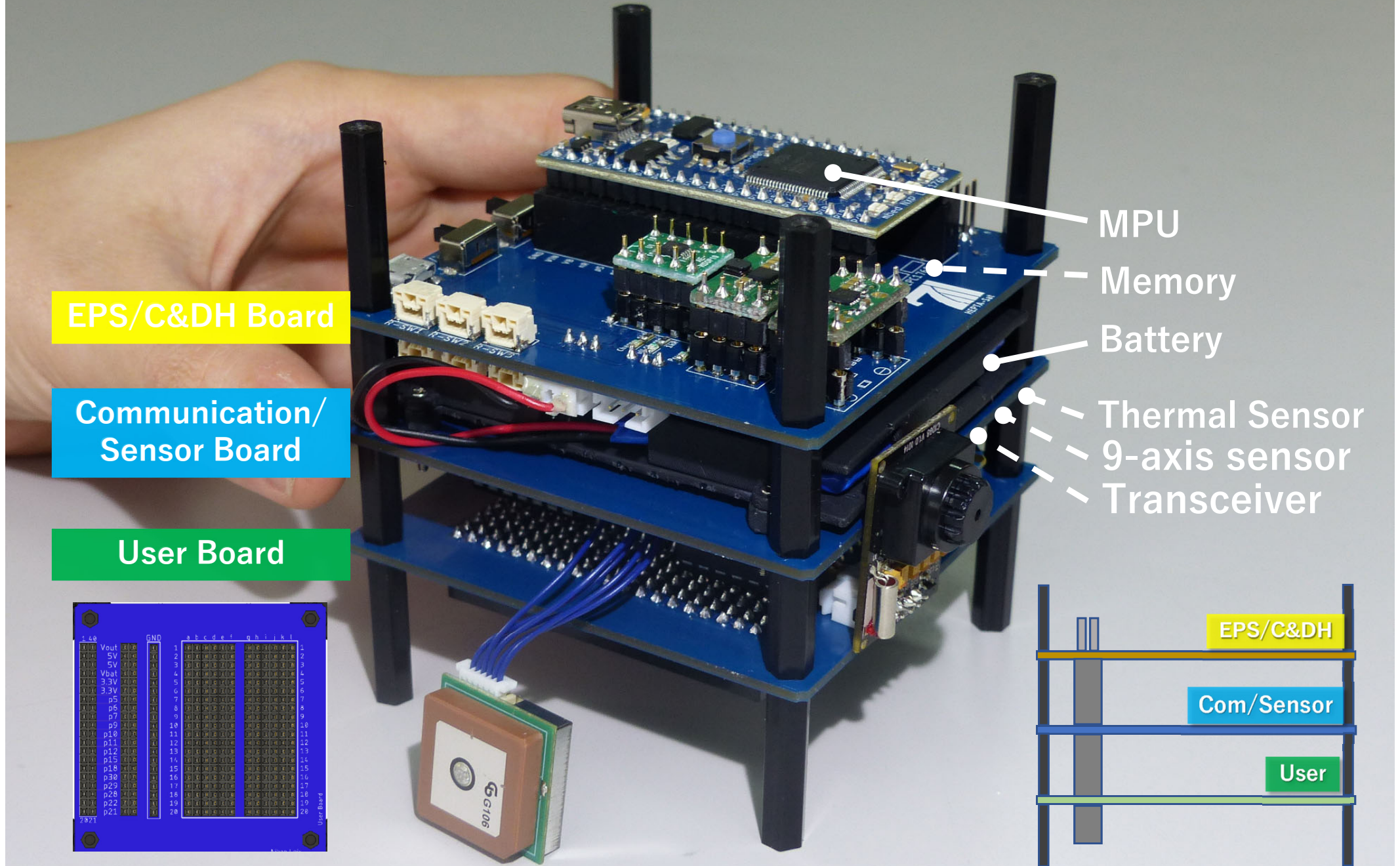
Antenna

Flight Switch

Release Detection Switch

Solar cell

Structure (3D printed)



EPS/C&DH Board

Communication/Sensor Board

User Board

MPU

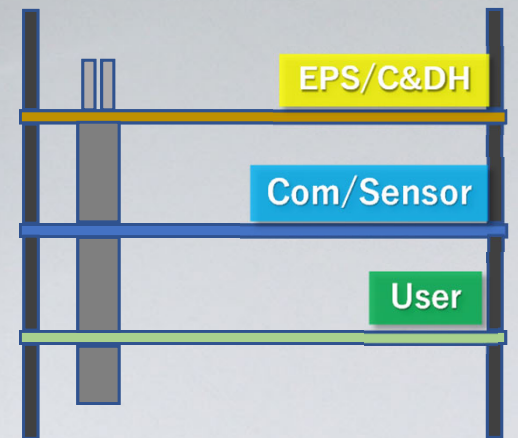
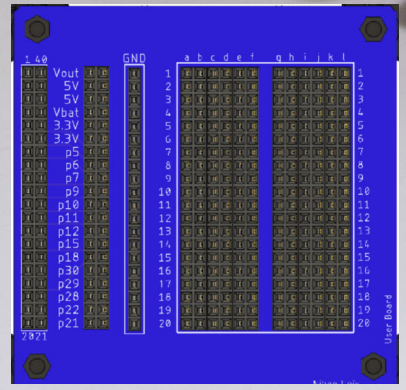
Memory

Battery

Thermal Sensor

9-axis sensor

Transceiver



HEPTA-Sat Training Kit > Self-learning Environment

Textbook

The screenshot displays the HEPTA-Sat textbook interface. On the left, a 3D model of the satellite is shown with dimensions: 100 mm width and 100 mm depth, and a height of 113.5 mm. Below it, the text reads "SEEDS-II ©Nihon University" and "Standard of CubeSat".

In the center, a detailed circuit diagram illustrates the power and control systems. It includes a Solar Cell, Charge Control Circuit, Battery, Flight Pin #1 and #2, Release Detection Switches, various Switches, Shunt Circuits, Onboard Equipment A, B, C, and D, an EPS microcomputer, and a DC-DC Converter.

On the right, a diagram shows a satellite in orbit around Earth, with a compass indicating North (N) and South (S) poles. Below this, a "Satellite" icon is connected to a "Ground Station" icon via "Downlink" and "Uplink" channels. The downlink is labeled "HK Data Mission Data".

At the bottom, there are several smaller diagrams: a 3D model of the satellite's internal structure, a "Sensor" diagram with a temperature scale, and a "Clock signal" diagram showing a square wave with a period of 1.01.00.0 and a temperature of 40°C.

Code snippets are visible on the left side of the interface:

```

1 #include "mbed.h"
2 #include "HEPTA_CDI.h"
3
4 Serial pc(USBTX, USBRX);
5 HEPTA_CDI cdi(p5, p6, p7, p8, "sd");
6
7 int main()
8 {
9     pc.baud(9600);
10    pc.printf("Hello world!\r\n");
11    char str[100];
12    mkdir("/sd/mydir", 0777);
13    FILE *fp = fopen("/sd/mydir/test.txt", "w");
14    if (fp == NULL) {
15        error("Could not open file for write\r\n");
16    }
17    for (int i=0; i<10; i++) fprintf(fp, "Hello my name is HEPTA\r\n");
18    fclose(fp);
19    fp = fopen("/sd/mydir/test.txt", "r");
20    for (int j = 0; j < 10; j++) {
21        fgets(str, 100, fp);
22        pc.puts(str);
23    }
24    fclose(fp);
25    pc.printf("Goodbye!\r\n");
26 }
    
```

Open source Library and Forum

The screenshot shows the GitHub repository page for HEPTA-Sat. The repository is named "HEPTA-Sat" and is located under the "HEPTA-Sat Training 2020" organization. The repository is marked as "deprecated".

The "Code" tab is selected, showing a list of files:

- Mbed 2 deprecated Lab1-0X_create_satellite_code_1b (Last updated: 04 Dec 2021, 1 download)
- Mbed 2 deprecated Lab1-0X_create_satellite_code_1a (Last updated: 04 Dec 2021, 1 download)
- Mbed 2 deprecated Lab5-6_create_satellite_program_step6_v1 (Last updated: 03 Dec 2021, 31 downloads)
- Mbed 2 deprecated Lab4_11_create_satellite_program_step5_v1 (Last updated: 20 Nov 2021)

The repository details section shows:

- HEPTA-Sat Training 2020 / Mbed 2 deprecated Lab1-0X_create_satellite_code_1b
- 20211204
- Dependencies: mbed
- Files at revision 0:89798219a0dd

The repository toolbox includes options to "Import into Keil Studio", "Export to desktop IDE", and "Build repository".

The repository details section shows:

- Type: Program
- Mbed OS support: Mbed 2 deprecated
- Created: 04 Dec 2021
- Imports: 15
- Forks: 0
- Commits: 1
- Dependents: 0

HEPTA-Sat Training Kit > Training Package

- Easy access to space for newcomers, requiring only an Internet environment and a laptop computer.

The image illustrates the HEPTA-Sat training package components:

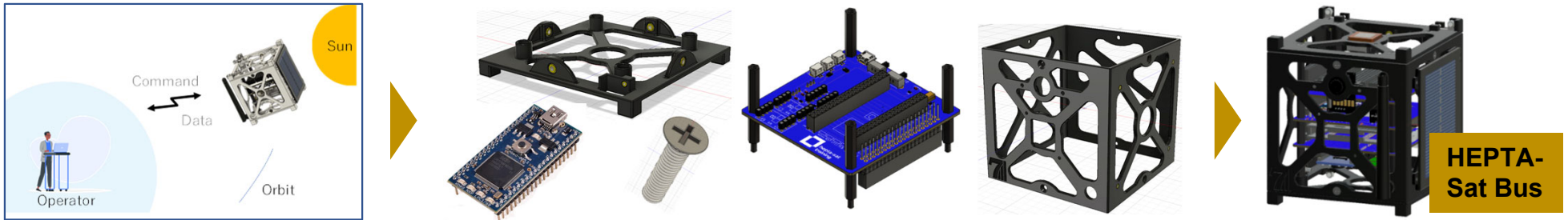
- Textbook:** A window showing a technical manual for HEPTA-Sat, including a 3D model of the satellite (100 mm x 100 mm x 113.5 mm), a circuit diagram, and a diagram of the satellite system (Satellite, Ground Station, Uplink Command, Downlink HK Data Mission Data).
- Open source Library and Forum:** A window showing a GitHub repository for HEPTA-Sat, listing code files such as 'Lab1-0X_create_satellite_code_1b' and 'Lab5-6_create_satellite_program_step6_v1'.
- Software and Hardware Design:** A diagram showing the relationship between software (code snippets), system model (block diagram), hardware (circuit board), and system design (flowchart).
- Kit Box:** A 3D exploded view of the physical satellite kit box, showing the internal components and the external structure.

At the bottom left, a photograph shows two students working on laptops in a classroom setting.

Three Steps of HEPTA-Sat Training Program

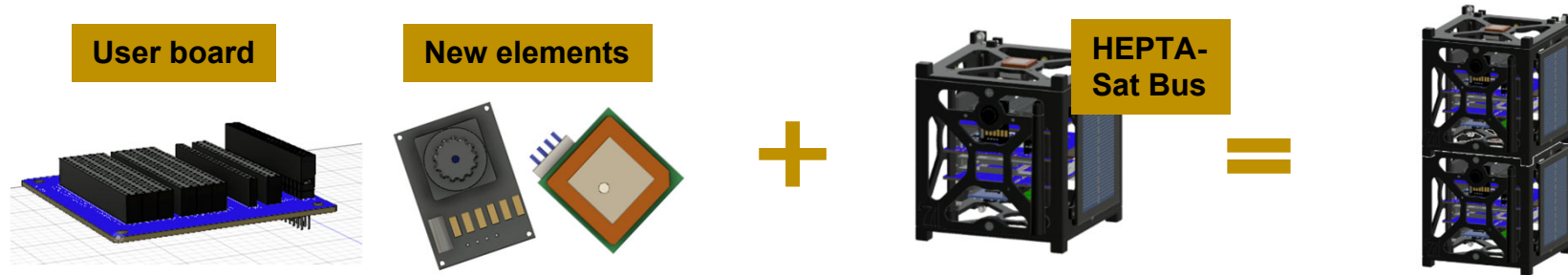
❖ Step1 : CubeSat System Assembly, Integration and Test with Textbook.

- ❖ Understand the functional and physical elements and their relationships.

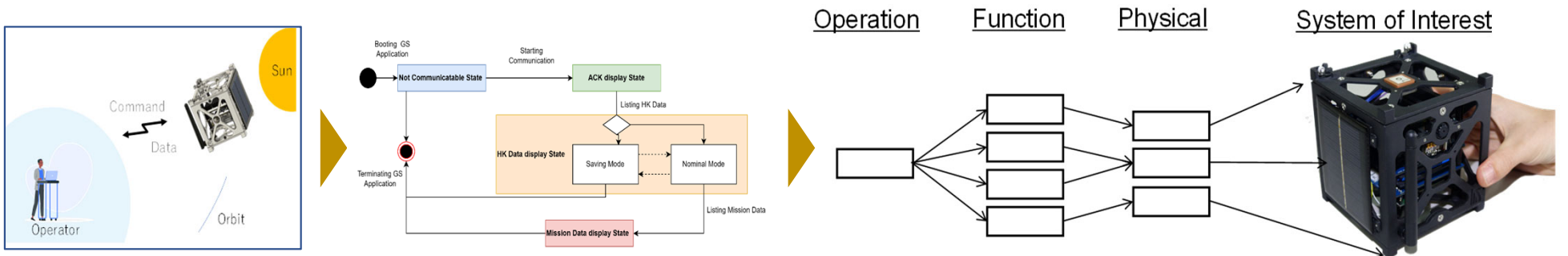


❖ Step2 : Problem and Project based learning with HEPTA-Sat Bus

- ❖ Understand the relationship between operational, functional, physical point of view and there relation with design & development.

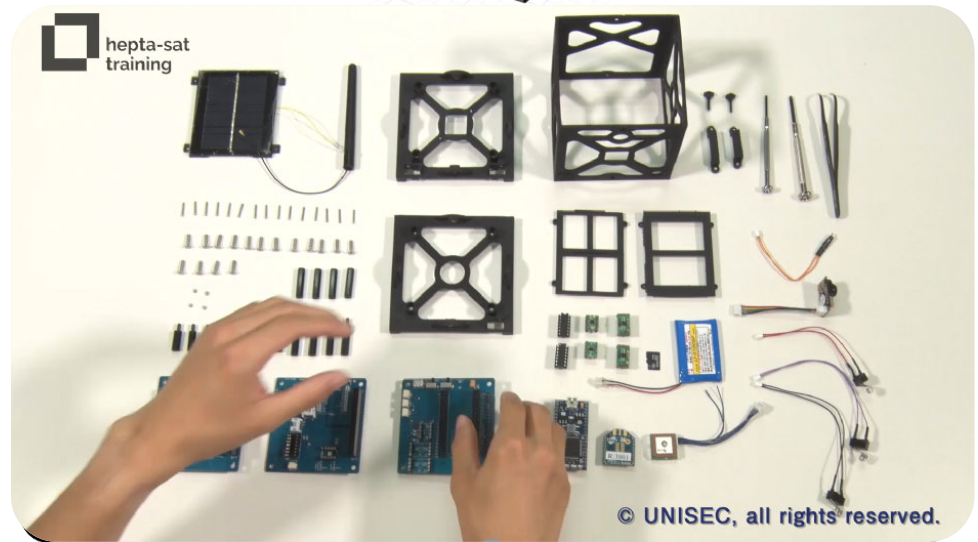
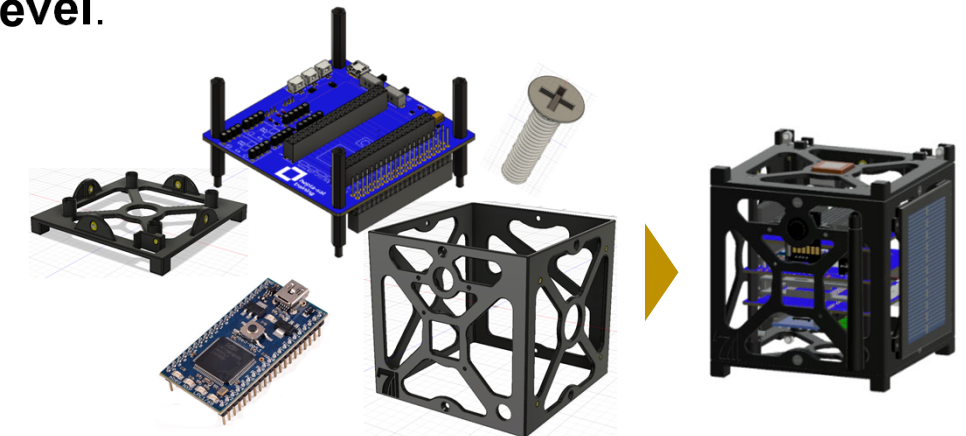
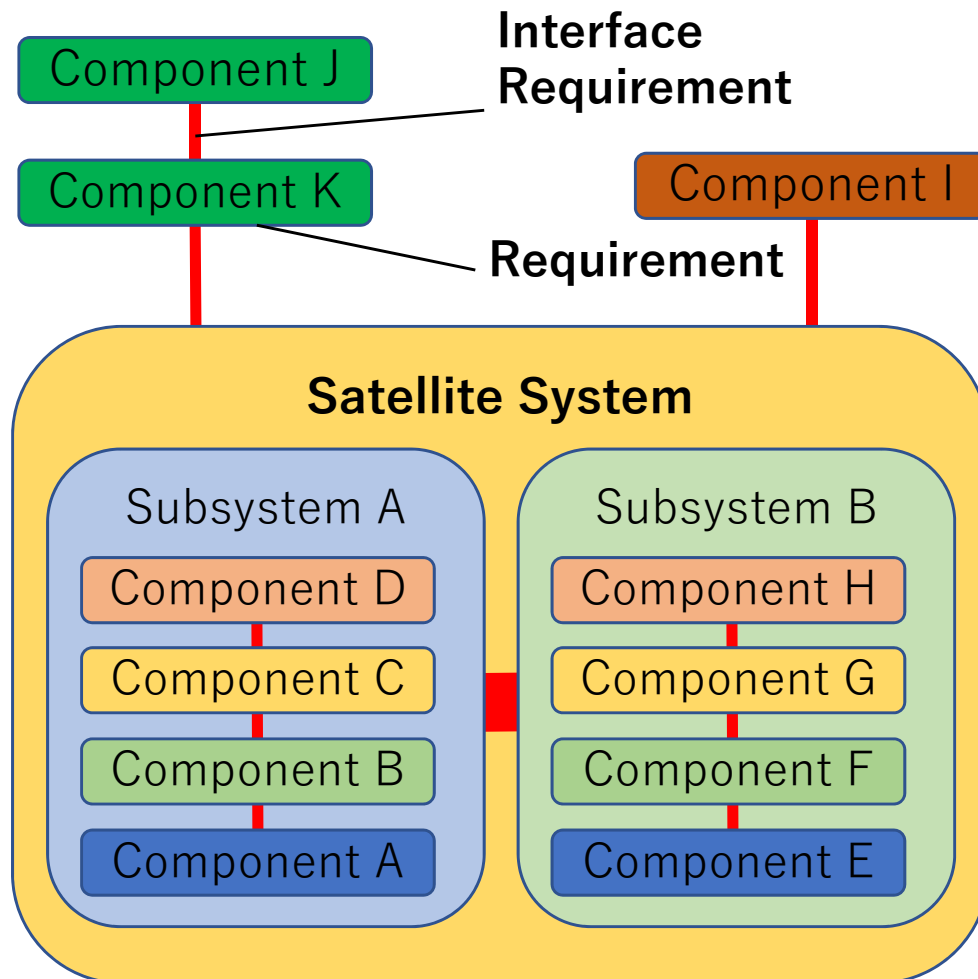


❖ Step3 : Visualization of system, design and development process(MBSE)



Step1 : CubeSat System A, I & T with Textbook

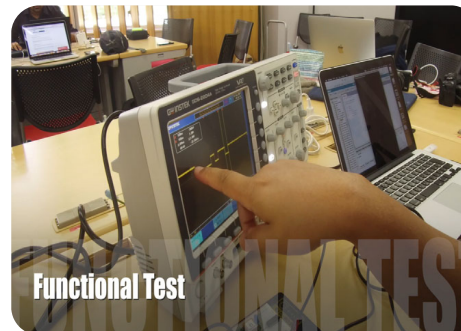
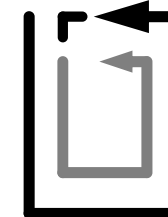
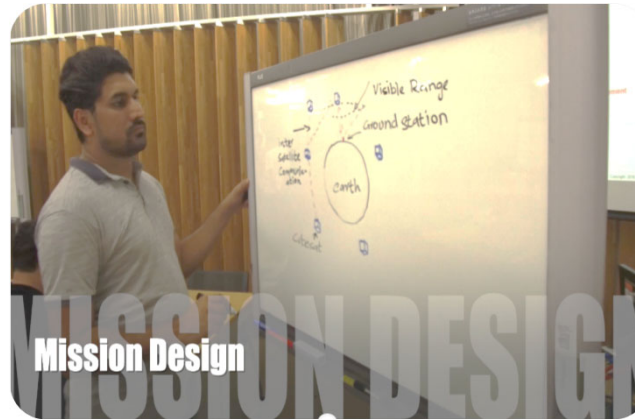
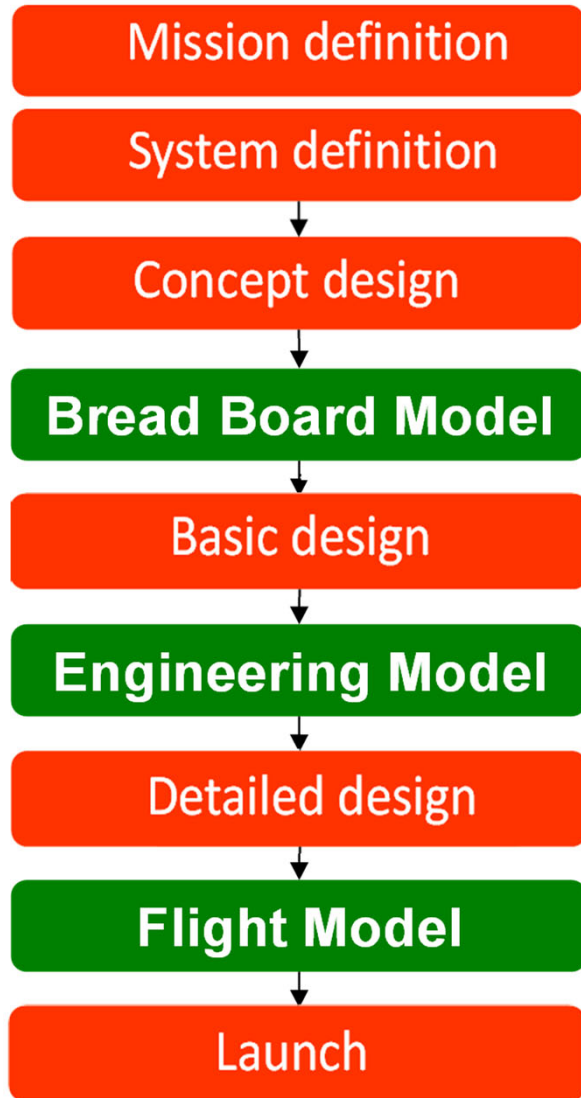
- ❖ Understand the functional and physical elements and their relationships.
- ❖ Focuses mainly on understanding, assembling, integrating, and testing the function of the CubeSat Kit and carrying out it in a hands-on manner step by step form components level to the system level.



Assembly videos without testing and understanding process

Step2 : Problem and Project based Learning with HEPTA-Sat Bus

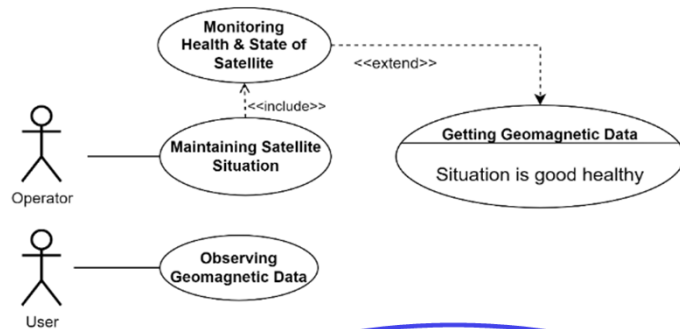
- Understand the relationship between operational, functional, physical point of view and there relation with design & development.



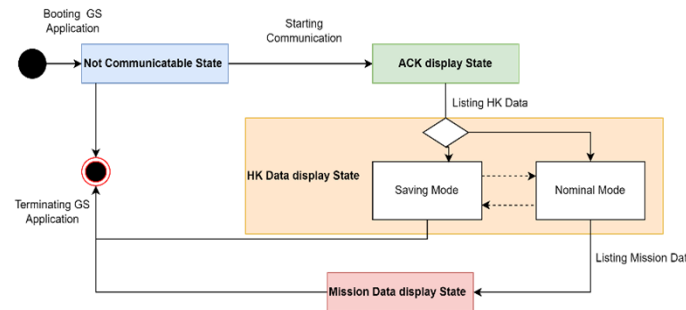
Step3: Visualization of system design and development process

After reflecting on the first PBL, visualize and apply the next PBL.

Use case scenario

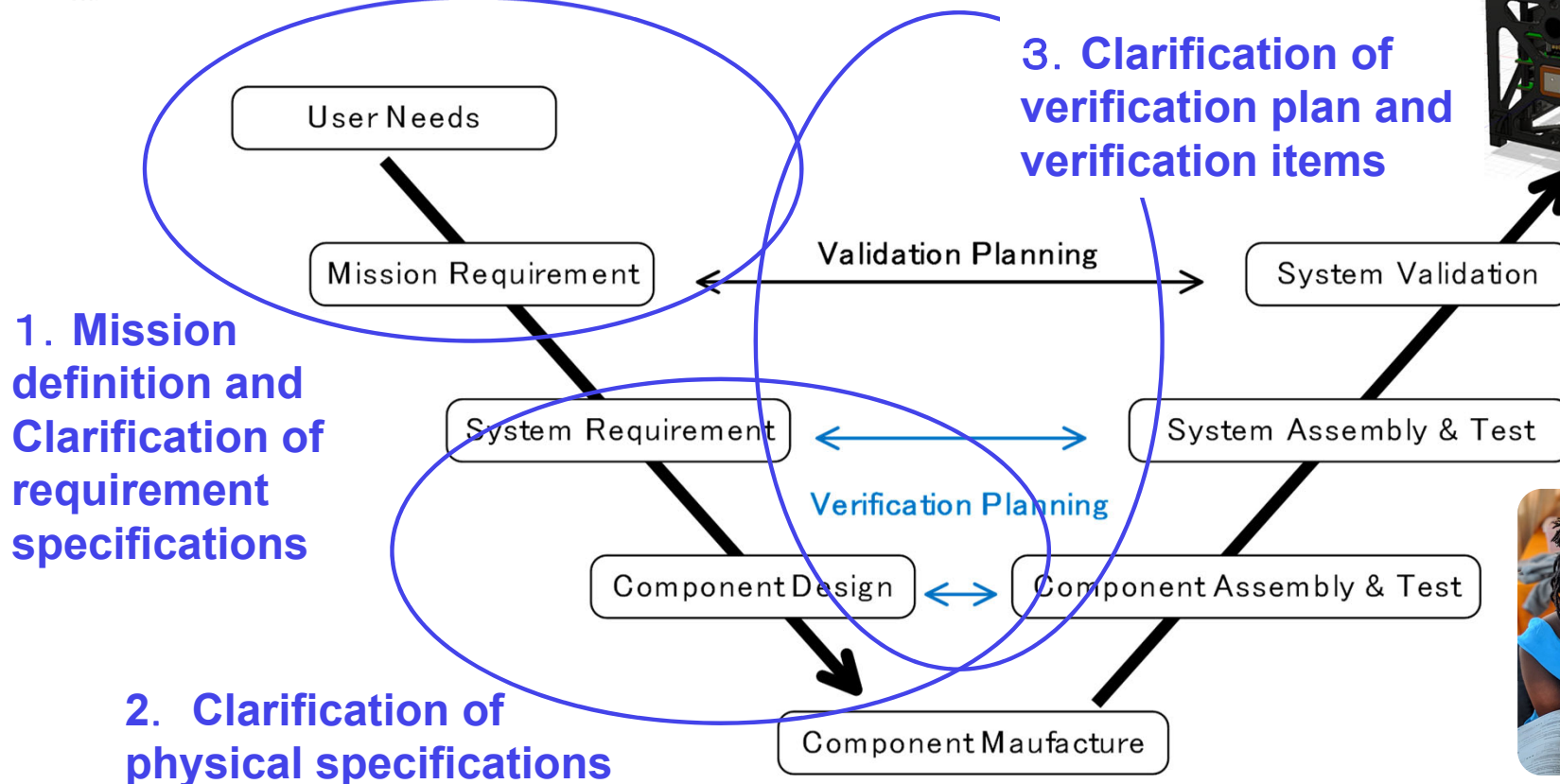


State Machine Diagram



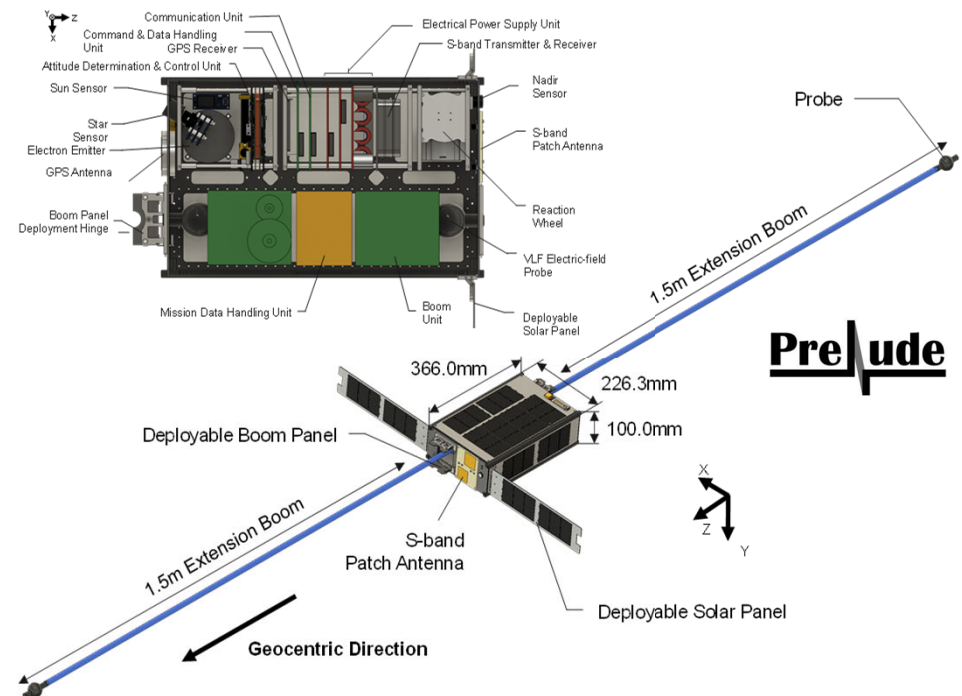
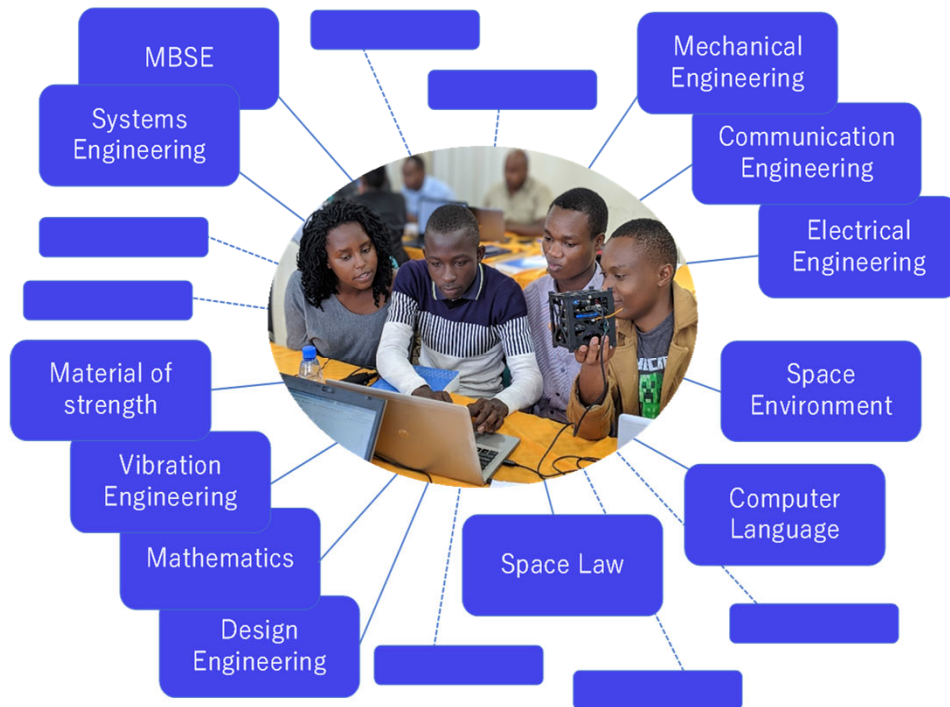
Verification Matrix

System level	System level							
	Communication and Ground Station Test	Power System Test	Data Storage Test	Checkout System Test	HK Data Management Test	Observation Measurement Test	Left Server Test	Demarcation Subsystem
Verification name	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6	3.1.7	3.1.8
Document number # & benchmark	2023-03-07	2023-03-07	2023-03-07	2023-03-07	2023-03-07	2023-03-07	2023-03-07	2023-03-07
Features								
Observing power State Period								
Observation								
Controlling charge								
Controlling battery								
Controlling power								
Controlling sensor								
Controlling observation measurement								
Controlling left server								
Controlling subsystem								
Monitoring electronic HF								
Controlling power measurement								
Identifying communication								
Checking state								
Checking state period								
Checking temperature data								
Checking measurement data								
Checking observation data								
Checking left server								
Checking subsystem								
Checking input voltage								



Summary and Future work

- ❖ The HEPTA-Sat training program provides a practical space engineering education platform for engineers and non-engineers that can be learned in a short period of time to support radical collaborations among more diverse sectors.
- ❖ The Hands-on experience with some level of complexity and expansibility is a good hub/interface for connecting students with current and future disciplines.
- ❖ We would like to conduct earthquake prediction and tsunami early warning missions in the near future by using an open-design CubeSat like HEPTA-Sat, which enables the transfer of knowledge and technology, and university-originated satellite swarm observation.



Annual Training > CanSat Leader Training Program (CLTP)

- ❖ CLTP is a training program for professors/instructors to learn how to conduct CanSat (or HEPTA-Sat) training by experience. Participants are expected to teach their students after training
- ❖ **CLTP 11 Date: August 17-31, 2022 (TBD)**

<http://cltp.info/>

**Please take the course!
And together with us, let's create
a sustainable development
educational platform!**

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