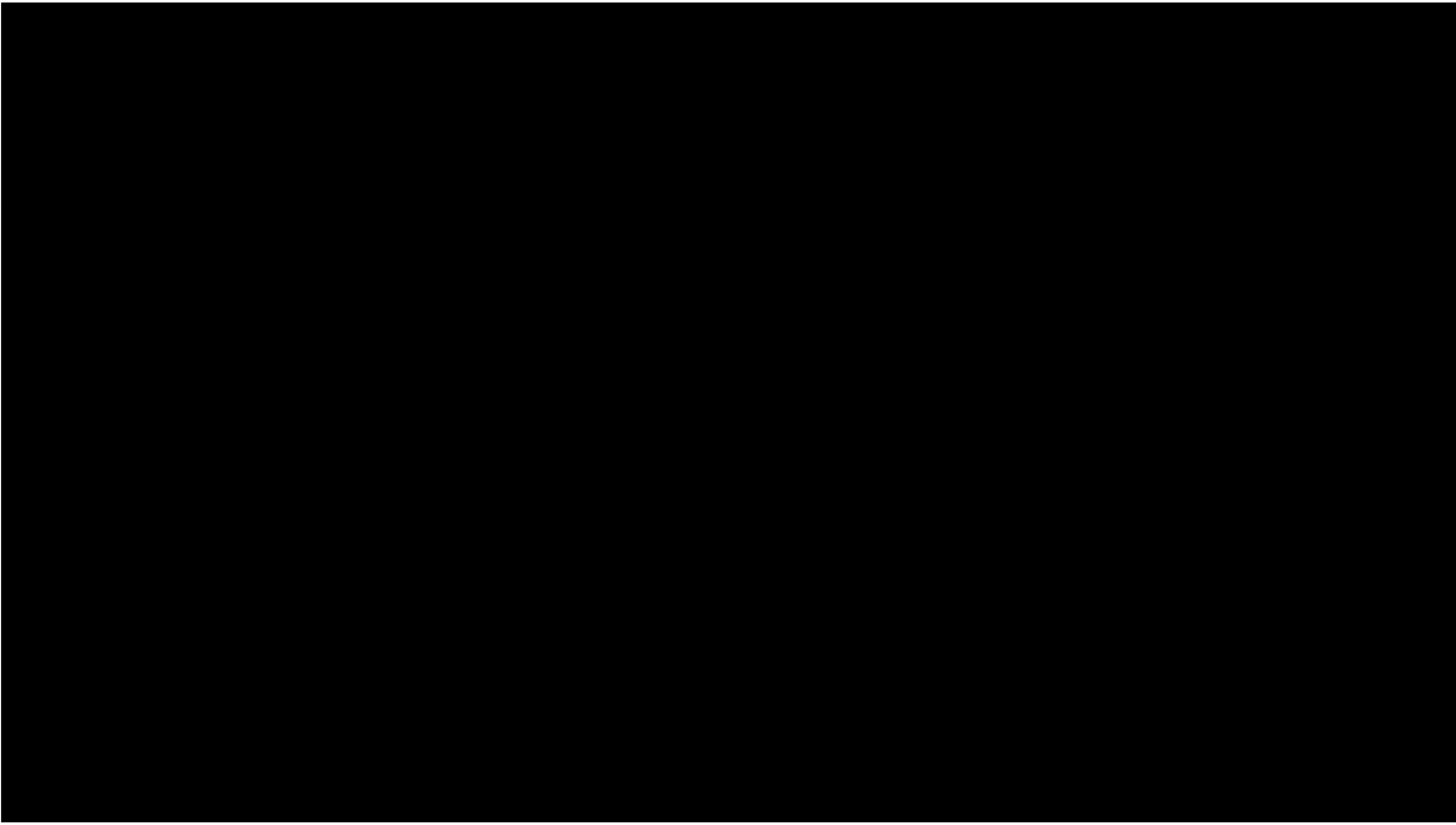
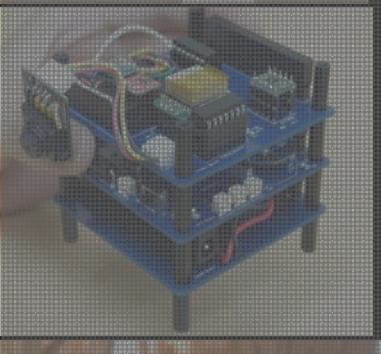


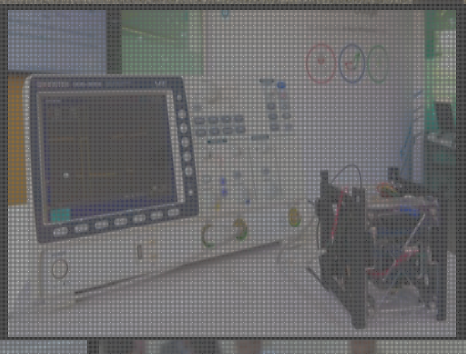
Space Systems Engineering Education with Hands-on Activities Using CubeSat Kit

Connecting to Space
Space Systems Engineering Education
with Hands-on Activities Using CubeSat Kit

Nihon Univ. & UNISEC
Masahiko Yamazaki



hepta-sat training



UNISEC GLOBAL
University Space Engineering Consortium

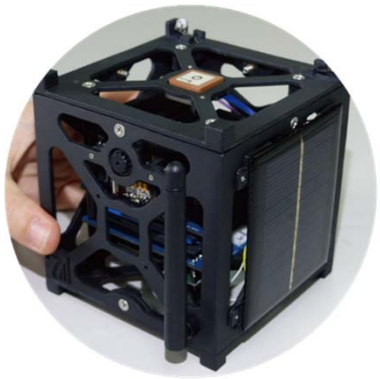
ASE NIHON UNIV. DEPARTMENT OF AEROSPACE ENGINEERING

Problem 3

- Human resources
- Barrier between disciplines
- No easy way to learn and experience

Solution

CubeSat Training Package



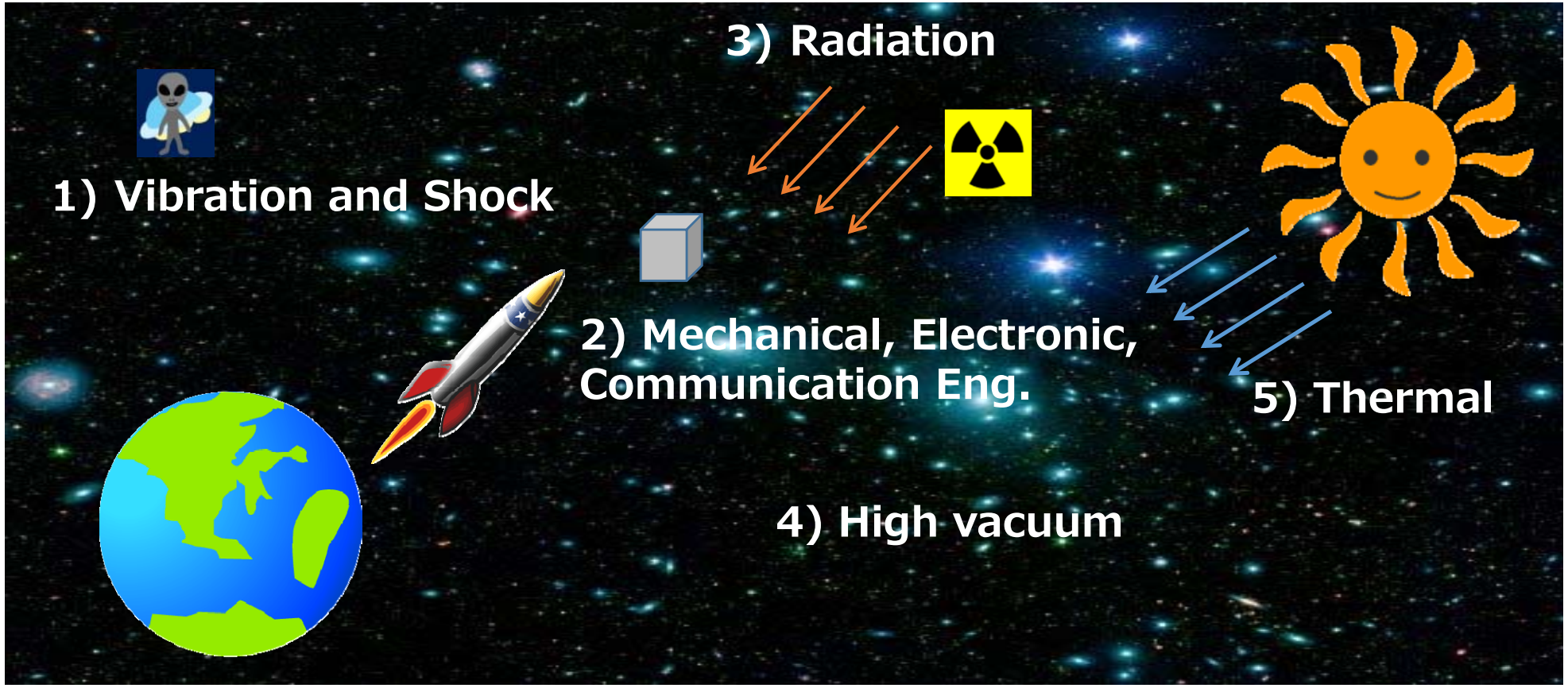
SAVE TIME

SAVE MONEY

SHARE Design Language

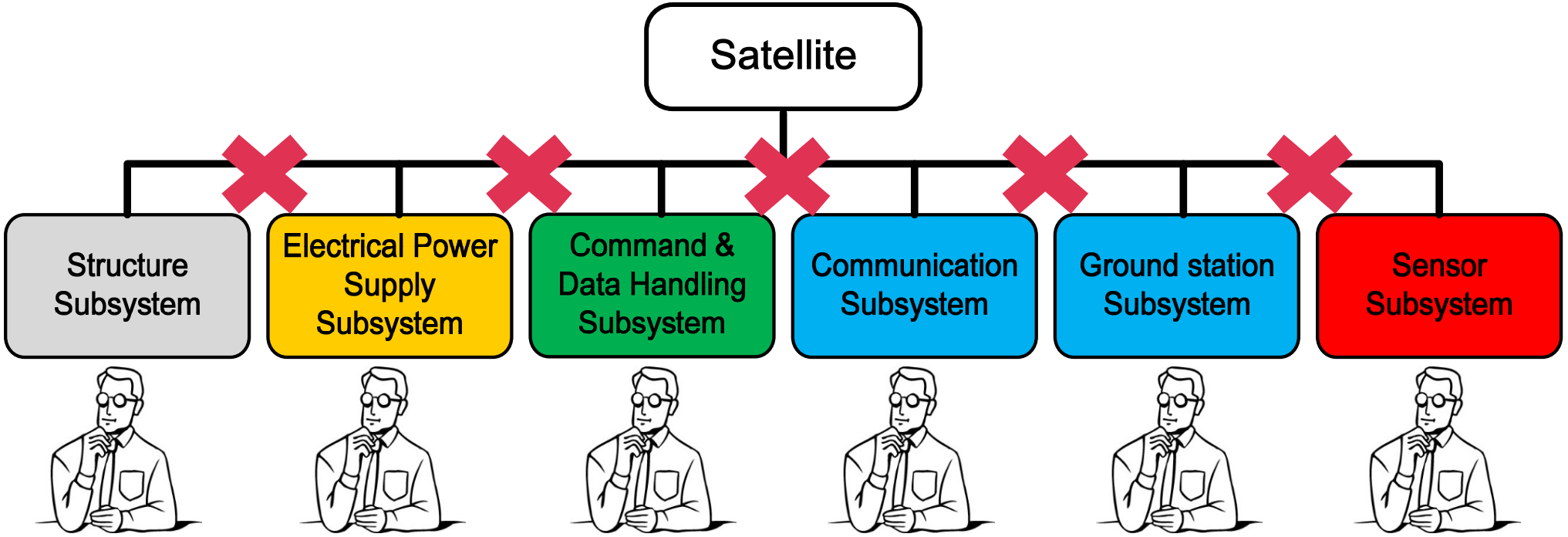
Why CubeSat Training? 5

- Satellite is possible to learn <u>variety of elemental technologies</u>
  - Mechanical engineering, electronic engineering and communication engineering and it's systems integration.
  - To learn the space systems engineering, CubeSat development project based learning is a very effective training way.



Why Training Package? 6

- It is sometimes **hard to gain knowledge or experience** of the **whole development process** because the roles are divided into team members.



- Not only a **local optimization insight** but also **global optimization insight** for developing the system.
- Our training program offer a such kind of experience before starting real satellite or real system design/development in a **short time and reasonable cost**.

Solution

- Systems Engineering and Project Management to Realize Large and Complicated Systems.

Space Systems “CubeSat”

CubeSats are a class of research spacecraft called nanosatellites. CubeSats are built to standard dimensions (Units or “U”) of 10 cm x 10 cm x 10 cm. They can be 1U, 2U, 3U, or 6U in size, and typically weigh less than 1.33 kg per U. CubeSats are deployed from a Picosatellite Orbital Deployer (POD). — NASA, 2018.

Systems Engineering

"System engineering” is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals.— NASA Systems Engineering Handbook, 1995.

Solution - International Training Experience - 8

Host countries

9

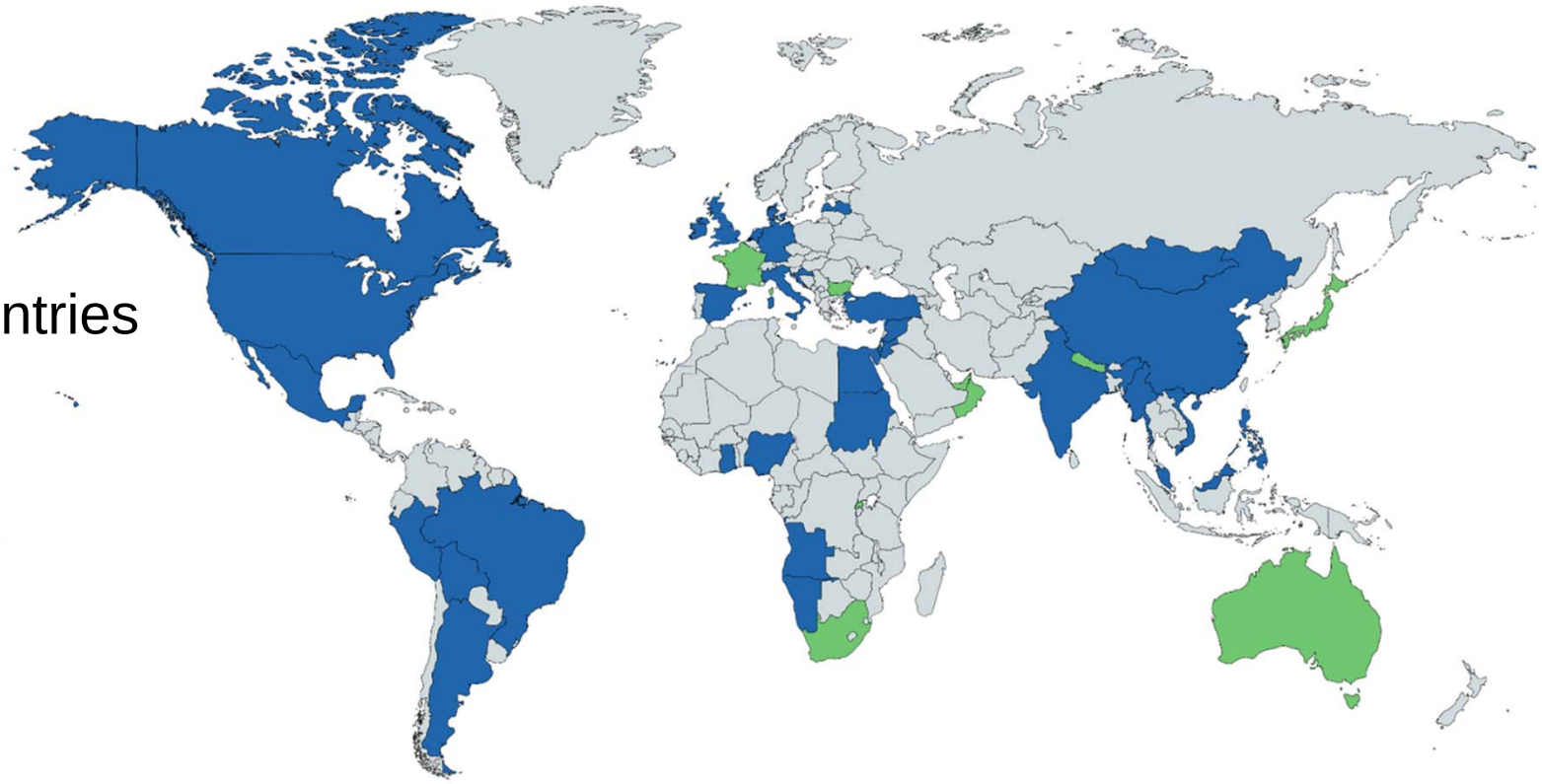
Participating countries

53

Trainees

+400

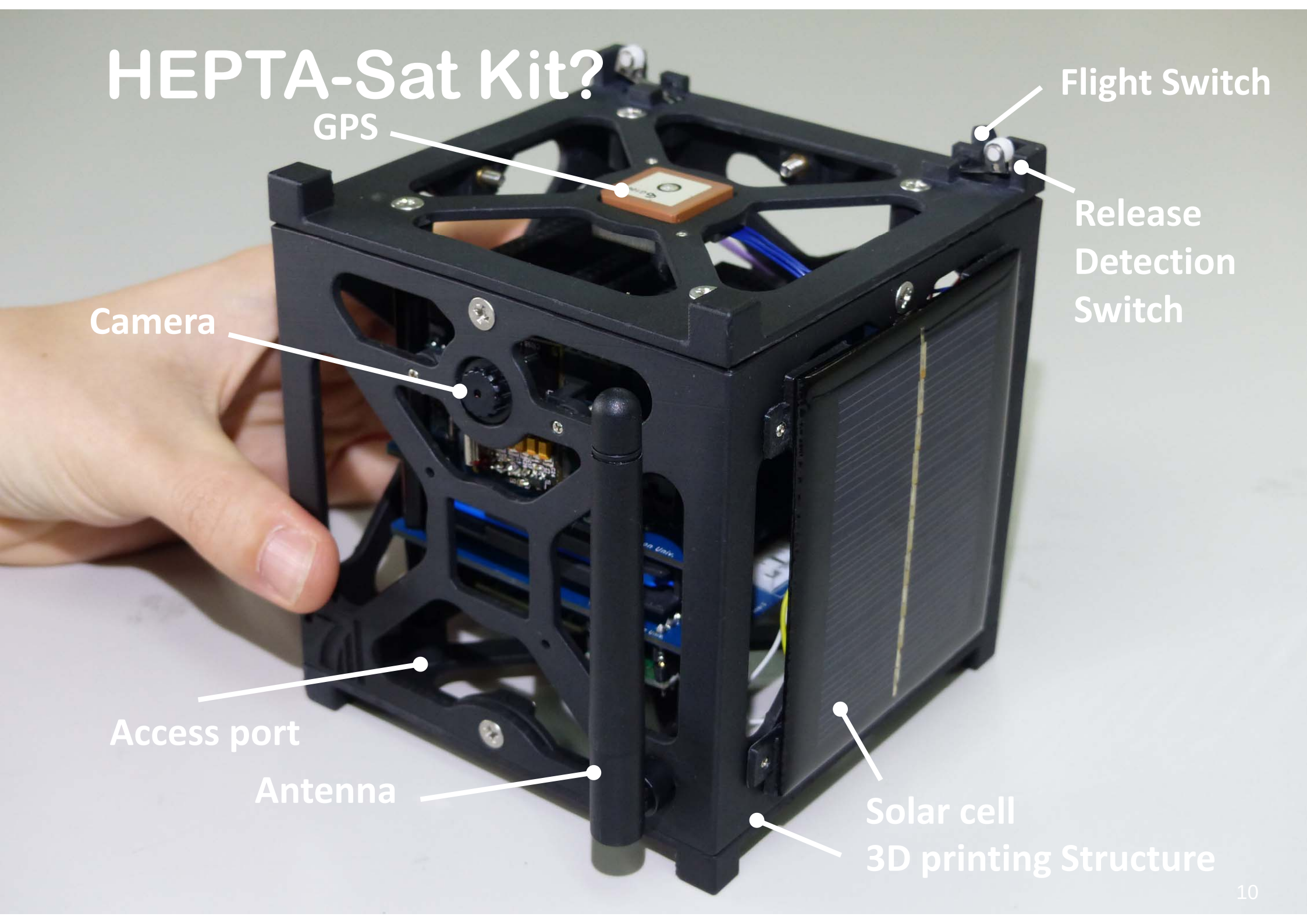
During 2017.10～2019.11



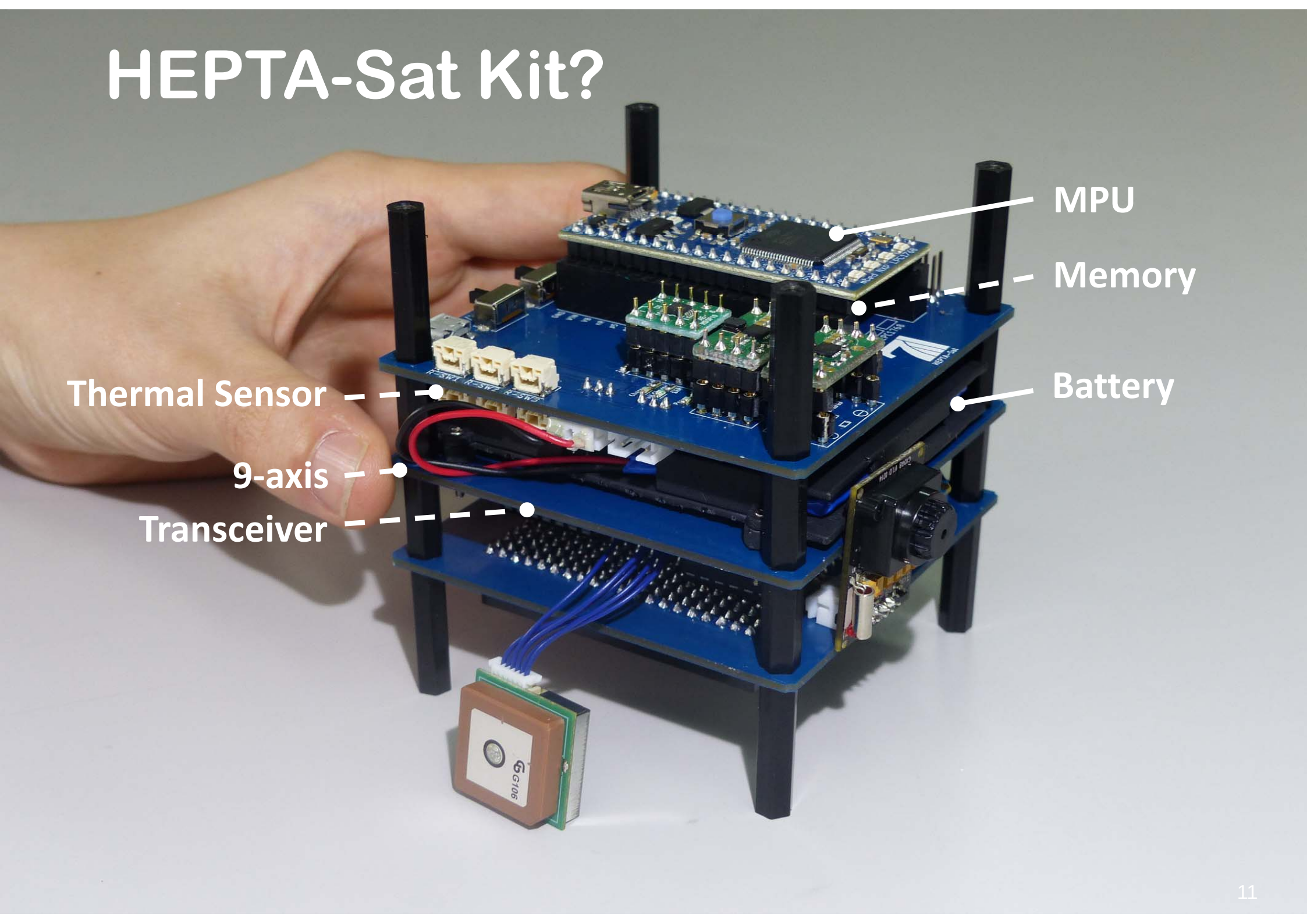
- ◆ Annual Training for Instructors
- ◆ International Space University (France)
  - ◆ SHSSP(2019,2020), SSP(2019)
- ◆ Japan International Cooperation Agency(JICA) (Japan)
- ◆ Space and Space related Agency (Kenya, Oman, etc.)
- ◆ University (UAE University, Titec, etc.)
- ◆ United Nation Workshop (South Africa)
- ◆ Science Museum
- ◆ Company

Solution - Training for Instructors -

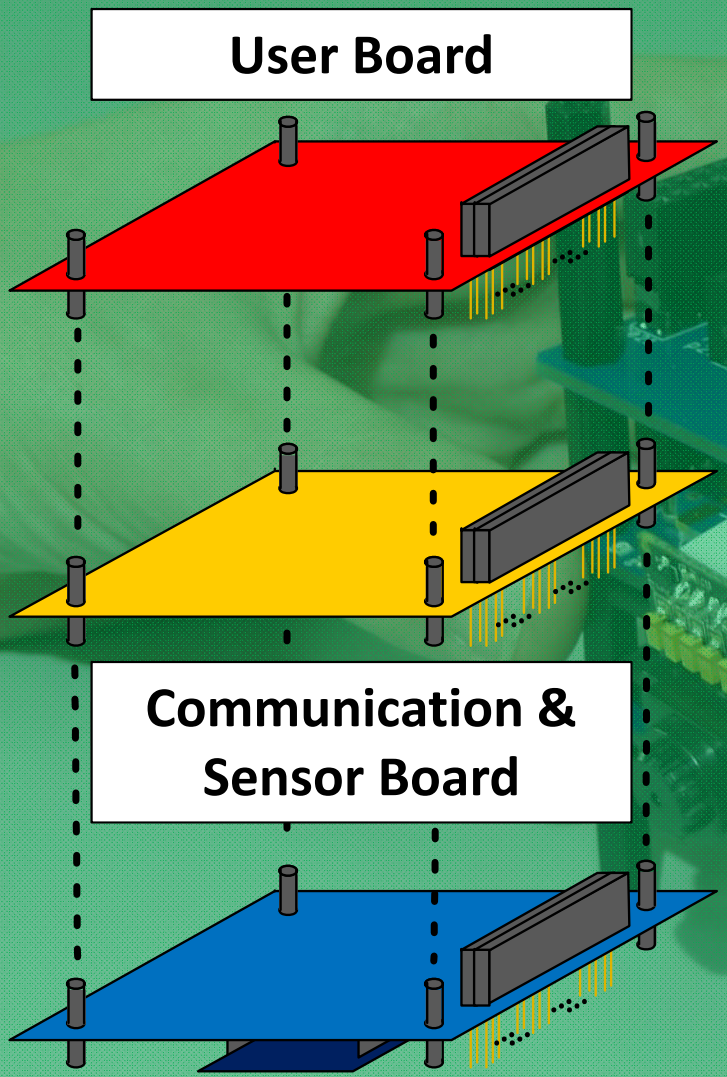
HEPTA-Sat Kit?



HEPTA-Sat Kit?



HEPTA-Sat Kit?



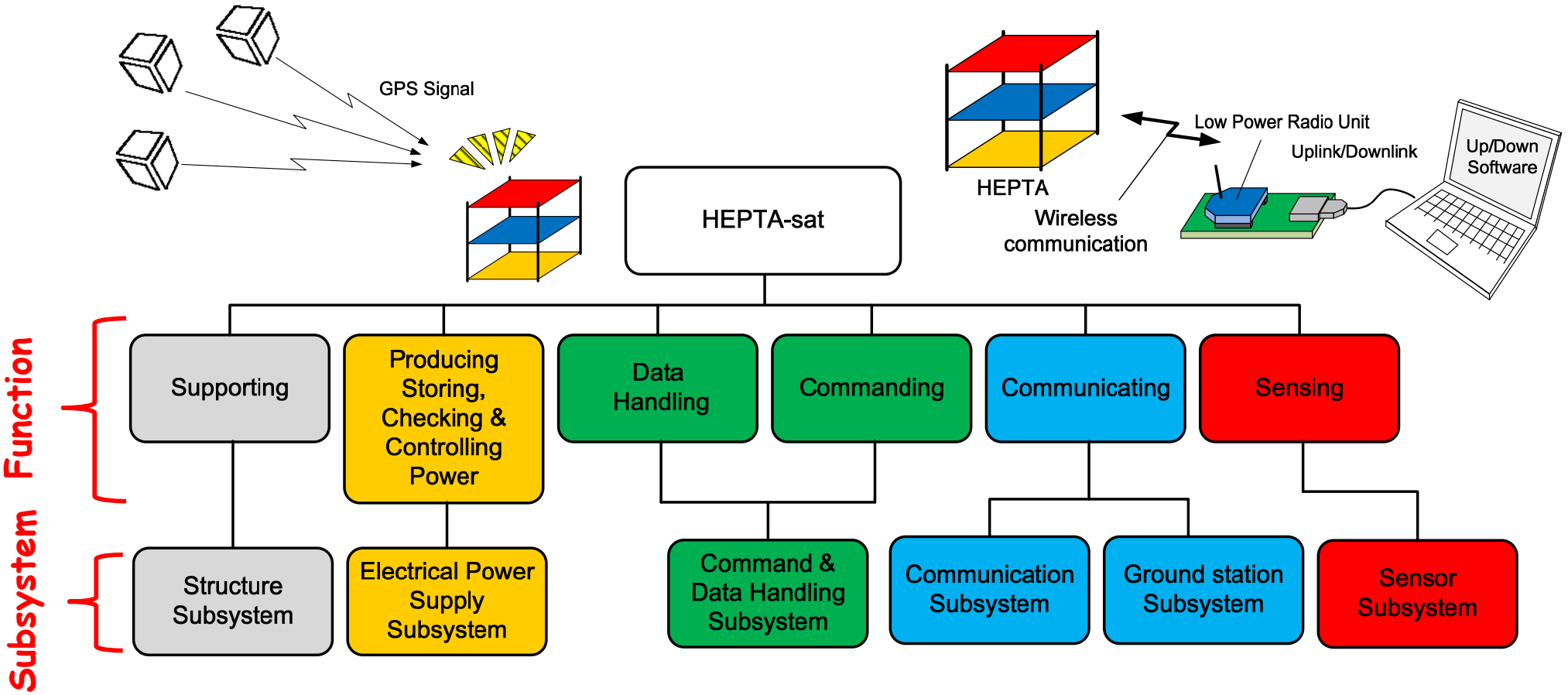
User Board

Communication
& Sensor Board

EPS, C&DH Board

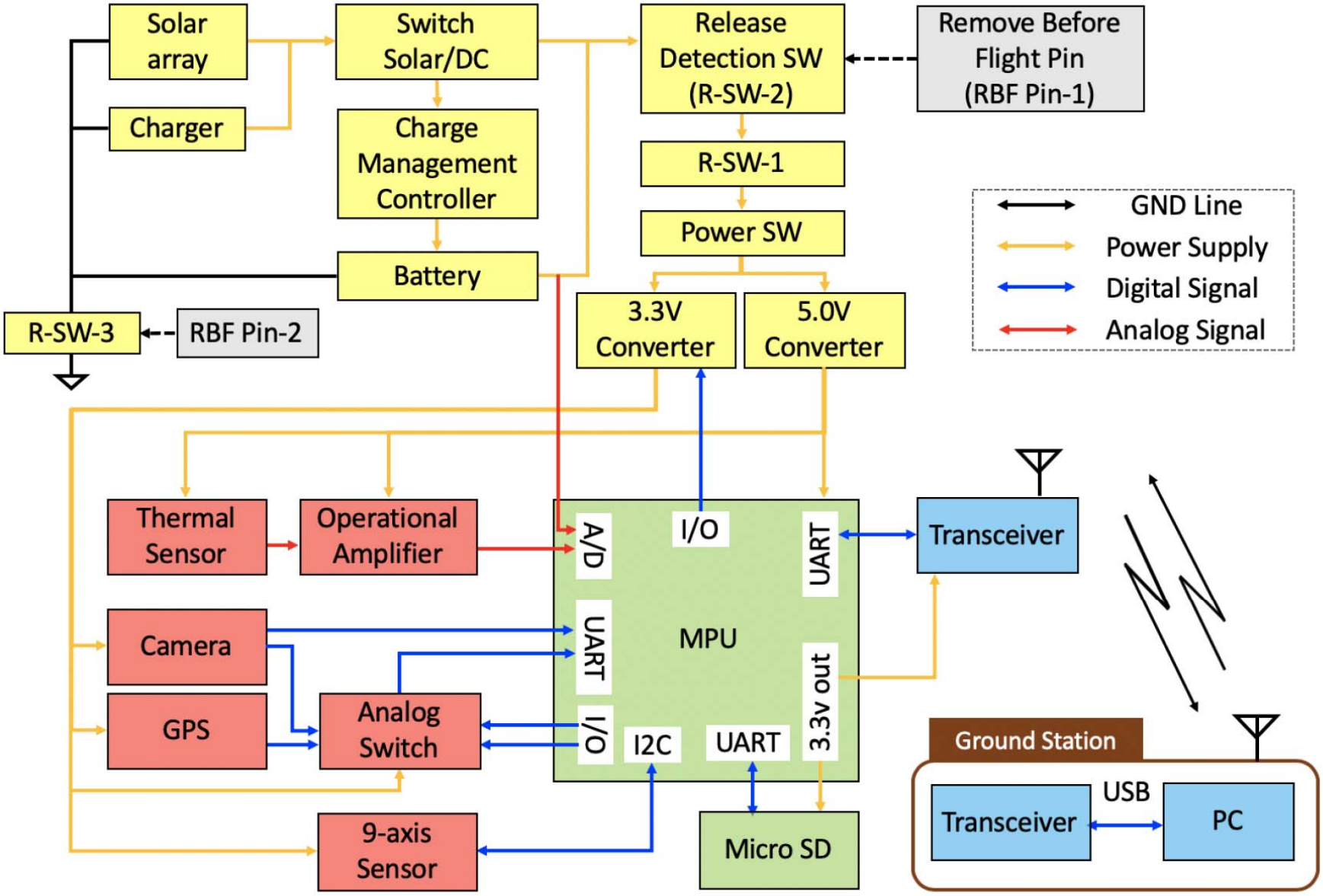
HEPTA-Sat Kit?

- Composed of 6 function and 6 primary sub-systems.
- You can learn how each subsystem functions and how to integrate subsystems into a satellite through experiencing the process of assembly, integration including programing & system implementation and test.



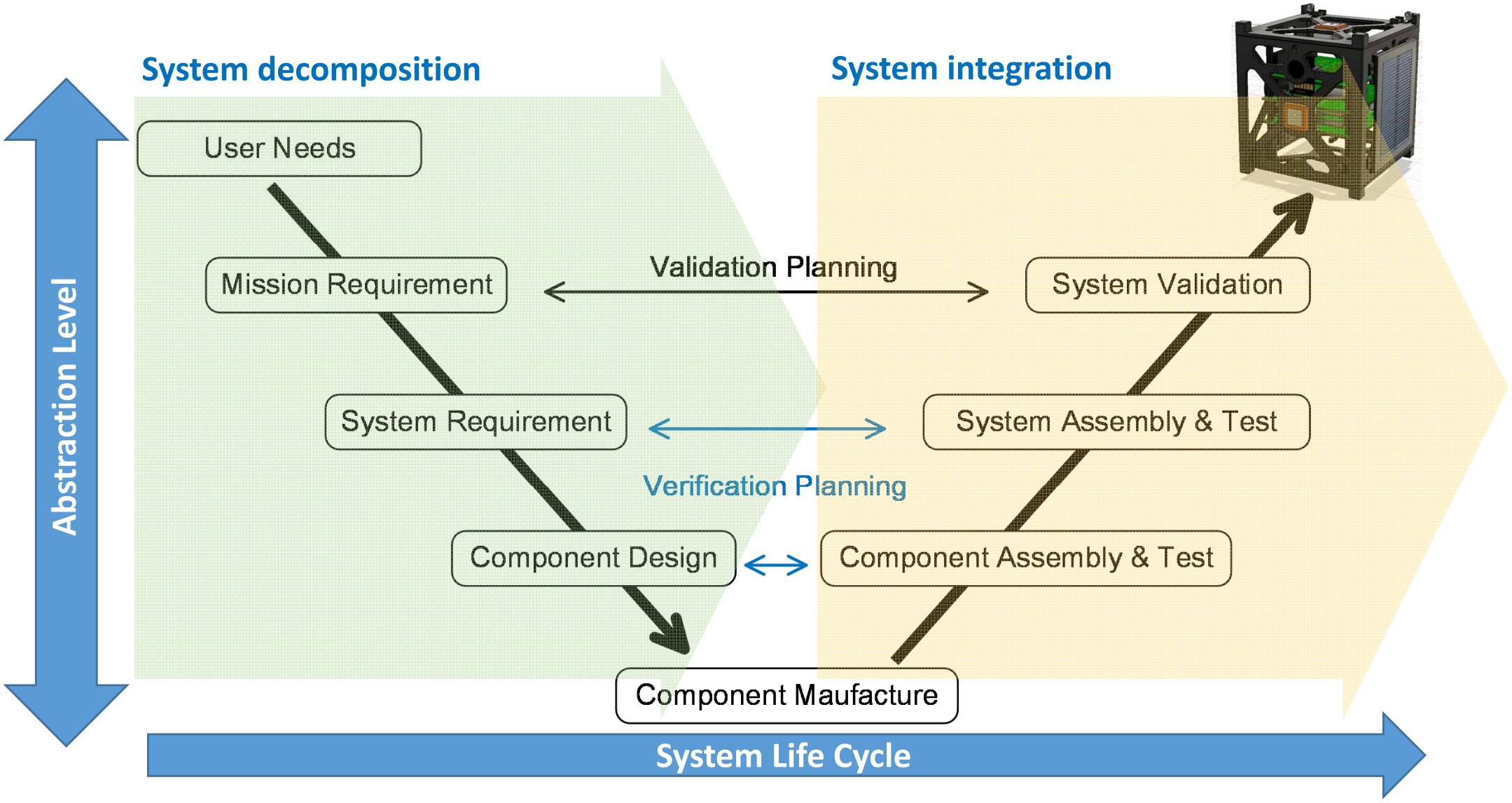
HEPTA-Sat Kit? – Physical View - 14

- Composed of 6 function, 6 primary sub-systems and physical elements.



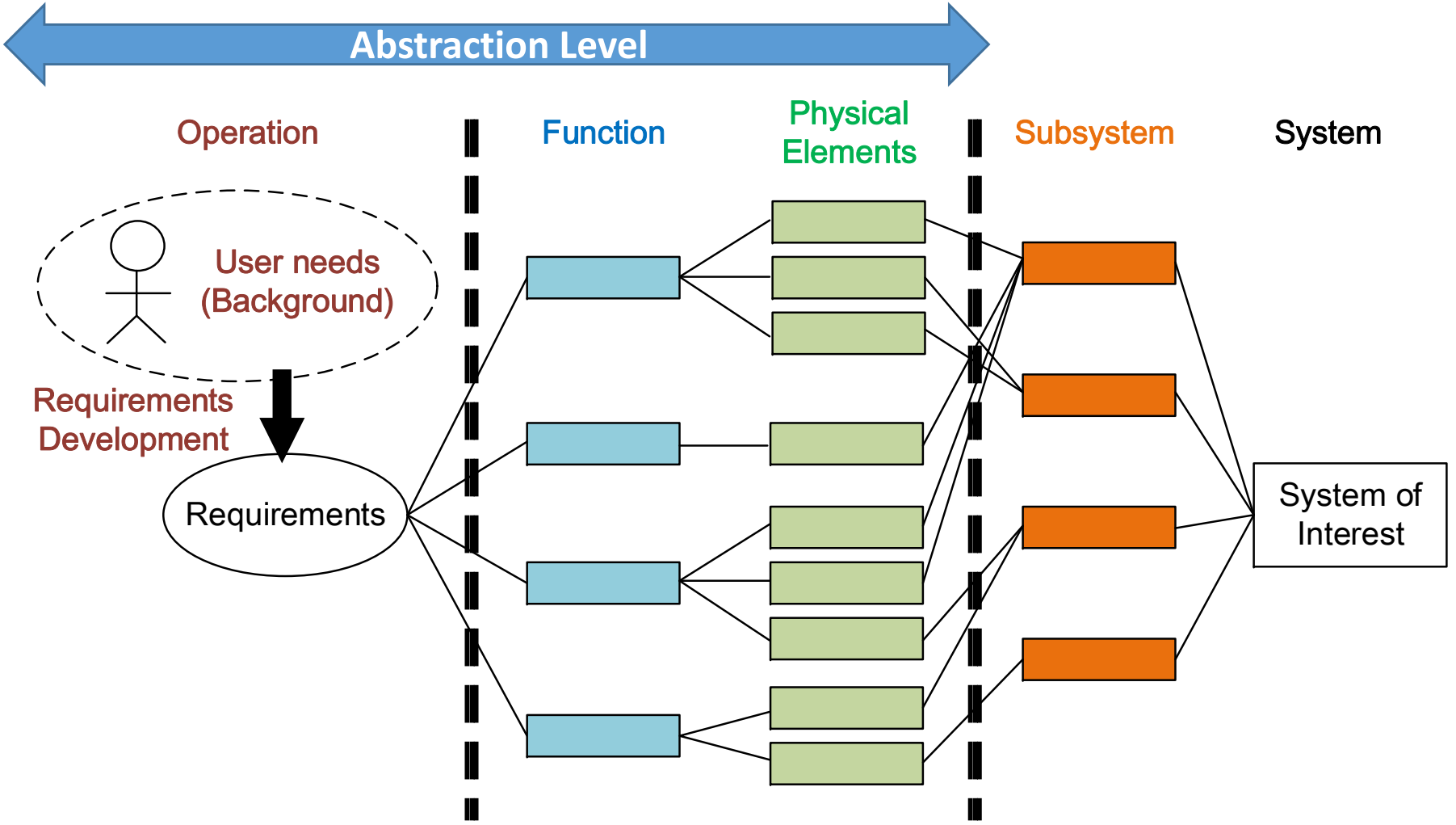
HEPTA Training? – Multi Point of View -15

- **Abstract View (Operational & User Experiment) to Physical View (HW & SW)**



HEPTA Training? – Multi Point of View -16

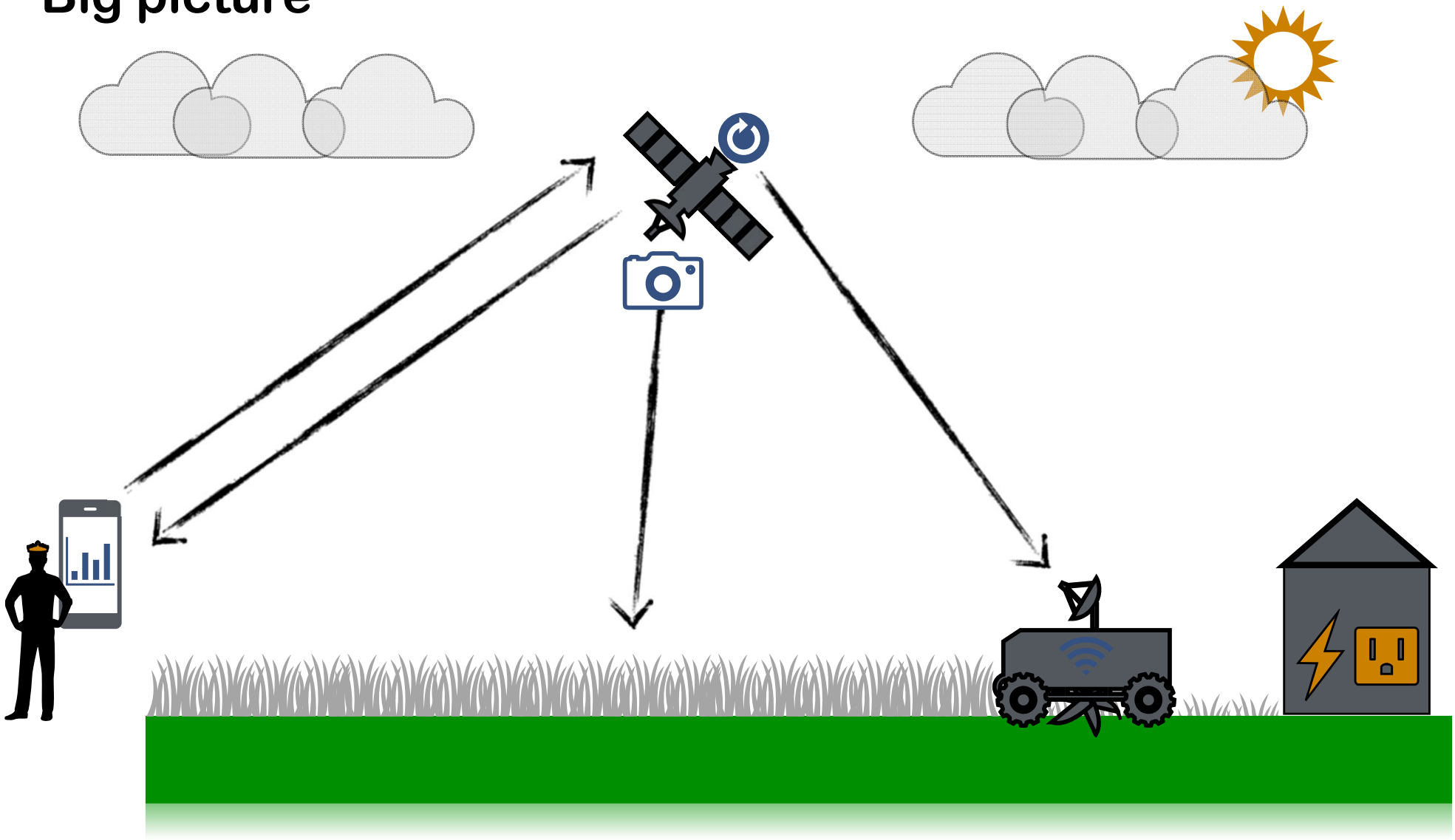
- Design and Integration experience.
- From requirement to element, From element to systems.



HEPTA Training? – Multi Point of View -17

- Abstract View (Operational & User Experiment) to Physical View (HW & SW)

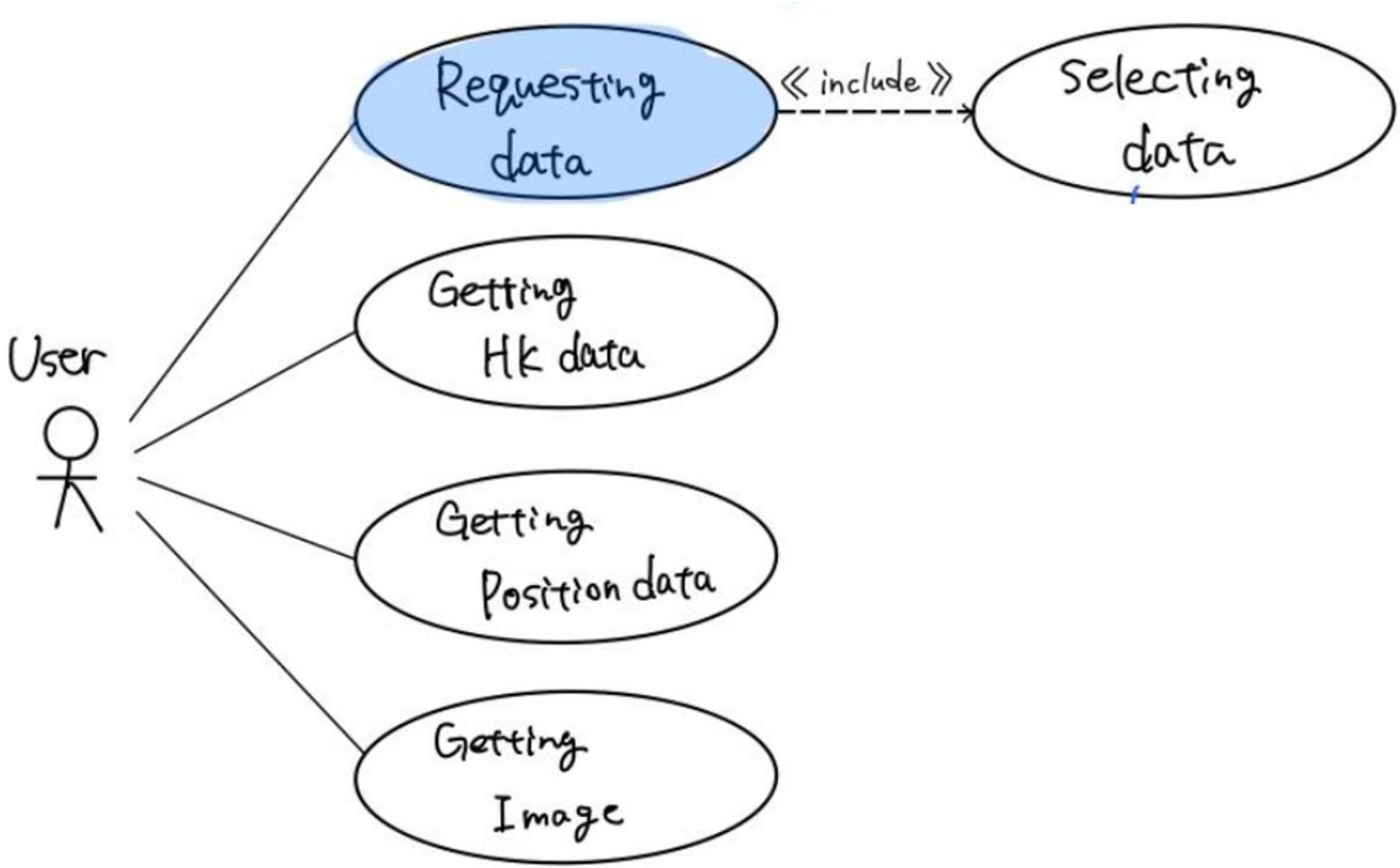
Big picture



HEPTA Training? – Multi Point of View -18

- Abstract View (Operational & User Experiment) to Physical View (HW & SW)

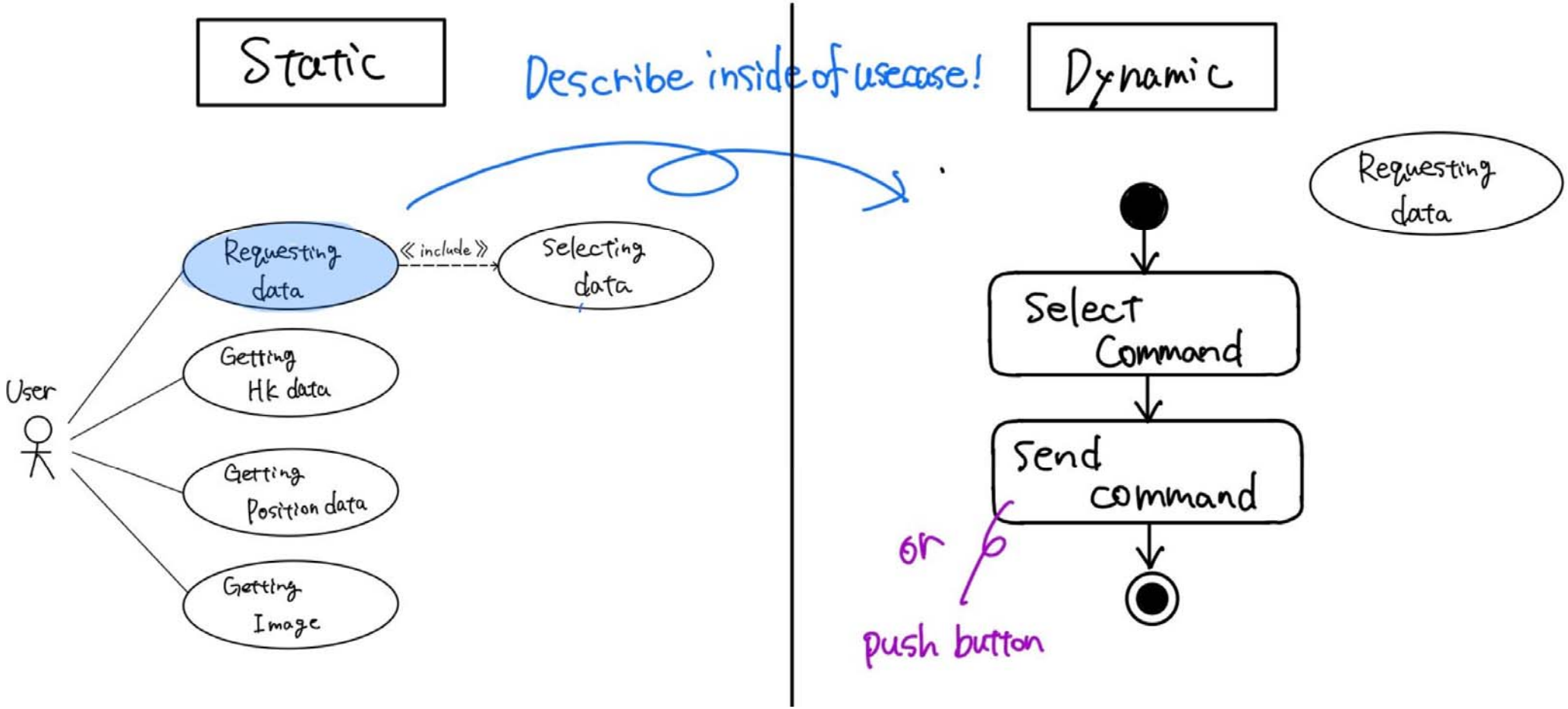
Static Operational model



HEPTA Training? – Multi Point of View -19

- Abstract View (Operational & User Experiment) to Physical View (HW & SW)

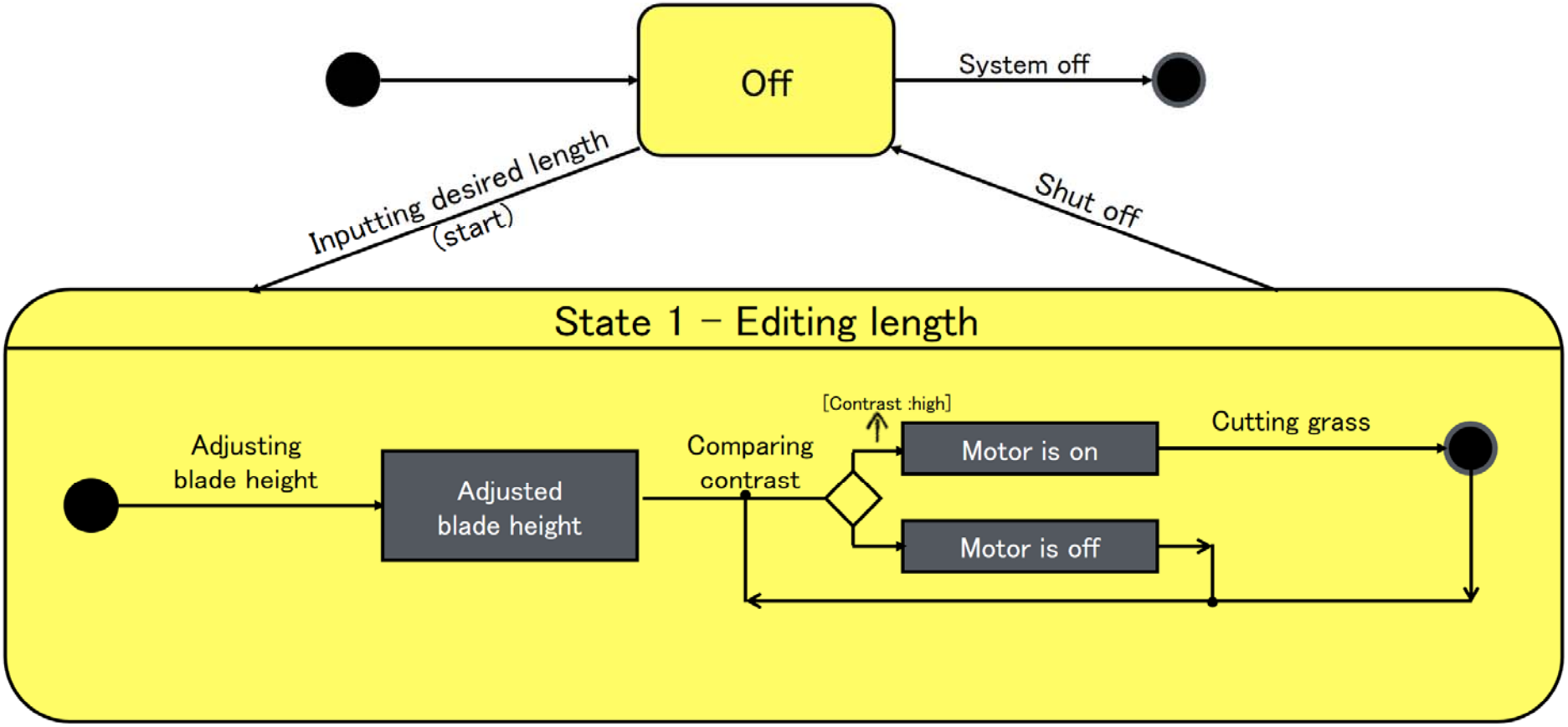
Dynamic Operational model



HEPTA Training? – Multi Point of View -20

- Abstract View (Operational & User Experiment) to Physical View (HW & SW)

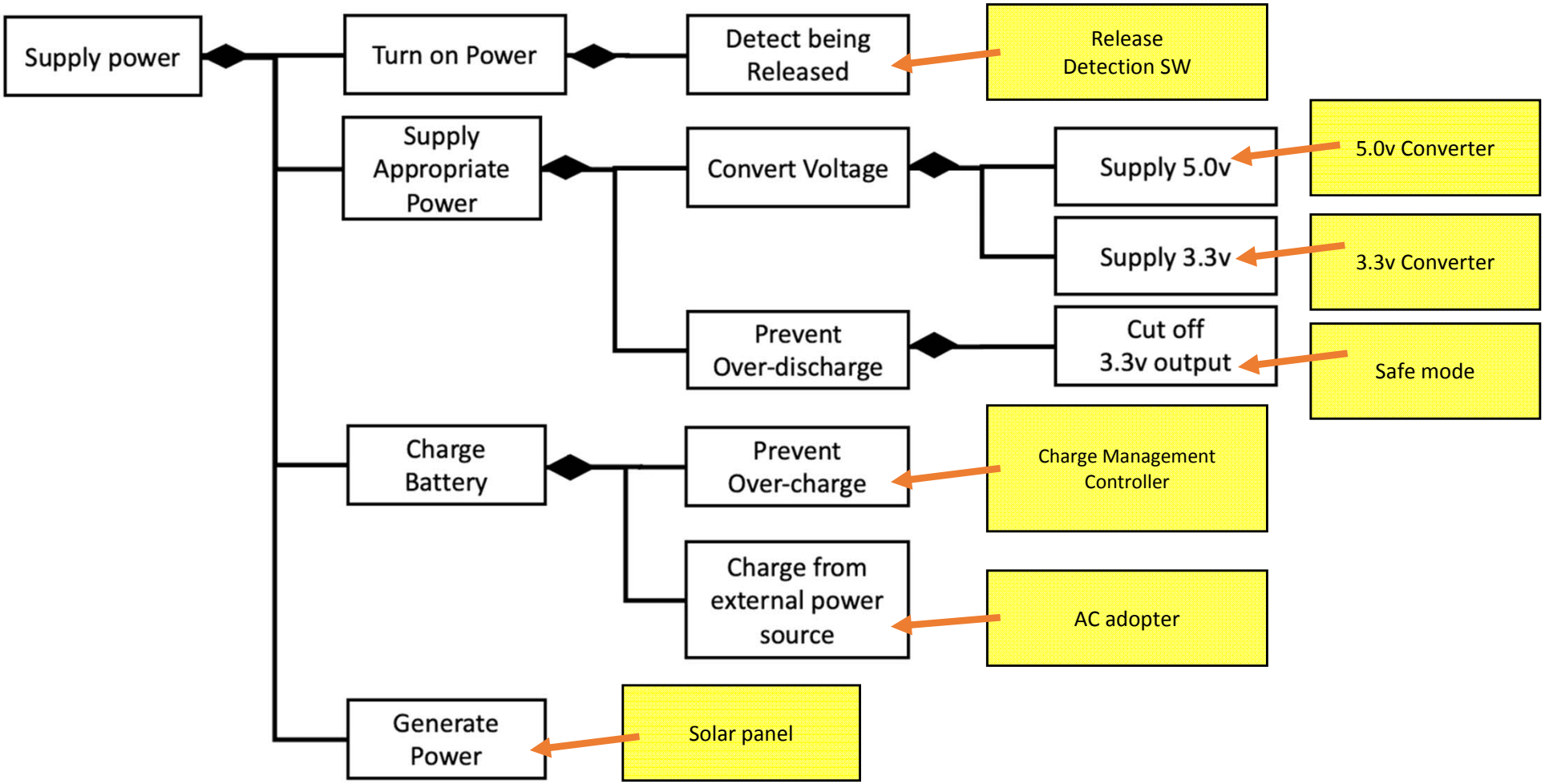
Dynamic Functional model



HEPTA Training? – Multi Point of View -21

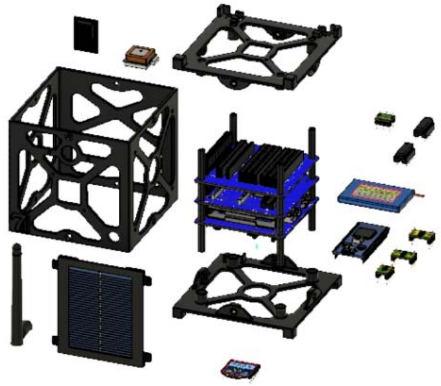
- Abstract View (Operational & User Experiment) to Physical View (HW & SW)

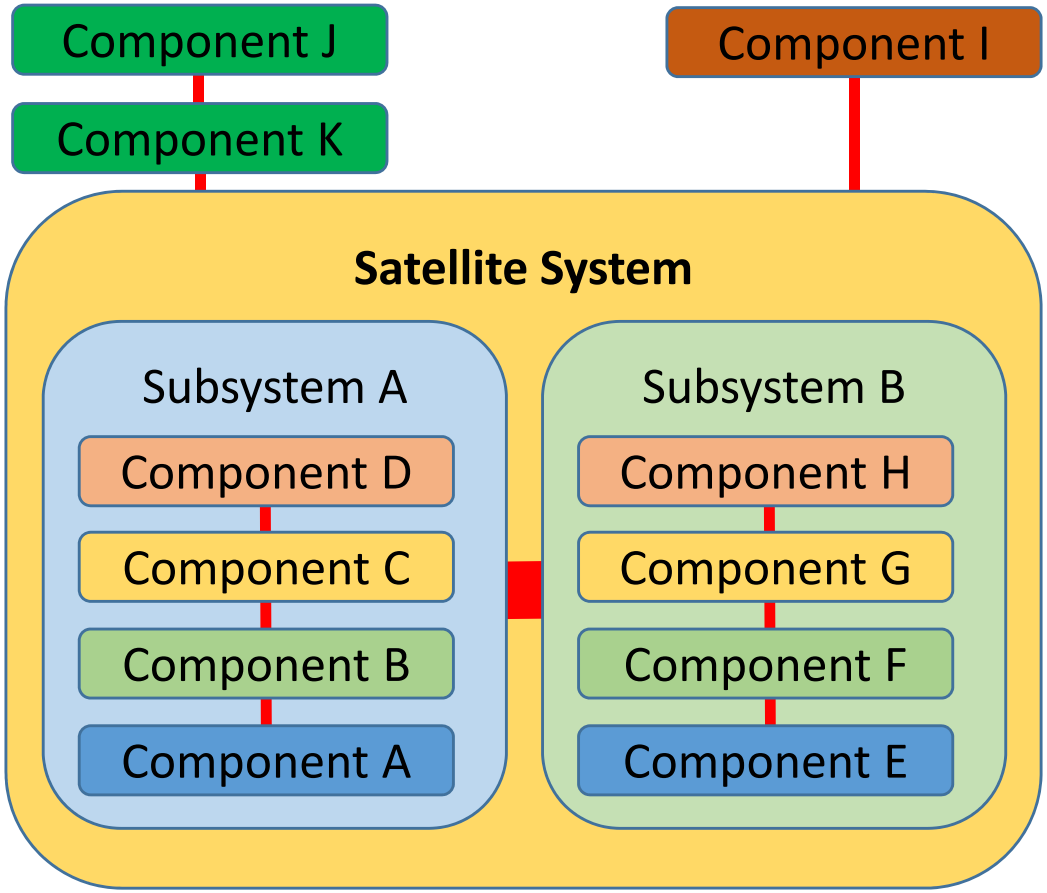
Static Functional model and Allocation



HEPTA Training? – System Integration -22

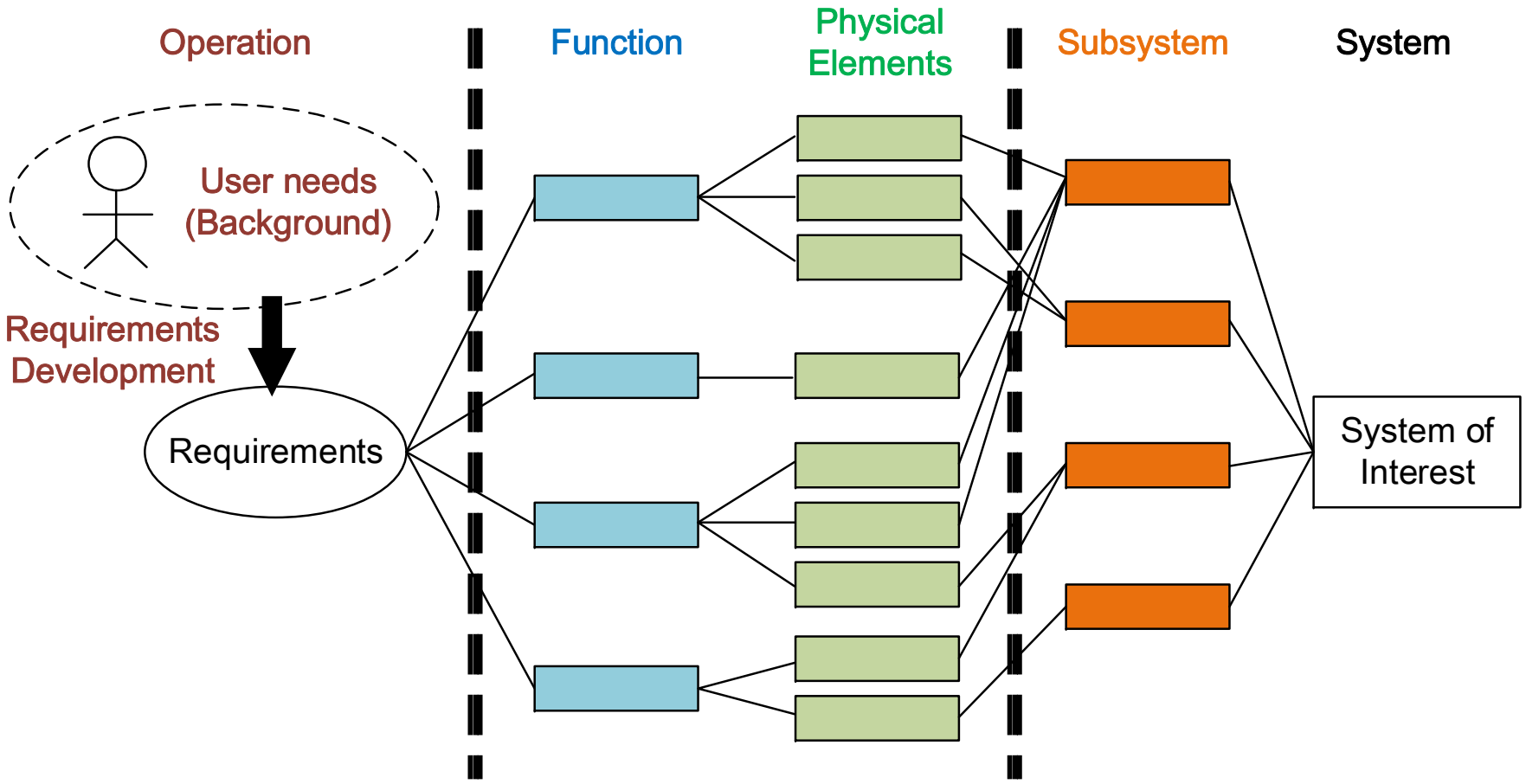
- From Element to Satellite System
- System has certain characteristics (functions / effects) by combining various elements such as hardware, software, people, data, service, e.t.c. to achieve one or more stated purposes.





HEPTA Training? – System Integration -23

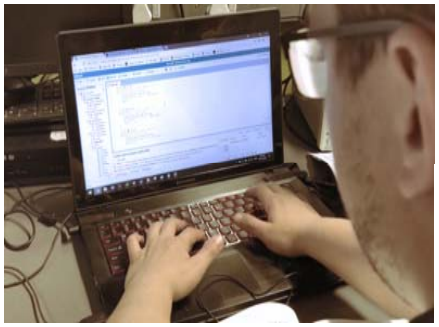
- Design and Integration experience.
- From requirement to element, From element to systems.

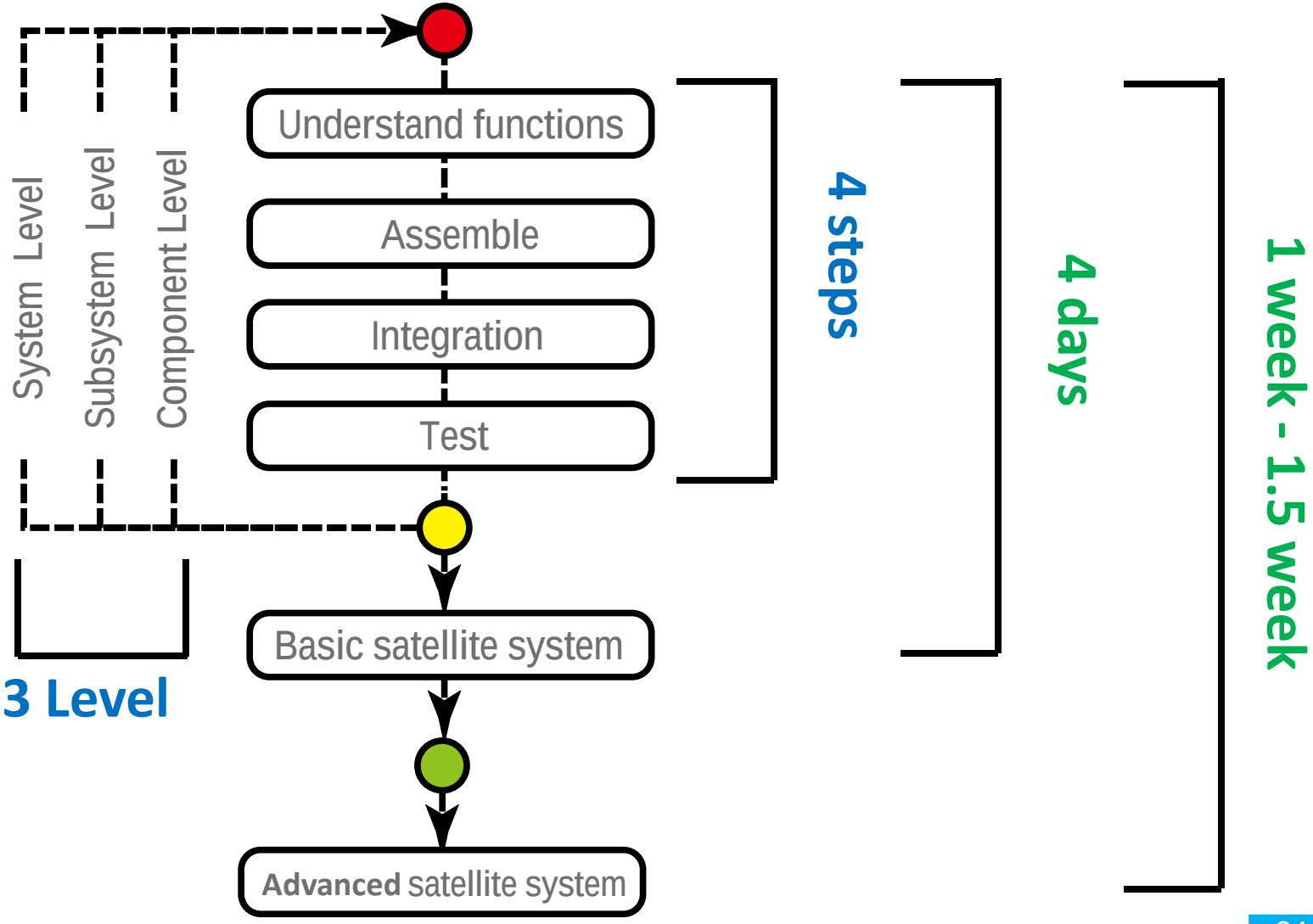


System Life Cycle

HEPTA Training? – Way of learning- 24

- Focuses mainly on understanding, assembling, integrating, and testing the function of the CubeSat model and carrying out it in a hands-on manner step by step from the component level to the system level.

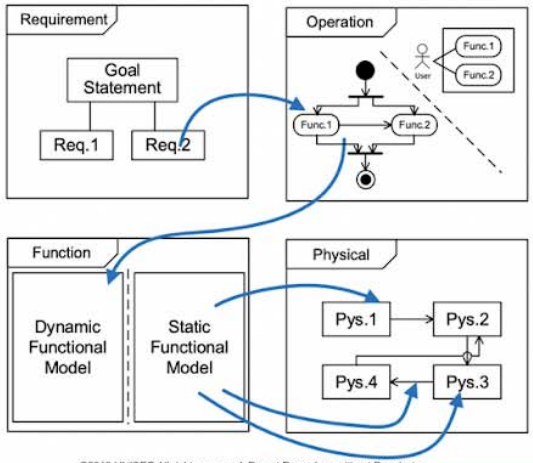




hepta-sat training

6. Understand Systems Engineering

6.5 What is MBSE and Modeling Language?

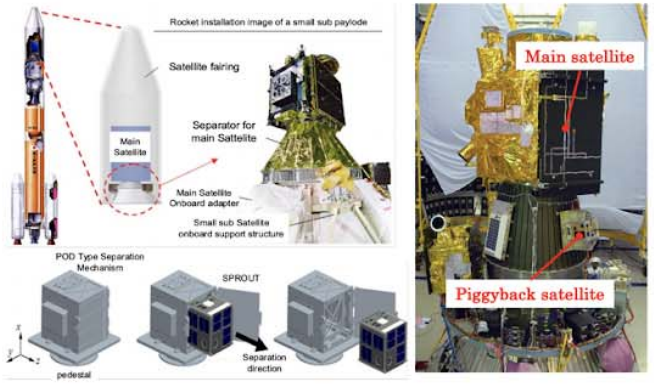


hepta-sat training

3. Understand Structures of the Satellite

3.1 Piggyback satellites

- Micro/Nano satellites are often launched on rockets as piggyback satellites.



Systems Engineering | Space Development | Technology | Project Management

Exercise 1.2 Download

hepta-sat training

3. Create your program

3.2 Communication with PC

- Data Display

File name : Lab1-01_PC_communication

```
#include "mbed.h"                          include mbed library
Serial pc(USBTX,USBRX);                    serial class declaration
int main(){                                main loop start
  pc.baud(9600);                           set communication rate
  int i1 = 7;
  float i2 = 7.5;                          variable declaration
  char i3 = 'H';
  char i4;
  pc.printf("Hello World!\r\n");           display "Hello world" on PC
  pc.printf("i1 = %d\r\n",i1);
  pc.printf("i2 = %f\r\n",i2);            display "i1, i2, i3" on PC
  pc.printf("i3 = %c\r\n",i3);
  pc.putc(i3);                             display "i3" on PC
  for(i1 = 0; i1 < 10; i1++) {             loop 10 times
    pc.printf("i1 = %d\r\n",i1);          display "i1" on PC
    i4 = pc.getc();                        store input in "i4"
    pc.putc(i4);                           display "i4" on PC
  }                                        loop end
}                                          main loop end
```

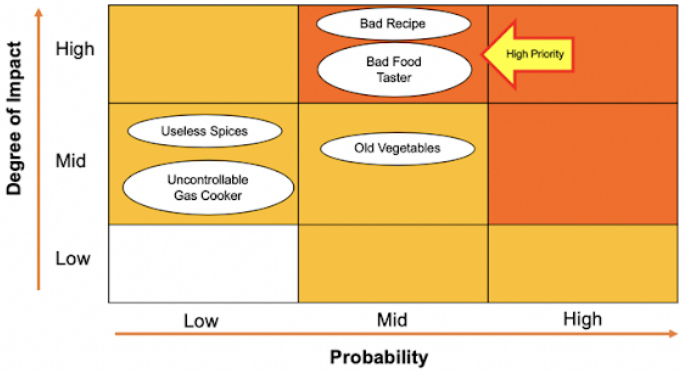
- The program on the left is written to display each variable type.
- Conduct internet search in the mbed handbook for other Serial Class functions.

hepta-sat training

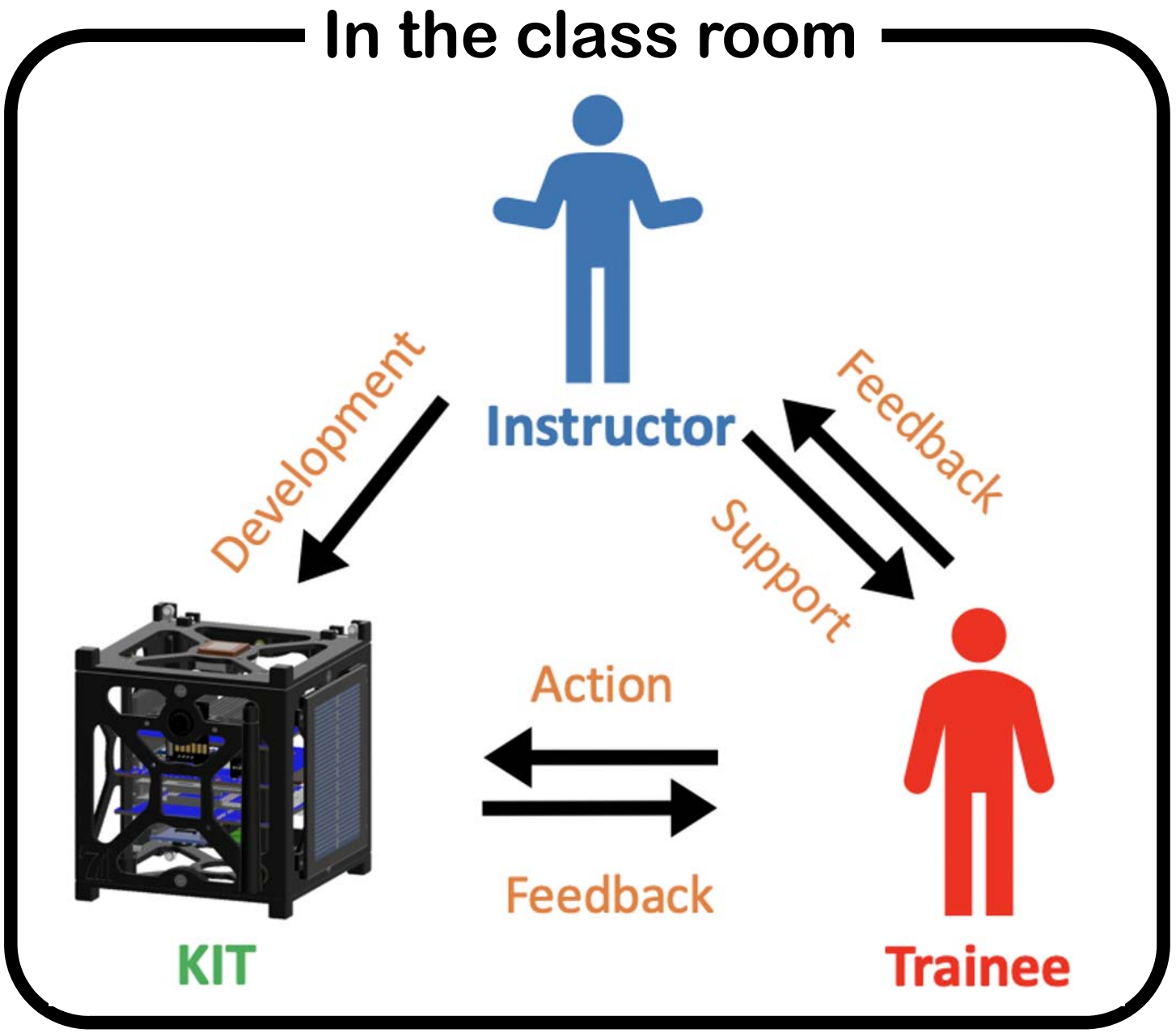
4. Understand Risk Management

4.2 How to Understand Risk Management

- Visualize the priority by making a table.

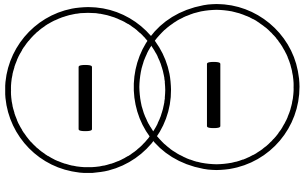


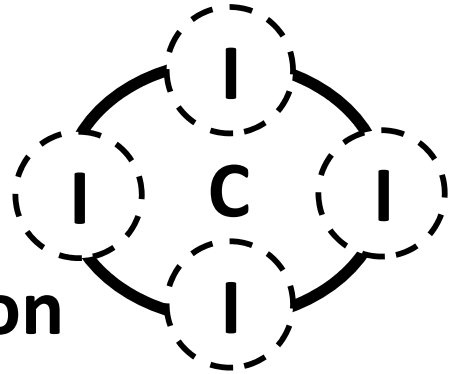
Interactive Knowledge Transfer 26



Interactive Knowledge Transfer 27

Increasing understanding and Creating knowledge through experiencing sharing, verbalizing, deducing and internalizing in Knowledge Management Ba.

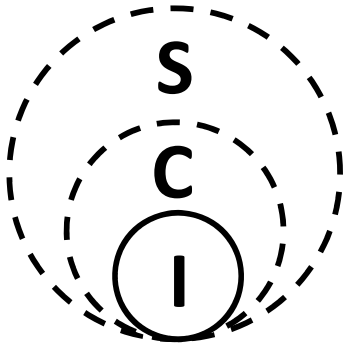




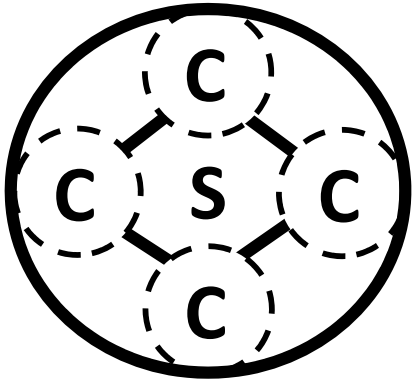
Experience ——— **Reflection**

= **Knowledge**

I : **Individual**
C : **Collective**
S : **Systematize**



Internali zation ——— **Experime ntation**



HEPTA-Sat Training

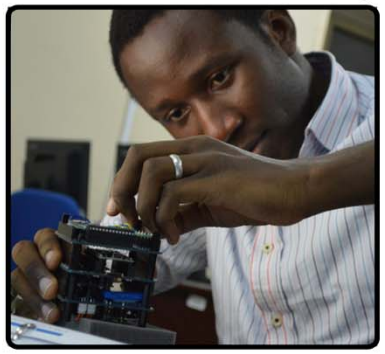
(1) Getting Overview of CubeSat Design and Development.

(2) Getting Abstract to Physical design point of view.

(3) Getting element to systems integration experience and insight.

Step 1:
Lecture

Step 2:
Hardware Assembly

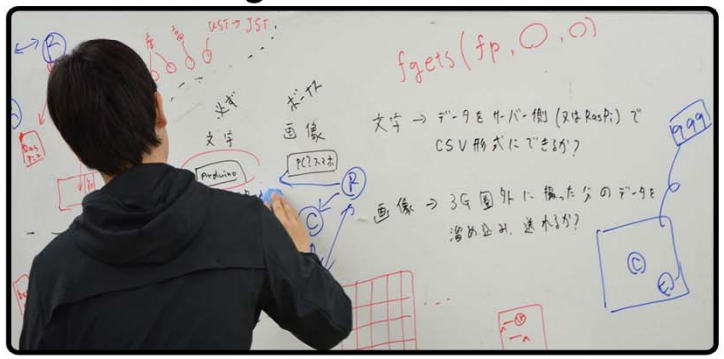


Step 5:
Field test

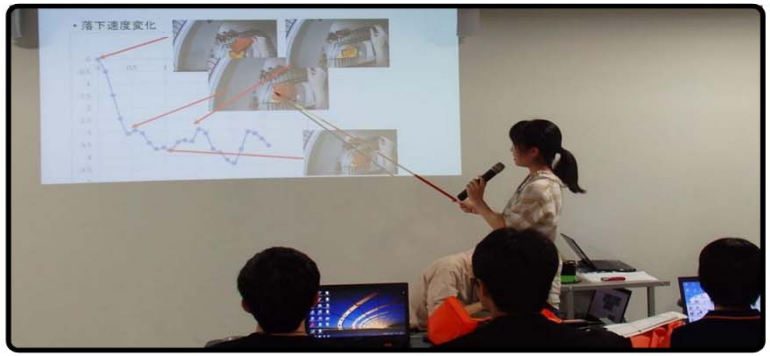
Congratulations!

Step 3:
Hardware & Software
Integration

Step 4:
Mission Design



Step 6:
Review & Presentation

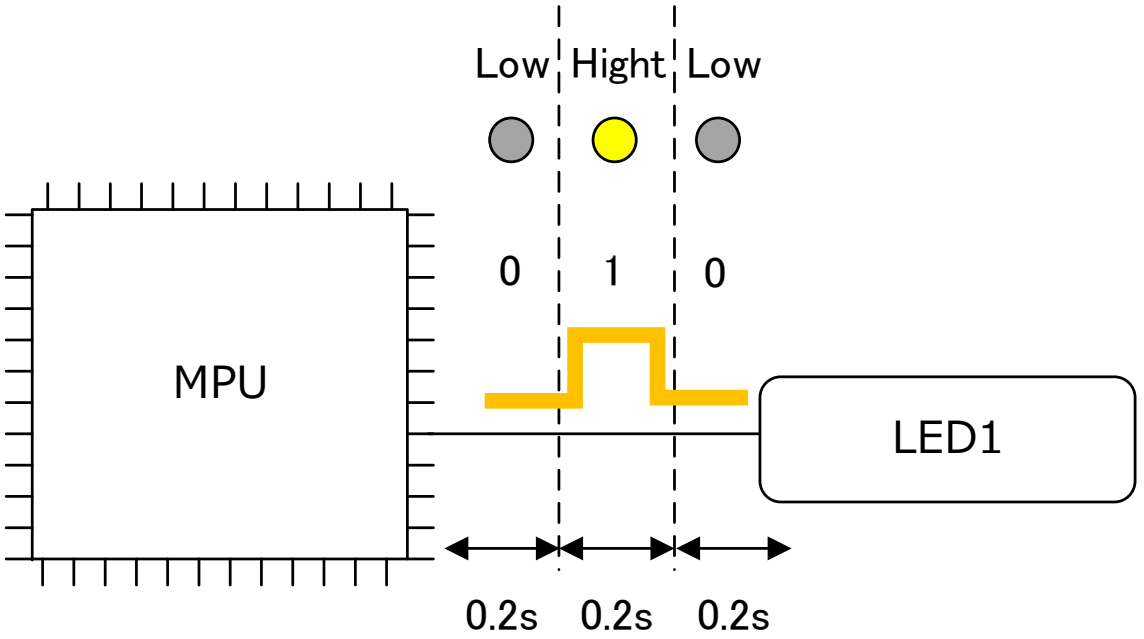


3. Create your program

3.1 Create and Compile Blinky LED Hello World Program

- Blinking LED:
- After myled lights up for a duration of 0.2 seconds, wait(0.2).
- After myled lights off for a duration of 0.2 seconds, wait(0.2).

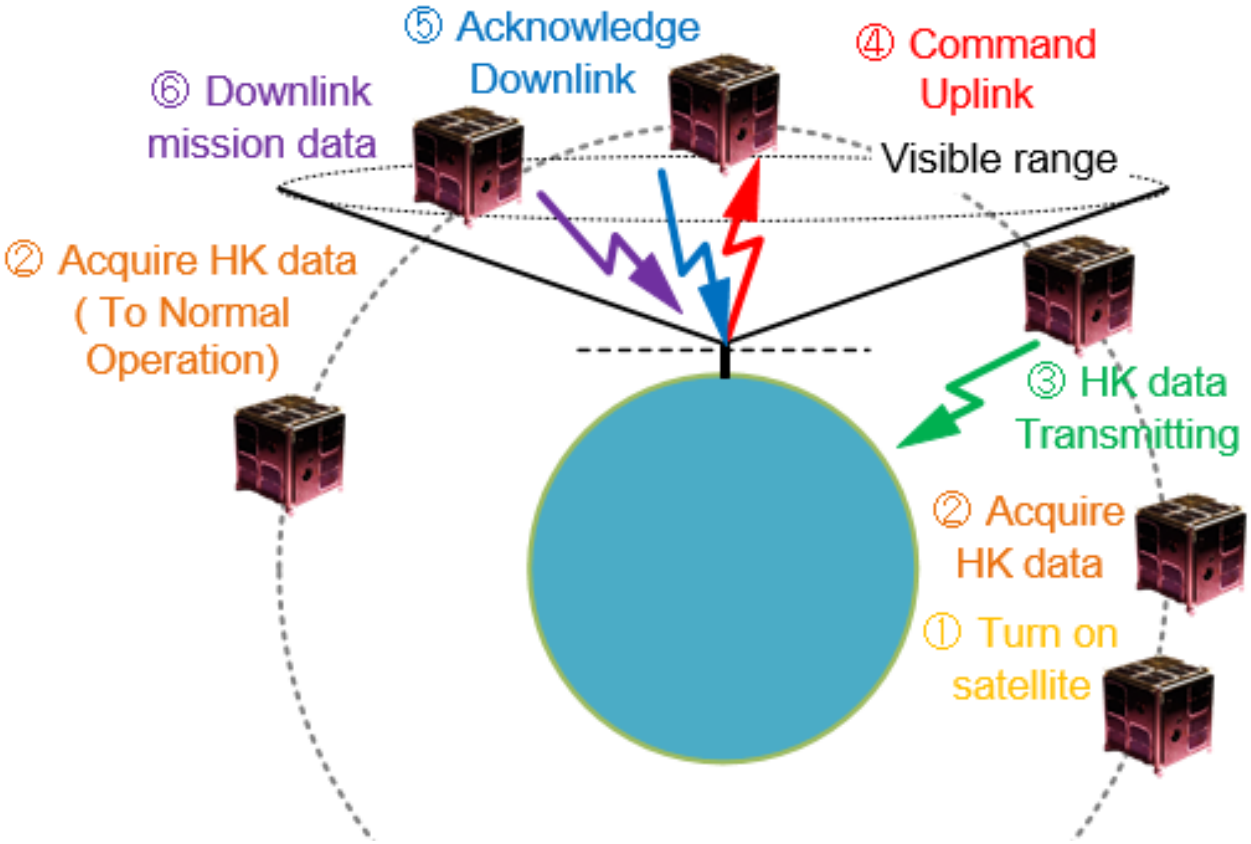
```
#include "mbed.h"

DigitalOut myled(LED1);

int main() {
    while(1) {
        myled = 1;
        wait(0.2);
        myled = 0;
        wait(0.2);
    }
}
```

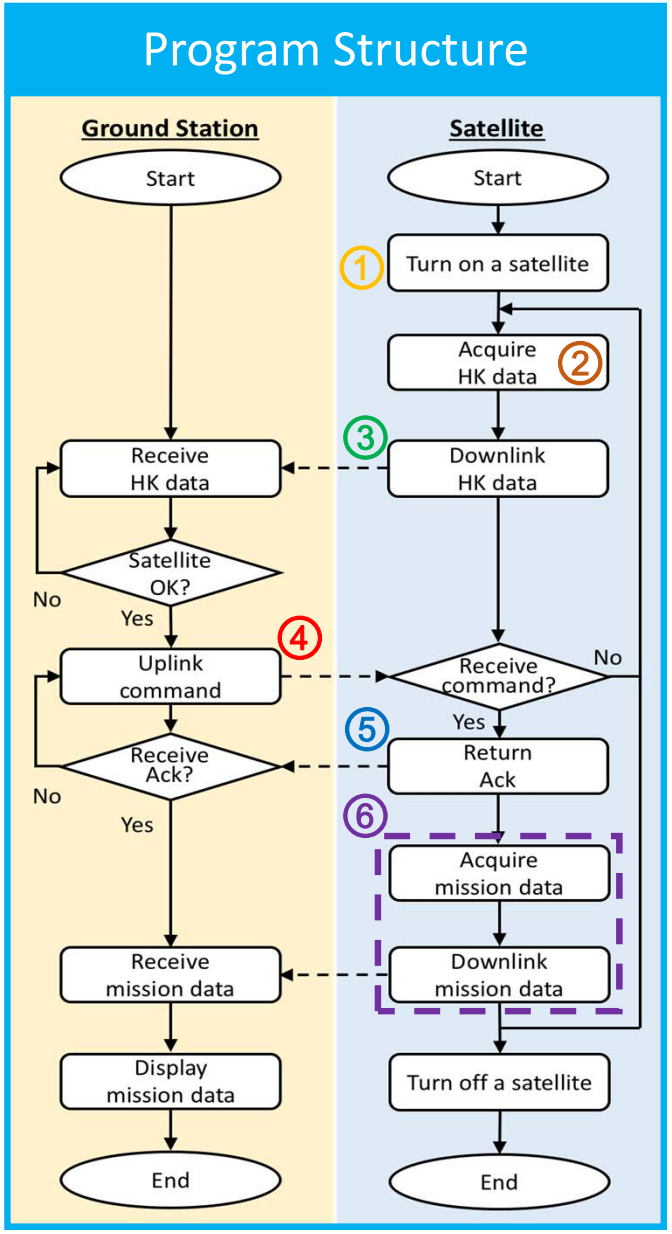


3. Create your program

3.6 Check and Create Satellite Program

- To understand a satellite software architecture, let's make the following type actual satellite program to simulate the satellite and ground station operation.

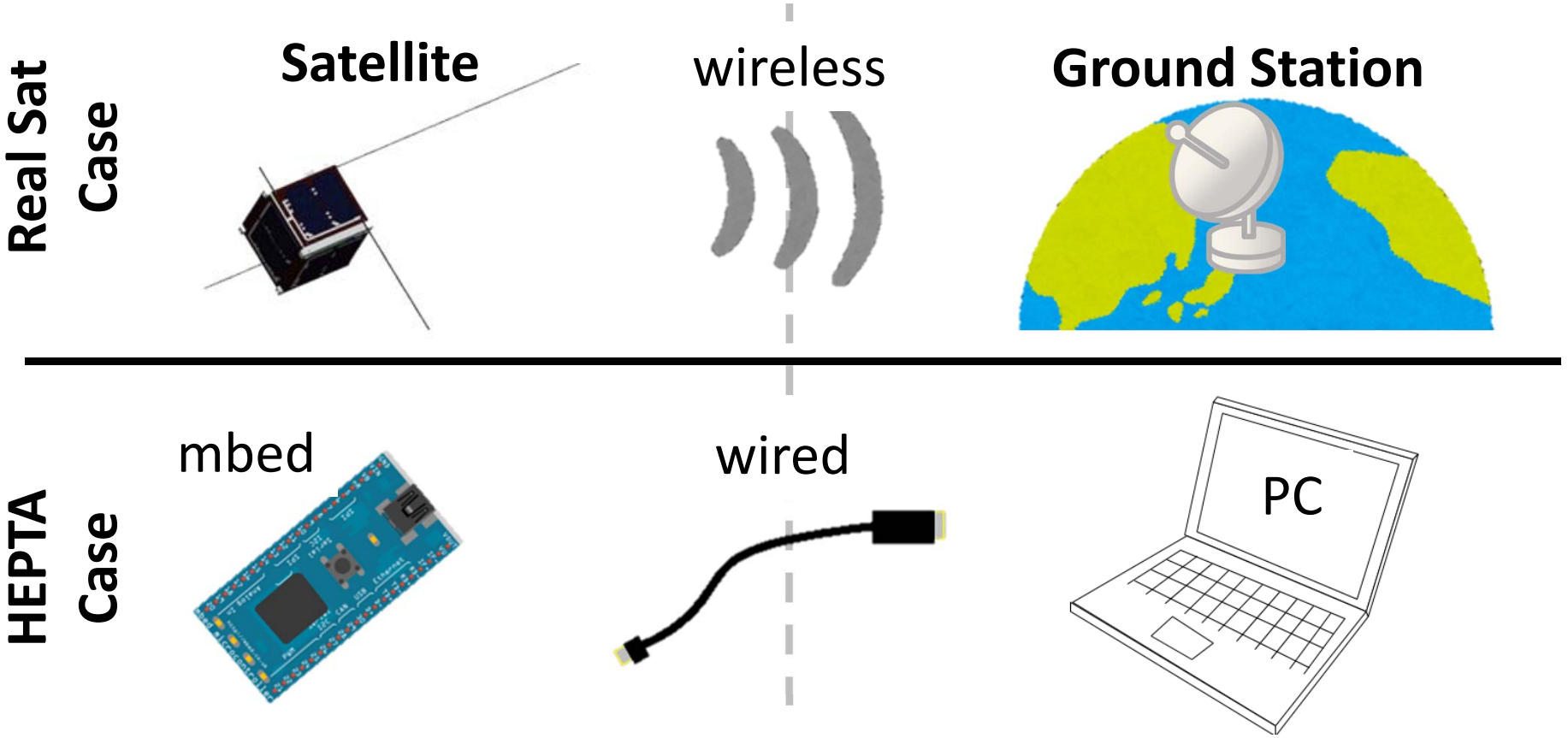


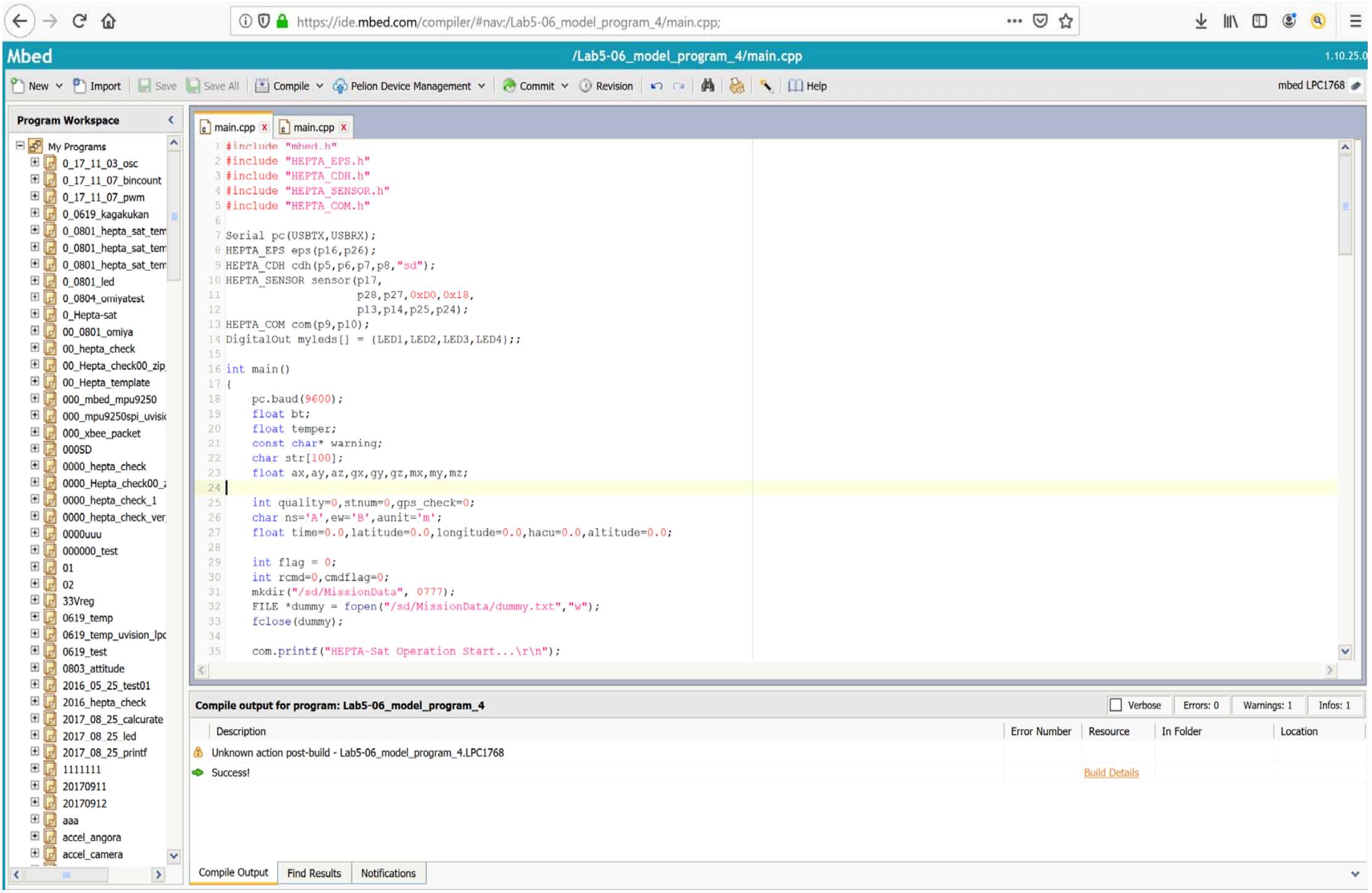


3. Create your program

3.6 Check and Create Satellite Program

- Originally the satellite uses communication device to communicate with space and the ground.
- But here let's use USB cable as a communication device and PC as a ground station for the simplicity (gradually increase a element Lab2, Lab3, Lab4…).





COM10 - Tera Term VT

ファイル(F)　編集(E)　設定(S)　コントロール(O)　ウィンドウ(W)　ヘルプ(H)

```
HEPTA-Sat Operation Start...
HEPTA-Sat Condition Checking...
HEPTA-Sat Condition Checking...
HEPTA-Sat Condition Checking...
HEPTA-Sat Condition Checking...
HEPTA-Sat Condition Checking...
Nominal Battery and Nominal Temperature Condition
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.91 [V]
HEPTASAT::Condition = 0, batVol = 3.91 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
HEPTASAT::Condition = 0, batVol = 3.89 [V]
HEPTASAT::Condition = 0, batVol = 3.90 [V]
Command Number = 101
Ax = 0.028740, Ay = 9.680669, Az = 0.423918
Gx = -0.015260, Gy = -0.030520, Gz = -0.656180
Mx = 0.000000, My = 0.000000, Mz = 0.000000
Ax = 0.014370, Ay = 9.829160, Az = 0.356858
Gx = -1.762530, Gy = 0.038150, Gz = -0.854560
Mx = 1.500000, My = 75.000000, Mz = -84.300003
Ax = 0.028740, Ay = 9.831555, Az = 0.404758
Gx = -1.587040, Gy = 0.038150, Gz = -0.450170
Mx = 0.300000, My = 76.500000, Mz = -82.500000
Ax = 0.016765, Ay = 9.843531, Az = 0.411943
Gx = -1.533630, Gy = 0.404390, Gz = -0.457800
Mx = 0.600000, My = 74.699997, Mz = -82.800003
```

Thank you for your Attention
Questions?

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